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SCIENTIFIC INVESTIGATIONS

Self-reported view on work capacity predicts abnormal Oxford Sleep Resistance Test results in patients with obstructive sleep apnea

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Study Objectives: The Oxford Sleep Resistance Test is an objective vigilance test based on behavior. It is a modified version of the maintenance of wakefulness test and is considered less burdensome and less expensive than the maintenance of wakefulness test. Although professional drivers with obstructive sleep apnea in Europe must be assessed for their ability to maintain adequate wakefulness on a yearly basis, Oxford Sleep Resistance Test results are usually normal in this population. In this retrospective observational study, we searched for predictive factors of abnormal Oxford Sleep Resistance Test sleep latency.

Methods: We included 1,071 Oxford Sleep Resistance Test results of patients with obstructive sleep apnea (95% men, aged 21–74 years). Mean sleep latency < 40 minutes was considered abnormal.

Results: Sleep latency was abnormal in 12.0% of tests. Participants at risk for abnormal test results self-reported as being sleepy, depressed, on sick leave, unemployed, or retired or considered themselves unable to work. In a logistic regression model, the self-reported view on work capacity was the most important predictor of abnormal Oxford Sleep Resistance Test sleep latency (odds ratio, 3.5). Ongoing sick leave was also an important predictor for abnormal test results.

Conclusions: A self-reported good ability to work predicts that a patient with sleep apnea can maintain wakefulness in a vigilance test. This may help in reducing the increasing challenge with frequent tests.

Keywords: vigilance, wakefulness, OSA, professional driver, work ability

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Professional drivers with obstructive sleep apnea may have difficulties in maintaining adequate wakefulness, which must be assessed regularly according to regulations. The Oxford Sleep Resistance Test is a practical vigilance test based on behavior; however, results from this test are often normal among professional drivers.

Study Impact: The study showed that a self-reported view on work capacity is strongly associated with Oxford Sleep Resistance Test results. If a professional driver finds no problem with working ability, uses continuous positive airway pressure every night, has low self-reported sleepiness, and is not on sick leave for any reason, a vigilance test will be abnormal very rarely.

INTRODUCTION

Obstructive sleep apnea (OSA) leads to recurrent pauses in air flow, oxyhemoglobin desaturations, and sleep fragmentation. OSA is also associated with other serious conditions, such as hypertension and stroke. Excessive daytime sleepiness is often associated with untreated OSA and sometimes even with treated OSA. OSA affects many aspects of neurocognitive performance, including attention and vigilance, memory and learning, psychomotor function, emotional regulation, and executive function.[1]

Vigilant attention is consistently affected by sleep loss caused by either reduced quantity or reduced quality of sleep. Vigilance is crucial for occupational tasks such as motor vehicle operation or industrial equipment monitoring. Although OSA increases the relative risk of motor vehicle accidents 3- to 6-fold, disease severity does not predict individual risk.[2,3]

The Epworth Sleepiness Scale (ESS) is the most commonly used self-assessment of enduring sleepiness. Scores > 10 are indicative of a higher than usual tendency for drowsiness.[4] The maintenance of wakefulness test (MWT) is the most widely used objective test for sustained ability to stay awake in soporific circumstances.[5] The test sessions last for 40 minutes and are repeated 4 times a day. The analysis of the MWT is based on electroencephalography and other polysomnographic channels. Sleep onset is defined as the first epoch of > 15 seconds of cumulative sleep in a 30-second epoch.[5]

The Oxford Sleep Resistance Test (OSLER) is a modified MWT based on behavior.[6] An individual is instructed to sit quietly and respond by hitting a button on portable device each time a dim light flashes for 1 second at 3-second intervals during a 40-minute period. If the individual fails to respond for 21 seconds, the test is concluded and sleep latency is set to that particular moment. If the individual does not make those 7 subsequent errors, then sleep latency is considered 40 minutes. The original test consisted of four 40-minute sessions,[6] but other researchers, including our group, have since attempted versions with 3 sessions or even less.[7–9]

In addition to sleep latency, analysis of the error profile during the test, including 1 to 6 consecutive missed hits, has been shown to reveal abnormal fluctuations in vigilance.[7–9] An OSLER error index can be obtained by dividing the total number of errors made in 1 session by the duration of the session (time spent awake) in hours.[9] An error index ≥ 10 errors/h is considered abnormal.[9] OSLER results have been shown to closely correlate with MWT results[7,10] and to reveal response to continuous positive airway pressure (CPAP) treatment.[8,9] Patients with OSA with more missed stimuli in a modified OSLER test had more motor vehicle accidents.[11] OSLER has several advantages over MWT: the device is portable and has minimal technical requirements, and the analysis is much faster and does not require experienced professionals.

