https://doi.org/10.5664/jcsm.8574

JCSM | Journal of Clinical Sleep Medicine

SCIENTIFIC INVESTIGATIONS

Observation and Interview-based Diurnal Sleepiness Inventory for measurement of sleepiness in patients referred for narcolepsy or idiopathic hypersomnia

Laure Peter-Derex, MD, PhD[1,2,3]; Fabien Subtil, MD, PhD[2,4,5]; Guillaume Lemaitre, BSc[2]; François Ricordeau, MD[1]; Hélène Bastuji, MD, PhD[1,3]; Agathe Bridoux, MD, PhD[1]; Fannie Onen MD, PhD[6,7,8]; S-Hakki Onen, MD, PhD[1,3]

[1]Center for Sleep Medicine and Respiratory Diseases, Croix-Rousse Hospital, Hospices Civils de Lyon, Lyon, France; [2]Lyon 1 University, Lyon, France; [3]Lyon Neuroscience Research Center, CNRS 5292, INSERM U1028, Lyon, France; [4]Service de Biostatistiques, Hospices Civils de Lyon, Lyon, France; [5]Laboratoire de Biométrie et Biologie Évolutive, CNRS UMR 5558, Villeurbanne, France; [6]Centre Hospitalier Universitaire Bichat Claude Bernard, Service de gériatrie, Assistance Publique, Hôpitaux de Paris, Paris, France; [7]INSERM 1178 and Centre de Recherche en Epidémiologie et Santé des Populations, Université Paris Sud, Paris, France; [8]Center for Sleep and Circadian Neurobiology, Division of Sleep Medicine, School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania

Study Objectives: First, to determine whether the 3-item Observation and Interview-based Diurnal Sleepiness Inventory (ODSI) measures the degree of excessive daytime sleepiness in patients with suspected narcolepsy or idiopathic hypersomnia (IH). Second, to assess the correlation between the ODSI and the Epworth Sleepiness Scale (ESS) as well as objective polysomnographic measurements. Third, to test the accuracy of the ODSI to detect narcolepsy or IH (narcolepsy/IH) compared with the ESS.

Methods: A total of 181 patients complaining of excessive daytime sleepiness filled in the ESS and the ODSI and underwent measurements including actigraphy, full-night polysomnography, Multiple Sleep Latency Test, and 24-hour bedrest sleep recording.

Results: Narcolepsy or IH was diagnosed in 76 patients. The ODSI found excessive daytime sleepiness in 92.3% of all patients and in 98.7% of those diagnosed with narcolepsy/IH. In the whole population, the ODSI was significantly positively correlated with the ESS ($R = .547$; 95% confidence interval: .436, .642; $P < .001$) and weakly with 24-hour total sleep time on bedrest recording ($R = .208$; 95% confidence interval: .056, .350; $P = .047$) but not with the Multiple Sleep Latency Test. The ODSI offered a higher negative (92.9%) and positive (44.9%) predictive value to detect narcolepsy/IH than did the ESS (66.7% and 43.3%, respectively). In the IH group, the ODSI's third-item score (daily sleepiness duration) was significantly higher in patients with than without increased 24-hour total sleep time ($P = .023$).

Conclusions: The ODSI is a brief, simple first-line questionnaire that explores both intensity and duration of daytime sleepiness and offers a high sensitivity to detect narcolepsy and IH.

Keywords: hypersomnia, narcolepsy, ODSI, MSLT, bedrest, ESS

Citation: Peter-Derex L, Subtil F, Lemaitre G, et al. Observation and Interview-based Diurnal Sleepiness Inventory for measurement of sleepiness in patients referred for narcolepsy or idiopathic hypersomnia. *J Clin Sleep Med*. 2020;16(9):1507–1515.

BRIEF SUMMARY

Current Knowledge/Study Rationale: Excessive daytime sleepiness is a major public health issue with many causes, including neurological hypersomnia such as narcolepsy and idiopathic hypersomnia. As narcolepsy and idiopathic hypersomnia are infrequent severe conditions whose diagnosis requires highly specialized in-laboratory explorations, accurate tools for excessive daytime sleepiness screening and assessment are needed.

Study Impact: The ODSI's (Observation and Interview-based Diurnal Sleepiness Inventory's) high sensibility and simple administration, as well as its ability to quantify sleepiness duration, makes it a good first-line screening tool for narcolepsy and idiopathic hypersomnia, especially before scheduling prolonged bedrest recordings. The weak correlation between self-reported scores and objective explorations observed in our study underlines the complex nature of drowsiness, and highlights the importance of a multimodal comprehensive diagnostic approach.