In European Union countries, there are driving restrictions for patients with OSA, especially drivers of vehicles in categories C, D, and E (ie, group 2 driving licenses).[12] Drivers of buses and trucks need to have a group 2 driving license. In addition, the same driving restrictions are applied to commercial taxi drivers, even if their vehicles are not heavy. Drivers' ability to maintain adequate vigilance must be assessed on a regular basis—every year with a group 2 license and every 3 years with a group 1 license—regardless of CPAP treatment. Because the number of professional drivers with OSA is very high, the current European regulations are very demanding. In many countries, including Finland, the regulations cannot be fully applied. In Finland, OSLER and MWT are both approved as an objective measurement for vigilance among professional drivers.

Not all patients with OSA are sleepy. Only 46% of patients with moderate-to-severe OSA have scored > 10 in ESS.[13] This finding has also been observed in our sleep unit, where the majority of OSLER results are normal even if we apply very strict limits (any result < 40 minutes as an average sleep latency is considered abnormal).

Our aim was to identify factors that predict a reduced ability for staying awake when tested in soporific conditions. We hypothesized that being unable to work (either objectively or as self-reported) predicts abnormal results in the OSLER.

METHODS

We studied all individuals referred to the sleep unit for suspicion of OSA who underwent an OSLER during the study period (November 2015–September 2018). Our sleep unit is considered a tertiary referral center for sleep apnea and serves as a part of the Helsinki University Hospital. Our ethics committee approved the study (HUS/152/2016). Because this retrospective observational study was based on documents completed during normally scheduled outpatient visits, no written informed consent was required.

Overnight cardiorespiratory polygraphy (home sleep apnea test) was performed with a Noxturnal T3 device (Nox Medical, Reykjavik, Iceland) at the participants' homes, usually a few weeks before the OSLER. Respiratory parameters were scored manually according to American Academy of Sleep Medicine criteria.[14] A respiratory event index (REI) ≥ 5.0 events/h without central apneas was defined as a finding of OSA. CPAP therapy was proposed for all patients with OSA and daytime symptoms related to sleep apnea. For professional drivers, CPAP therapy was also proposed even with negligible daytime symptoms if they had moderate or severe OSA (REI ≥ 15.0 events/h).

OSLER was performed exactly as previously described.[9] The first session began at 09:00 followed by 2 sessions at 2-hour intervals. Altogether, 1,150 OSLER tests were performed during the study period. The result was doubtful in 44 (3.8%) tests, so they were excluded. Of these 44 tests, the device had technical failure in 4 patients; the remaining doubtful results were because of individual circumstances. Because the test was always monitored with recorded video, in these 40 patients it could be seen that the individuals did not fall asleep but they had, by accident, started to hit the button carelessly, slightly sideways, and the device did not register the movement because of the capacitive sensing of the OSLER. These individuals did not pass their test then, but they were shortly either retested using the OSLER or tested using the MWT. For clarity, these individuals were excluded from the present study.

In the home sleep apnea study, the REI was < 5.0 events/h in 37 patients. These individuals did not have OSA but were sleepy for other reasons; these individuals were excluded. After 37 individuals without OSA and 44 doubtful test results were excluded, the study included 1,071 OSLER results.

Demographic information included sex, age, body mass index (BMI), smoking habits, alcohol use, ESS score, the Depression Scale (DEPS),[15] and occupation. Risk occupation was defined as being a professional driver or working in other professions where falling asleep constitutes a risk for the environment. The DEPS is a screening instrument designed for the Finnish adult population, and it has shown that the probability of clinical depression starts to rise with scores of 10 or more.[15] Parameters from the home sleep apnea test included REI and an oxygen desaturation index of 3%.

At the time of the OSLER, patients were asked if they were unemployed, retired, or on sick leave (regardless of the reason). Patients were also asked about their self-reported work ability (full, reduced, or absent work capacity). Further, data about prescribed CPAP therapy were collected and individuals were asked if they had used their CPAP device during the night preceding the OSLER day. Some individuals had taken their OSLER already before CPAP therapy had been started or even prescribed.

Statistical analyses were performed with a computerized statistical package (IBM SPSS Statistics 25.0, Armonk, NY). Because the variables were not normally distributed, we used the Mann-Whitney *U* test for continuous variables and the χ^2 test for categorical variables. Continuous variables were reported as medians and interquartile ranges, and categorical variables were reported as percentages. Logistic regression models were built with a forced method.