INTRODUCTION

Excessive daytime sleepiness (EDS) is a major public health issue affecting more than 5% of the general population.[1] It is associated with severe academic and professional issues, cognitive impairments, and increased accidental risk, especially at wheel.[2–4] Its main causes are sleep deprivation, sedative treatments, and sleep disorders, including obstructive sleep apnea (OSA) syndrome, or rare but highly disabling diseases such as narcolepsy and idiopathic hypersomnia (IH; narcolepsy/IH).[1,5]

Diagnosis of narcolepsy/IH relies on patient-reported clinical information, self-reported assessments of EDS, and several polysomnographic objective measures.[6] Questionnaires, such as the Epworth Sleepiness Scale (ESS),[7] Karolinska Sleepiness Scale,[8] and Stanford Sleepiness Scale,[9] are easy to use, inexpensive, but obviously self-reported and associated with confounding factors such as depression.[10,11] Thus, objective laboratory vigilance tests have been proposed: the Multiple Sleep Latency Test (MSLT), which evaluates the propensity to fall asleep when required during 4 or 5 successive nap opportunities, and the

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

Maintenance of Wakefulness Test, which measures the ability not to fall asleep in passive conditions.[12–14] However, such objective tests are time consuming, expansive, and they have been criticized for their "artificial" aspect and their poor correlation with self-reported tests.[13–16] Type 1 narcolepsy benefits from the dosage of hypocretin in the cerebrospinal fluid, but this exploration remains invasive and there is no biological marker available for type 2 narcolepsy and IH.[17,18] As a result, no objective or self-reported method alone is perfect for diagnosing most of neurological hypersomnia.

Thus, the development of new tools for measurement of vigilance may be useful and likely to find application in clinical practice, for screening of patients who require specific inlaboratory explorations, as well as to help provide a better understanding of the multiple dimensions of drowsiness. Recently, the Observation and Interview-based Diurnal Sleepiness Inventory (ODSI) questionnaire has been proposed as a tool for assessing EDS regardless of education and socioeconomic status.[19,20] This new 3-item questionnaire evaluates drowsiness in a passive and in an active situation and quantifies the duration of daytime sleepiness; it can be self-administered or completed by a health professional as an interview with patients and informants. The ODSI allows assessment of sleep propensity and daytime sleepiness duration in an individual's everyday life without cultural, scholarly, or professional references. Among the numerous factors that may cause a person to be excessively sleepy all the time, the ODSI does not aim to distinguish what those factors may be, but rather distinguishes that excessive sleepiness may be a health concern that warrants further diagnosis. This questionnaire is brief, easy to administer, and exhibits a good internal consistency, test-retest reliability, and concurrent (as compared with the ESS) validity in measuring sleepiness in a population of elderly apneic individuals.[19,20]

The purpose of this study investigating the usefulness of the ODSI in a wide population of patients reporting EDS and referred for suspicion of IH or narcolepsy is 3-fold: first, to determine whether the 3-item ODSI questionnaire measures the degree of EDS in patients with suspected narcolepsy/IH; second, to assess the correlation of the ODSI with the ESS and objective polysomnographic measurements; and third, to test the accuracy of the ODSI to detect narcolepsy/IH as compared with the ESS.

METHODS

Patients

Adult patients referred to the Center for Sleep Medicine and Respiratory Diseases with a suspicion of narcolepsy or IH between June 2017 and January 2019 were retrospectively screened to be included in the study. Most of them had been referred by a general practitioner or a pneumologist as they complained of EDS without an obvious etiology according to previous evaluation (sleep diary, ambulatory polygraphy, etc). Thus, full exploration had been performed in our center, including clinical evaluation, questionnaires, actigraphy (for sleep–wake schedules assessment in order to rule out sleep deprivation or sleep–wake rhythm disorder),[21] and 48-hour in-hospital recording including 1-night polysomnography (PSG; to exclude sleep fragmentation and OSA despite negative polygraphy),[22] MSLT, and 24-hour ad libitum sleep monitoring (for diagnosis of narcolepsy and IH).[23,24] In some patients, additional evaluations had been performed: forced awakening test (for sleep inertia assessment),[25] psychiatric evaluation (when psychiatric hypersomnia was suspected), and urinary 6-sulfatoxymelatonin assay (in case of sleep–wake rhythm disorder suspicion).[26] Patients were classified into 4 diagnostic groups according to clinical and electrophysiological evaluation results, *International Classification of Sleep Disorders*, *Third Edition*, criteria,[27] and pluri-disciplinary consensus meeting of sleep experts when diagnosis was equivocal, as follows: (1) central disorder of hypersomnolence due to narcolepsy type 1, narcolepsy type 2, or IH (narcolepsy/IH); (2) central disorder of hypersomnolence due to insufficient sleep syndrome; (3) central disorder of hypersomnolence due to other causes (neurological disorder, Kleine Levin syndrome, psychiatric hypersomnia, sedative treatments, sleep–wake rhythm disorder); and (4) hypersomnia secondary to OSA (an apnea-hypopnea index >15 events/h with significant sleep fragmentation [arousal index >20 events/h] was considered likely to explain EDS). The aim of this classification was to distinguish patients with primary neurological hypersomnia in whom vigilance tests or bedrest were needed for diagnosis (narcolepsy or IH) and other patients with either a well-defined diagnosis (OSA diagnosed with PSG, insufficient sleep syndrome diagnosed with actigraphy) or less well-defined diagnosis (the "other" group, which also included rare diseases or "elimination" diagnosis).

All patients had given informed consent for the use of their data for research purposes.

Study protocol and data collection

Clinical data

The following clinical data were reviewed in patients' medical file: age, sex, medical history, current treatments, body mass index, wake-promoting substances (eg, coffee, cola) consumption.

Questionnaires

As part of routine diagnosis evaluation, patients were asked to complete several questionnaires: ESS,[7] Pichot fatigue scale,[28] Beck Depression Inventory,[29] and ODSI, which had been implemented in our Sleep unit since the publications by Onen and colleagues.[19,20] The ODSI is a 3-item assessment tool. The first item examines sleepiness during basic activities of daily living (such as driving, eating, speaking). The second item is related to falling asleep during periods of inactivity (such as reading or watching television). The third item asks about cumulated hours of daytime sleep (including sleepiness, falling asleep, and naps). A weighting of the 3 subscores allows taking into account the fact that falling asleep during active situations (the first item) is likely more dangerous and more abnormal. The total score ranges from 0 (no somnolence) to 24 (excessive somnolence). Previous studies have reported that a cutpoint of 6 was effective for identifying older adults with excessive levels of daytime sleepiness.

Actigraphy

A wrist-worm accelerometer (MotionWatch 8, CamNtech Ltd, Cambridge, UK) was used for ambulatory actigraphy during the

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

7–14 days preceding hospitalization. Patients completed a sleep diary during the actigraphy recording. MotionWare software was used for data analyses.

PSG

Full-night PSG was conducted in the Sleep Medicine and Respiratory Disease Center. Patients arrived in the late afternoon, returned the wrist accelerometer, and underwent instrumentation for the electrodes and sensors required for PSG. The following signals were recorded: electroencephalogram (Fp2–C4, C4–T4, T4–O2, Fp1–C3, C3–T3, T4–O2, Fz–Cz, Cz–Pz), electro-oculogram, chin and tibialis electromyogram, electrocardiogram, nasal airflow (nasal pressure and thermistor), pulse oxymetry, microphone, and respiratory efforts (thoracic and abdominal). Bedtime was free, but patients were informed that they would be awakened at 7:00 AM in the morning for MSLT protocol and that they should have had at least 6 hours of sleep before MSLT.

MSLT

The day following PSG recording, a standard MSLT protocol was administered to patients according to the American Academy of Sleep Medicine guidelines.[14] The initial nap opportunity began 1.5 to 3 hours after termination of the nocturnal recording. Nap opportunities were at 2-hour intervals. Mean sleep latency over all tests and total number of naps containing sleep-onset rapid eye movement (REM) periods were calculated for each patient.

Usually, mean sleep latency of 10 minutes or less indicates objective daytime sleepiness. The current cutoff for the central disorders of hypersomnolence is a mean sleep latency of 8 minutes or less. This cutoff is used as a diagnostic criterion mainly for narcolepsy and IH. In addition, 2 or more sleep-onset REM periods were used to distinguish narcolepsy from IH.[27]

Twenty-four-hour ad libitum sleep monitoring

After the end of the last nap of the MSLT session, a continuous 24-hour ad libitum sleep monitoring was performed: electroencephalogram, electro-oculogram, chin electromyogram, and electrocardiogram were recorded with an ambulatory device that allowed the patients either to stay in the hospital room or to have a walk around the hospital but not to go back home (in order to prevent them from restricting their sleep time because of everyday life activities). Patients were advised not to resist sleep and to sleep as long as they wished. They were not disturbed during 24 hours and could ask for meals whenever they wanted. This recording allowed the measurement of total sleep time per 24 hours in the absence of constraints. Polysomnograms and MSLT were scored by trained sleep medicine physicians (L.P.-D., H.B., A.B., and F.R.). The 24-hour ad libitum sleep monitoring was performed as a total sleep time of 660 minutes or more as an additional criterion for IH if other polysomnography/MSLT findings are absent.[27]

Statistical analysis

Quantitative variables were described by the mean (SD) and median (first and third quartiles); qualitative variables were described by the frequency and percentage of each modality (excluding missing data from percentages). Comparisons of results between groups (diagnostic groups, included/excluded patients, groups stratified by age, sex, or body mass index) were performed using the Kruskal-Wallis or Wilcoxon tests for quantitative results, and the chi-square or Fisher's tests for qualitative results. When the difference was significant, post hoc comparisons were performed to compare groups between one another using the Holm method to take into account multiple testing. Correlations between different tests (ODSI, ESS, MSLT, bedrest) were assessed by the Spearman rank correlation coefficient (R), with its 95% confidence interval (95% CI); the Holm method was used to adjust P values when necessary. The diagnostic value of the tests was assessed by the area under the receiver operating characteristic curve (AUC) with its 95% CI. For sensitivity and specificity, positive- and negative-predictive values were calculated for different thresholds. $P < .05$ was considered significant. The analyses were performed using the R software version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Population