RESULTS

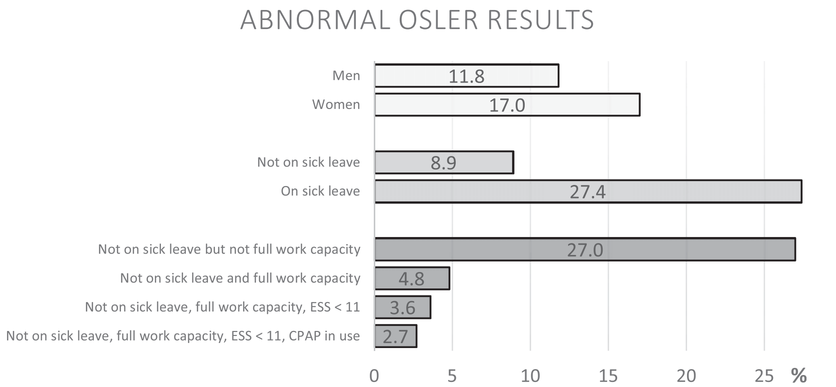
A total of 1,071 individuals (95.1% men, mean age 51 years) were included (**Table 1**). Twelve percent had an abnormal

Table 1—Demographic characteristics for individuals with normal and abnormal OSLER results.

	All (n = 1,071)	Normal OSLER (n = 942)	Abnormal OSLER (n = 129)	*P*
Men (%)	95.1	95.3	93.0	.257[b]
Age (y)	52 (45–57)	52 (45–57)	52 (48–58)	.247[c]
BMI (kg/m^2)	32 (28–37)	32 (28–37)	33 (29–36)	.276[c]
Risk occupation (%)	62.2	62.1	65.1	.385[b]
Unemployed or retired	9.2	8.4	15.5	.009[b]
Active smoker (%)	15.9	15.8	16.3	.893[b]
Alcohol doses per day	0.5 (0.0–1.1)	0.5 (0.0–1.1)	0.7 (0.1–1.0)	.696[c]
DEPS	3 (1–7)	3 (1–6)	8 (3–13)	< .001[c]
ESS	5 (2–9)	4 (2–7)	11 (7–16)	< .001[c]
REI baseline	31 (18–54)	30 (18–53)	34 (18–59)	.256[c]
ODI3 baseline	30 (17–53)	29 (17–51)	32 (16–57)	.590[c]
CPAP therapy prescribed (%)	66.8	67.7	61.7	.281[b]
CPAP in use[a] (%)	80.4	81.0	75.9	.288[b]
On sick leave (%)	17.4	14.4	39.5	< .001[b]
Not full self-reported work capacity (%)	25.1	19.3	67.4	< .001[b]

Data are expressed as the median (interquartile range) or percentages as appropriate. *P* value shows the statistical significance between individuals with normal and abnormal OSLER sleep latency. [a]CPAP therapy prescribed and in use the night before OSLER. [b]Pearson's χ^2 test. [c]The Mann-Whitney *U* test. Statistically significant differences between groups are in *P* value rows 5, 8, 9, 14, and 15. BMI = body mass index, DEPS = Depression Scale, ESS = Epworth Sleepiness Scale, ODI3 = oxygen desaturation index of 3 percentage units, OSLER = Oxford Sleep Resistance Test, REI = respiratory event index.

Figure 1—Percentages of abnormal test results in various subgroups in the study.



Percentages of abnormal sleep latencies in the OSLER with respect to some background characteristics and their combinations. ESS = Epworth Sleepiness Scale, OSLER = Oxford Sleep Resistance Test.

OSLER result (ie, mean sleep latency < 40 minutes). Sixty-two percent were professional drivers or worked in other professions where dozing or falling asleep constitutes a significant risk for the individual and the environment (eg, industrial equipment monitoring or other risk occupations). Sex, age, BMI, smoking habits, use of alcohol, or being in a risk occupation were not statistically different between the groups with normal or abnormal OSLER results. Severity of OSA, prescribed CPAP therapy, or adherence to CPAP were also not statistically significant characteristics. Being outside working life (ie, being unemployed or retired), ongoing sick leave, DEPS scores, ESS scores, and self-reported view on absent or reduced work capacity were the most significant factors.

Figure 1 shows the percentages of abnormal OSLER results with respect to some characteristics and their combinations. Of those patients who did not have ongoing sick leave, only 8.9% had a mean sleep latency < 40 minutes. Of those who had ongoing sick leave for any reason, as many as 27.4% had an abnormal sleep latency. Of those who were not on sick leave and who considered themselves fully capable of working, only 4.8% had an abnormal result. On the other hand, of those who were not presently on sick leave but considered themselves not fully capable of working, 27.0% had an abnormal OSLER result, an approximately 5.6-fold greater result with respect to self-reported view on work capacity. Furthermore, of those who did not have ongoing sick leave, had a self-reported full work capacity, had a normal ESS score, and had used CPAP the night before the OSLER, as few as 2.7% had an abnormal result.