A total of 235 consecutive adult patients referred for suspicion of narcolepsy/IH and who had benefited from clinical evaluation, actigraphy, and 48-hour sleep recording were retrospectively identified in our database. Fifty-four patients were excluded because of missing data regarding questionnaires that had not been exhaustively completed by some patients: among them, 34 did not complete any of the 4 questionnaires and at least 1 questionnaire was missing for the 20 others. Among the 181 included patients (mean ± SD age: 38.27 ± 15.93 years; 121 women), 76 (42%) had a final diagnosis of narcolepsy or IH (among which, 64.5% were IH), 24 had a diagnosis of hypersomnia secondary to insufficient sleep syndrome (ISS), 36 had a diagnosis of OSA, and 45 had a diagnosis of "other" hypersomnia including 21 patients with psychiatric hypersomnia. In the narcolepsy/IH group, 17 patients were taking wake-promoting drugs, which had been stopped for at least 4 days before the recordings. A total of 26 patients were taking antidepressant drugs (7 in the narcolepsy/IH group, 2 in the ISS group, 11 in the OSA group, and 6 in the "other hypersomnia" group). Demographic, clinical, and questionnaires results of the patients according to the hypersomnolence cause, are presented in **Table 1**. The 4 groups of patients significantly differed in age, sex, and body mass index. Post hoc analysis revealed that patients with OSA were significantly more often male (vs narcolepsy/IH, adjusted $P = .017$; vs ISS, $P = .017$; vs "others," $P = .003$), older (vs narcolepsy/IH, $P < .001$; vs ISS, $P = .011$; vs "others," $P = .023$), and they had a higher body mass index ($P < .001$ vs narcolepsy/IH, ISS, and "others") than patients in the 3 other groups, which did not differ in these variables between one another. The comparison of demographic variables between patients who were (n = 181) and were not (n = 54) included in the study is provided in **Table S1**. The sex ratio differed between the 2 groups (fewer males in the included group: 33.1% vs 55.4%; $P = .005$) and the MSLT mean latency was lower in the excluded group (median

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

Table 1—Demographic and clinical characteristics of the patients.

	Diagnosis				*P*
	Narcolepsy/IH (n = 76)	Insufficient Sleep Syndrome (n = 24)	OSA (n = 36)	Others (n = 45)	
Age, mean (SD), years	32.87 (14.95)	37.71 (15.22)	49.03 (13.27)*	39.09 (15.80)	<.001
Sex, female, n (%)	53 (69.7)	19 (79.2)	14 (38.9)*	35 (77.8)	<.001
BMI, mean (SD), kg/m^2	24.34 (5.58)	23.48 (4.43)	28.52 (5.56)*	23.54 (4.48)	<.001
ODSI					
Mean (SD)	16.62 (4.47)	14.71 (5.54)	12.83 (6.60)*	14.58 (5.89)	.023
Median	17.50	16.00	14.00	16.00	
Q1–Q3	14.75–20.00	11.75–18.25	8.00–18.00	12.00–19.00	
Min–Max	4.00–24.00	3.00–22.00	0.00–23.00	2.00–24.00	
ODSI ≥6, n (%)	75 (98.7)	22 (91.7)	29 (80.6)*	41 (91.1)	
ESS					
Mean (SD)	16.49 (4.35)	15.12 (4.84)	13.31 (4.43)*	15.44 (3.86)	.005
Median	17.00	15.00	14.00	16.00	
Q1–Q3	14.00–19.00	11.75–18.50	11.00–16.00	14.00–18.00	
Min–Max	6.00–24.00	5.00–23.00	3.00–22.00	1.00–22.00	
ESS ≥11, n (%)	68 (89.5)	20 (83.3)	28 (77.8)*	41 (91.1)	
Pichot scale					
Mean (SD)	19.41 (6.06)	17.71 (8.34)	17.50 (6.81)	21.33 (6.42)	.054
Median	20.50	18.00	17.00	22.00	
Q1–Q3	15.00–23.00	12.00–23.25	14.00–22.50	16.00–26.00	
Min–Max	2.00–32.00	3.00–32.00	1.00–28.00	5.00–32.00	
BDI					
Mean (SD)	9.84 (6.94)	10.22 (7.57)	10.56 (6.85)	13.36 (8.29)	.105
Median	9.00	7.00	10.00	12.00	
Q1–Q3	5.00–13.00	4.50–14.50	5.00–16.25	6.00–19.00	
Min–Max	0.00–31.00	1.00–29.00	0.00–22.00	0.00–37.00	

BDI = Beck Depression Inventory; BMI = body mass index; ESS = Epworth Sleepiness Scale; IH = idiopathic hypersomnia; Max = maximum; Min = minimum; ODSI = Observation and Interview-based Diurnal Sleepiness Inventory; OSA = obstructive sleep apnea syndrome; Q, quartile. Post hoc analyses: *Significant (P < .05) differences between groups. Patients with OSA were significantly older, less often female, and more obese than the 3 other groups; they had significantly lower ODSI and ESS scores than patients with narcolepsy/IH.

[quartile 1–quartile 3]: 7.88 [4.81–11.50] vs 10.00 [7.00–13.88], P = .013). No difference was found for the other variables including the distribution of the 4 diagnoses.

Results of questionnaires and sleep recordings

With regard to questionnaires, 92.3% and 86.7% of patients had abnormal ODSI and ESS scores, respectively. No difference between groups was seen for Pichot (despite a strong trend, P = .054, with higher values observed in the "other" group) and Beck Depression Inventory scales, nor for the proportion of patients with abnormal ESS scores. After adjusting for sex, which was found to be a determining factor of Pichot scale (see **Table S2**), the 4 groups differed (P = .04516), with no significant post hoc results. ESS mean score, ODSI mean score, and proportion of patients with abnormal ODSI score were significantly higher in the narcolepsy/IH group than in the OSA group (respectively, adjusted P = .003, P = 0.24, P = .003). All patients but one had an abnormal ODSI score in the narcolepsy/IH group.

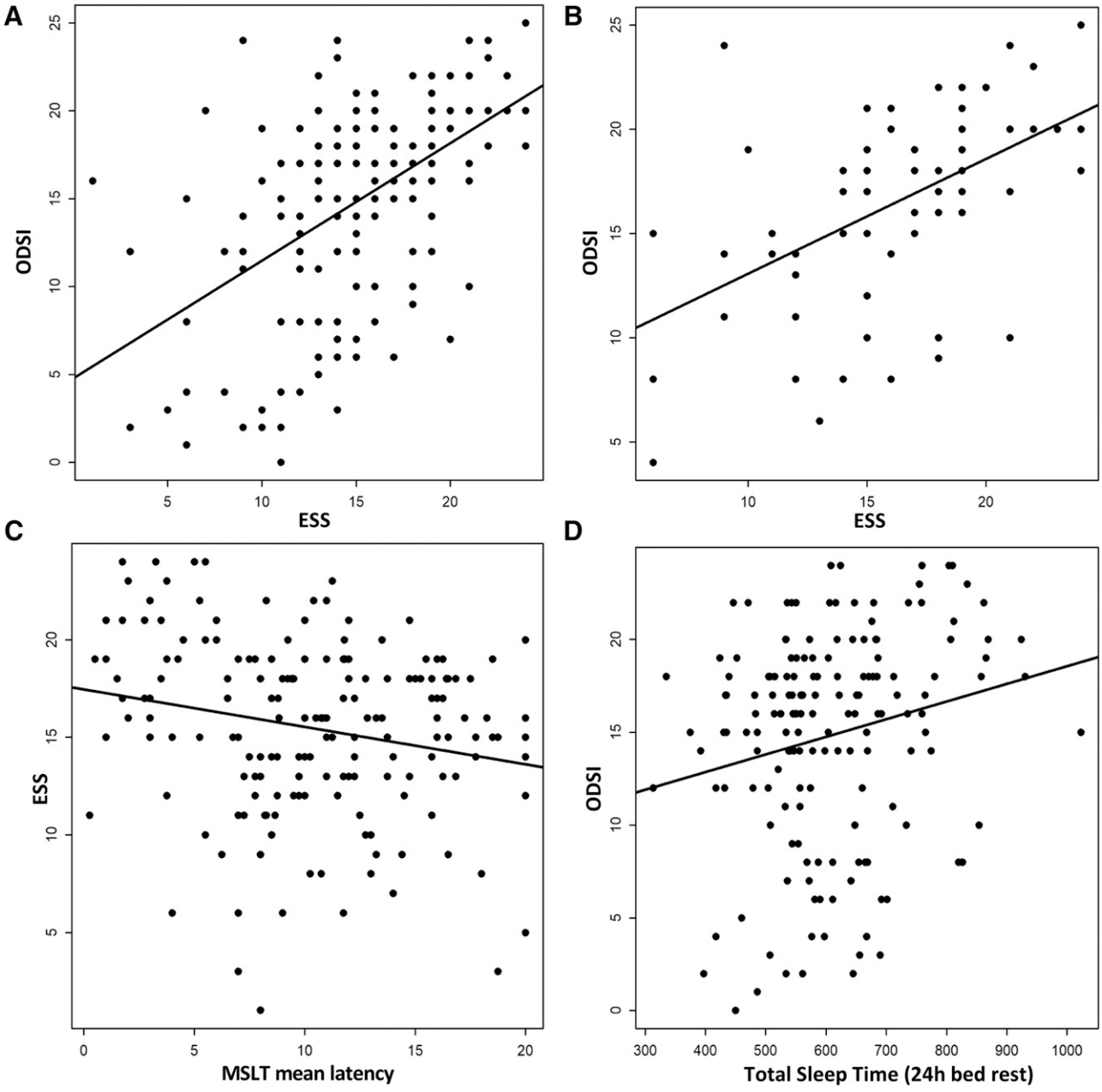
Detailed results of sleep recordings are provided in **Table S3**. Mean MSLT latency was abnormal in 61.8% of patients with narcolepsy/IH, but also in 8.3% of patients with ISS, 14.7% of patients with OSA, and 15.6% in the "other" group. Five out of the 29 recorded sleep-onset REM periods were found in patients without narcolepsy/IH. As expected, sleep was more disturbed in patients with OSA with reduced sleep efficiency as compared with the narcolepsy/IH group (P = .014) and they had an increased arousal index as compared with the 3 other groups (P < .001).