We then built a logistic regression model to identify which factors might predict an abnormal sleep latency in the OSLER.

Table 2—Logistic regression model to define factors that predict abnormal OSLER result.

	B	SE	Wald	*df*	Sig.	Exp (B)	95% CI for Exp (B)	
							Lower	Upper
ESS	0.195	0.024	69.050	1	< .001	1.216	1.161	1.273
REI	0.010	0.004	6.125	1	.013	1.011	1.002	1.019
On sick leave	0.537	0.252	4.554	1	.033	1.712	1.045	2.804
Unable to work	1.232	0.247	24.767	1	< .001	3.427	2.1110	5.566
Constant	–4.621	0.327	199.455	1	< .001	0.010	—	—

Statistically significant differences between groups are in the first 4 statistical significance rows. B = beta coefficient, CI = confidence interval, *df* = degrees of freedom, ESS = Epworth Sleepiness Scale, Exp (B) = odds ratio, OSLER = Oxford Sleep Resistance Test, REI = respiratory event index, SE = standard error, Sig. = statistical significance.

An abnormal OSLER served as the dependent factor. We first applied sex, age, BMI, DEPS score, ESS score, REI, CPAP prescribed but not in use right before the OSLER, ongoing sick leave, and self-reported inability to work as independent factors (data not shown). Notably, we did not apply retirement to the model, because we aimed to find factors among the working-age population in particular. Statistically significant factors were ESS score, REI, CPAP not in use right before the OSLER, and self-reported inability to work. We observed that DEPS score and ESS score had a strong intercorrelation, as did DEPS score and ongoing sick leave. We then built another logistic regression model with fewer variables and tried to avoid intercorrelations as much as possible (**Table 2**). This second model only had the following statistically significant factors: ESS score, REI, ongoing sick leave, and self-reported inability to work. The Nagelkerke R^2 value of the model was reasonable at .344 (ie, the model explained 34.4% of the variation of the dependent factor, an abnormal OSLER result). Self-reported view on work capacity was by far the most important predictor of abnormal OSLER sleep latency. The odds ratio of the self-reported view on work capacity was 3.427 (95% confidence interval, 2.110–5.566) in the logistic regression model.

As for the OSLER error index, the number of abnormal results, ≥ 10 errors/h, was 207 (19.3% of all tests included in the study). The error index and sleep latency were strongly correlated. The same demographic characteristics were associated with both. In addition, the same factors predicted for the abnormal OSLER error index as for the abnormal OSLER sleep latency (data not shown).

DISCUSSION

This was the first study on predictive factors for abnormal OSLER results. We had a large cohort, which included patients with OSA with various demographic characteristics from everyday clinical practice. Because the OSLER is a behavioral vigilance test, it was expected that a self-reported view on sleepiness (ESS scores) would be strongly associated with abnormal sleep latency on the OSLER. Unexpectedly, age, BMI, smoking, or alcohol were not associated with poorer results.

Consistent with previous studies, the severity of sleep apnea (ie, REI and an oxygen desaturation index of 3% in a home sleep apnea test) was not associated with abnormal OSLER results.[9] REI was a statistically significant predictive factor in our regression model, although the odds ratio was weak. Moreover, prescribed CPAP therapy or CPAP actually in use the night before the OSLER (adherence to CPAP) was not associated with abnormal OSLER results. Previously, CPAP therapy was shown to ameliorate vigilance.[8,9] In the present study, we started CPAP treatment for professional drivers with moderate-to-severe OSA even with very mild daytime symptoms. This condition may explain the fact that their OSLER results were often normal even without CPAP, which prevented us from observing any statistically significant amelioration.

By far the strongest predictor for abnormal sleep latency in OSLER was shown to be the self-reported view on work capacity being absent or reduced. Individuals who did not consider themselves fully capable to work were 5 times more likely to have abnormal test results than those who considered themselves fully capable. According to our regression model, the odds ratio of the self-reported view on work capacity was 3.5. Even though the OSLER is an objective vigilance test, it is based on behavior, and behavior is affected by subjective thoughts. Lack of motivation was perhaps the key factor in this connection. It may be that these individuals were unable to motivate themselves sufficiently to stay awake during the test. When a person is tired, 40 minutes 3 times a day is a long time to resist falling asleep. These individuals may have felt that failing in the test did not have repercussions for their present situation. Furthermore, individuals with reduced or absent work ability may have had problems with executive function because of disrupted sleep or reduced self-discipline because of a depressive mood.