Correlations between questionnaires and objective tests

Results of correlation analyses are presented in **Figure 1**. The ODSI and ESS were significantly positively correlated with each other in the whole population (R = .547; 95% CI: .436, .642; P < .001) and in the narcolepsy/IH group (R = .562; 95% CI: .386, .699; P < .001). A weak negative correlation was found between the ESS and MSLT both in the whole population

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

Figure 1—Correlations between self-reported and objective tools.



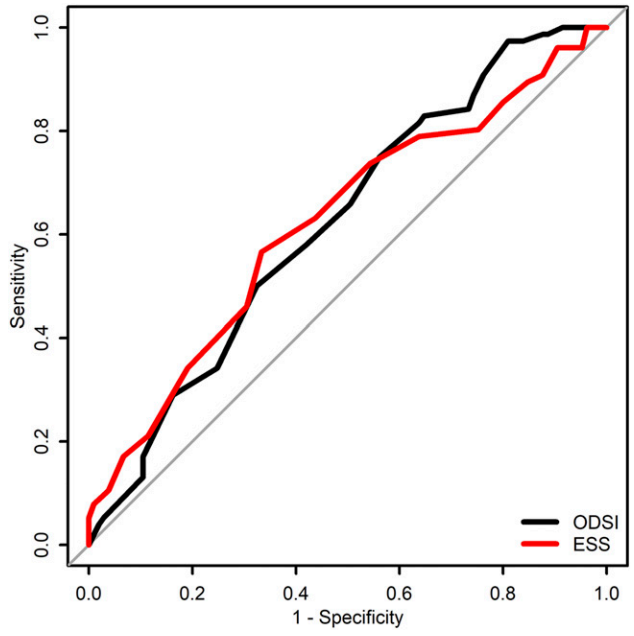
The ODSI and ESS are significantly positively correlated with each other in the whole population (R = .547; 95% CI: .436, .642; P < .001) **(A)** and in patients with narcolepsy/IH (R = .562; 95% CI: .386, .699; P < .001) **(B)**. In the whole population, the MSLT mean latency is significantly but weakly negatively correlated with the ESS (R = −.208, 95% CI: −.344, −.063; P = .021) **(C)** and the ODSI is significantly but weakly positively correlated with the total sleep time assessed by 24-hour Holter recording (R = .208; 95% CI: .056, .350; P = .047) **(D)**. P values are adjusted for multiple comparisons. CI = confidence interval; ESS = Epworth Sleepiness Scale; IH = idiopathic hypersomnia; MSLT = Multiple Sleep Latency Test; ODSI = Observation and Interview-based Diurnal Sleepiness Inventory.

(R = −.208; 95% CI: −.344, −.063; P = .021) and in patients with narcolepsy/IH (R = −.304; 95% CI: −.495, −.084; P = .023). A weak negative correlation was also found between the ODSI and MSLT in the whole population (R = −.175; 95% CI: −.314, −.029; P = .038), whereas this correlation did not remain significant after correction for multiple correlations in patients with narcolepsy/IH (R = −.158; 95% CI: −.370, .070; P = .173).

A weak but significant positive correlation was found between the ODSI and total sleep time recorded during 24-hour bedrest in the whole population (R = .208; 95% CI: .056, .350; P = .047) but not in the narcolepsy/IH group (R = .279; 95% CI: .036, .491; P = .127), or between the ESS and total sleep time recorded during 24-hour bedrest in the whole population (R = .117; 95% CI: −.037, .266; P = .407) and in the narcolepsy/IH group (R = .070; 95% CI: −.179, .311; adjusted P = .685, P = 1). No significant correlation was found either between MSLT and 24-hour bedrest results in the whole population (R = −.136; 95% CI: −.285, .019; P = .342)

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

Figure 2—Accuracy of self-reported tools alone to detect narcolepsy/IH.



ROC curves of the ODSI and ESS; both questionnaires exhibit a high sensitivity. ESS = Epworth Sleepiness Scale; IH = idiopathic hypersomnia; ODSI = Observation and Interview-based Diurnal Sleepiness Inventory; ROC = receiver operating characteristic.

or in the narcolepsy/IH group (R = .121; 95% CI: −.129, .356; P = .685).

Accuracy of the ODSI for the detection of narcolepsy/IH

Global ODSI score

Receiver operating characteristic curves of diagnosis value for the ODSI and the ESS are presented in **Figure 2**: AUCs were, respectively, .622 (with 95% CI: .541, .704) and .623 (with 95% CI: .539, .706), demonstrating very close diagnostic accuracies of the 2 questionnaires.

Sensitivity, specificity, and positive- and negative-predictive value of ESS and ODSI, according to different thresholds for narcolepsy/IH diagnosis, are presented in **Table 2**. Among patients with narcolepsy/IH, 98.7% and 89.5% had abnormal scores on the ODSI (score ≥6) and the ESS (score ≥11), respectively. As a result, the ESS, and especially the ODSI, had an excellent sensitivity; ODSI with a threshold of 6 or higher exhibited the highest negative-predictive value (.929; 95% CI: .661, .998). On the other hand, positive-predictive values were low (.449). Only a high (≥18) threshold for the ODSI allowed reaching a satisfactory specificity (.676; 95% CI: .578, .764).

Subscore analysis

A more detailed analysis of the ODSI results was performed, using subscores on the 3 items. Results for each item are detailed in **Table 3**. Patients with OSA had significantly lower scores on item 2 than patients with narcolepsy/IH (P < .001). ODSI score did not differ between patients with narcolepsy and IH. However, subscores exhibited differences for item 1 and 2 (significantly higher in the narcolepsy group; P = .028 and P = .018, respectively) but no significant difference was found for item 3 (P = .834). In order to examine if item 3 (which aims to quantify sleepiness duration) was associated with a specific phenotype of IH, we compared the subgroup of IH with increased total sleep time on bedrest (24-hour total sleep time ≥660 minutes, n = 30) with the subgroup of IH without long sleep duration (n = 19); item 3 was significantly higher in the former group (3.03 ± 1.54 vs 1.80 ± 1.42, P = .023).

DISCUSSION

In the present study we assessed the diagnostic accuracy of a 3-item questionnaire, the ODSI, in a wide population of middle-aged adult patients complaining of EDS due to different causes. The ODSI had been previously evaluated in older adults with OSA.[19] We report here that, in younger patients with OSA, but also central disorder of hypersomnolence including narcolepsy and IH, ISS, and psychiatric hypersomnia, the ODSI is highly correlated with EDS complaints and with the ESS scores. In the specific population of patients diagnosed with narcolepsy and IH, its negative-predictive value is higher than that of the ESS, and subitem analysis allows discrimination between narcolepsy and IH, as well as between hypersomnia with and without long duration. However, the ODSI specificity remains low and, like the ESS, the ODSI is poorly correlated with objective vigilance tests.

Early diagnosis of narcolepsy/IH is warranted, given the clinical, social, and economic burden of these diseases.[30,31] Thus, high-sensitivity, simple, first-step screening tools that could be used in the primary care setting are needed to identify patients with hypersomnolence who require sleep exploration. The ODSI is an easy-to-use and brief questionnaire, that can be either self-, proxy- or physician-administered.[19,20] It is usable by nonspecialist physicians and may apply to a wide population of adult patients without social or occupational reference, whereas patients may not engage in all of the activities identified by the ESS (eg, some patients do not drive or barely read).[32] The ODSI reaches a high sensitivity (98.7%) and negative-predictive (92.9%) value that allow considering it as a first-line screening questionnaire. Moreover, the ODSI explores different components of hypersomnolence, including sleep propensity (sleepiness) but also sleep duration, which may be particularly interesting in the setting of IH in which some patients do not complain of EDS but rather experience an increase in sleep duration and sleep inertia.[23,33] Interestingly, item 3 ("estimated sleepiness duration") of the ODSI score was found to discriminate patients with hypersomnia with and without increase in sleep duration, as assessed by 24-hour Holter recording. The ODSI may thus be used to identify patients with IH who may need prolonged 24- or 36-hour bedrest because of a "long sleep time" phenotype.[23,33,34]

Accurate screening of patients who require evaluation in specialized centers is also needed in order to avoid unnecessary, time-consuming, and costly evaluations.[5,35–38] Diagnosis of narcolepsy/IH was confirmed in less than half of the patients

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

Table 2—Diagnostic value of the ODSI and ESS in the narcolepsy/IH group without any additional criteria.

Test Score	Sensitivity [95% CI]	Specificity [95% CI]	Positive-Predictive Value [95% CI]	Negative-Predictive Value [95% CI]
ODSI ≥6	.987 [.929, 1.000]	.124 [.068, .202]	.449 [.372, .528]	.929 [.661, .998]
ODSI ≥9	.921 [.836, .970]	.229 [.152, .321]	.464 [.382, .546]	.800 [.614, .923]
ODSI ≥13	.829 [.725, .906]	.352 [.262, .452]	.481 [.393, .570]	.740 [.597, .854]
ODSI ≥18	.500 [.383, .617]	.676 [.578, .764]	.528 [.407, .647]	.651 [.554, .740]
ESS ≥11	.895 [.803, .953]	.152 [.090, .236]	.433 [.354, .514]	.667 [.447, .844]

Sensitivity, specificity, and positive- and negative-predictive values are presented for different ODSI cutpoints and for the ESS. CI = confidence interval; ESS = Epworth Sleepiness Scale; IH = idiopathic hypersomnia; ODSI = Observation and Interview-based Diurnal Sleepiness Inventory.

Table 3—The ODSI subscores according to diagnosis.