Moreover, individuals who were presently on sick leave had abnormal OSLER results regardless of the reason. The main reasons for sick leave were back pain or excessive daytime sleepiness for an individual in a risk occupation. Some individuals may have slept poorly because of pain. An ongoing sick leave correlated with the DEPS score. Lack of sufficient motivation and willpower when taking the OSLER could be the common factor behind these findings related to sick leave, depressive mood, and self-reported work capacity.

This association with the self-reported inability to work and an abnormal OSLER result could also be explained by the fact that some patients may want to retire and thus pretend to be sleepier than they actually are during the test. Faking on the OSLER is possible, because only behavior is measured. Still, our years of experience allow us to see the difference between a someone who is faking and a sleepy individual. When a test session is started, someone who is faking very soon completely stops hitting the button every 3 seconds, and thus a technical problem is suspected. In contrast, a sleepy but motivated individual first looks very tired, closes their eyes unintentionally, makes some errors, struggles back to normal functioning, makes more errors, and finally falls asleep with 7 consecutive misses. It has been shown that the greater the level of drowsiness, the greater the moment-to-moment variability in behavioral alertness.[16] At least according to our experience in Finland, individuals rarely attempt to obtain a false result; patients taking the OSLER know that if they fail the test, then they may lose not only their group 2 but also their group 1 driving license. The MWT is considered the gold standard for a vigilance test, but an individual prone to cheating could intentionally present sleepiness and fall asleep during the test as well.

Compared to the MWT, the OSLER has several advantages, including minimal technical requirements for the device and lower costs. It is practical and does not require highly experienced professionals to run or analyze, unlike the MWT. If an individual has problems with fine motor skills or cooperation or received a doubtful result on the OSLER, then the recommended next step is the MWT. All other patients' ability to maintain adequate vigilance can be assessed with the OSLER as reliably as with the MWT.

Our finding can likely be generalized for other vigilance tests as well. Motivation and willpower are required for good results in all vigilance tests, including the MWT.[17,18] Loss of motivation or compliance affected the results of a short form of the psychomotor vigilance test.[19] Motivation and arousal states have common biological regulators.[20]

In everyday clinical practice, it is important to note that the result of a vigilance test is only one detail to notice when a clinician considers whether a patient with sleep apnea in a risk occupation is fit for work or not. Self-reported scales and objective tests investigate different dimensions of sleepiness, and sometimes even 2 different tests may be needed.[21] If a patient is worried about how to cope with sleepiness at work, then that person should not be permitted to drive despite a possible normal OSLER result. The consequences of dozing off even once could be fatal for the individual or others. The OSLER is at its most useful in the opposite situation—ie, when a patient with sleep apnea does not see any problem with daytime sleepiness but the test result is abnormal; thus the clinician has a document to show the patient and the patient's employer that the patient must be removed from normal responsibilities until the test results become normal. A normal maintenance of wakefulness could then be achieved individually with better adherence to CPAP therapy; longer sleep time; taking care of restless legs, pain, or other symptoms disturbing sleep; or paying attention to possible depressive mood.

Limitations

This study had some limitations. Because we did not have polysomnography or actigraphy from the preceding night, we cannot exclude the effect of partial sleep deprivation on OSLER results. The individuals were asked if they had slept normally, and it was to their benefit to only participate in the test after a good night of sleep. All individuals in the study were members of the same national insurance system for costs incurred because of health problems; therefore, we cannot generalize our conclusions to other health insurance systems.

CONCLUSIONS

The majority of the OSLER results were normal when the test was performed by patients with OSA in risk occupations. Self-reported reduced or absent work capacity predicted abnormal OSLER results; the severity of sleep apnea, age, or BMI was not predictive. Because the demand for vigilance tests largely surpasses available resources, we recommend prioritizing OSLER tests for professional drivers with a mismatch between their medical history, clinical findings, and self-reported work capacity.

ABBREVIATIONS

BMI, body mass index
CPAP, continuous positive airway pressure
DEPS, Depression Scale
ESS, Epworth Sleepiness Scale
MWT, maintenance of wakefulness test
OSA, obstructive sleep apnea
OSLER, Oxford Sleep Resistance Test
REI, respiratory event index

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DISCLOSURE STATEMENT

All authors have seen and approved the manuscript. The work was performed at the Sleep Unit, Heart and Lung Center, Helsinki University Hospital, Finland. The authors report no conflicts of interest.