	Diagnosis						Total (n = 181)
	Narcolepsy/IH			Insufficient Sleep Syndrome (n = 24)	OSA (n = 36)	Others (n = 45)	
	All Patients (n = 76)	Narcolepsy (n = 27)	Idiopathic Hypersomnia (n = 49)				
ODSI							
Mean (SD)	16.62 (4.47)	17.85 (4.19)	15.94 (4.51)	14.71 (5.54)	12.83 (6.60)	14.58 (5.89)	15.10 (5.59)
Median	17.50	19.00	17.00	16.00	14.00	16.00	16.00
Q1–Q3	14.75–20.00	15.50–20.00	14.00–18.00	11.75–18.25	8.00–18.00	12.00–19.00	12.00–19.00
Min–Max	4.00–24.00	4.00–24.00	6.00–24.00	3.00–22.00	0.00–23.00	2.00–24.00	0.00–24.00
ODSI item 1							
Mean (SD)	8.53 (3.68)	9.56 (3.14)	7.96 (3.85)*	7.83 (4.35)	6.75 (4.72)	7.16 (4.37)	7.74 (4.19)
Median	10.00	10.00	9.00	10.00	8.00	8.00	9.00
Q1–Q3	8.00–11.00	9.00–12.00	7.00–10.00	7.00– 11.00	0.00–10.00	7.00–10.00	7.00–11.00
Min–Max	0.00–12.00	0.00–12.00	00.00–12.00	0.00– 12.00	0.00–12.00	0.00–12.00	0.00–12.00
ODSI item 2							
Mean (SD)	5.41 (0.88)	5.70 (0.67)	5.24 (0.95)*	5.00 (1.14)	4.19 (1.72)**	5.11 (1.25)	5.04 (1.28)
Median	6.00	6.00	6.00	5.00	4.50	6.00	6.00
Q1–Q3	5.00–6.00	6.00–6.00	6.00–6.00	4.00– 6.00	3.75–6.00	4.00–6.00	4.00–6.00
Min–Max	2.00–6.00	3.00–6.00	2.00–6.00	2.00–6.00	0.00–6.00	1.00–6.00	0.00–6.00
ODSI item 3							
Mean (SD)	2.71 (1.63)	2.67 (1.54)	2.73 (1.69)	1.88 (1.54)	1.92 (1.71)	2.27 (1.72)	2.33 (1.68)
Median	2.50	2.00	3.00	2.00	2.00	2.00	2.00
Q1–Q3	1.75–4.00	1.00–4.00	2.00–4.00	0.75–3.00	0.00–3.00	1.00–3.00	1.00–3.00
Min–Max	0.00–6.00	1.00–6.00	0.00–6.00	0.00–5.00	0.00–6.00	0.00–6.00	0.00–6.00

IH = idiopathic hypersomnia; Max = maximum; Min = minimum; ODSI = Observation and Interview-based Diurnal Sleepiness Inventory; OSA = obstructive sleep apnea syndrome; Q, quartile. *Patients with narcolepsy have significantly higher scores for ODSI item 1 and 2 than patients with IH ($P = .028$ and $P = .018$, respectively). **Patients with OSA have lower scores for ODSI item 2 than patients with narcolepsy/IH ($P < .001$).

admitted to our center with suspected diagnosis of narcolepsy or IH. This emphasizes both the fact that numerous other causes lead to EDS and numerous patients remain overreferred for narcolepsy/IH, especially patients with polygraphy-negative OSA or patients with chronic sleep deprivation, in whom a sleep diary may not be reliable and actigraphy is not always performed despite recommendations.[21,39,40] According to the *International Classification of Sleep Disorders*, *Third Edition*, PSG followed by MSLT and/or 24- to 36-hour bedrest are considered the gold-standard evaluations for narcolepsy/IH diagnosis.[27] However, abnormal short sleep latency and sleep-onset REM periods, as well as increased total sleep duration can be observed in other conditions.[41] In our population, 14 patients without narcolepsy/IH had abnormal MSLT. On the other hand, sensitivity of this test depends on normative criteria but is not perfect.[42] This stresses the fact that objective measurements cannot be used in isolation to confirm or exclude narcolepsy/IH in patients with EDS and that they need to be interpreted in conjunction with the comprehensive analysis of clinical evaluation and questionnaires. Moreover, the weak correlation between self-reported scores and objective explorations observed in our study and by other teams underlines the complex nature of drowsiness, and highlights the importance of a multimodal comprehensive diagnostic approach.[13,43–45]

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

We acknowledge several limitations of our work. First, this was a retrospective study; 54 out of our 235 patients were excluded because of missing data in questionnaires. The comparison between included and excluded patients revealed that the 2 groups differed in sex ratio and MSLT mean latency. More females were present in the included group, potentially because sex may influence survey response rates in general.[46] However, since sex was not a determining factor of the ODSI in our study, we do not believe that this bias could have influenced our results. The lower MSLT latency in the excluded group may suggest that these patients experienced a more severe sleepiness that had prevented them from reading and filling in questionnaires. This may limit the generalization of our results to more severe populations. Second, our narcolepsy/IH population does not reflect the epidemiology of narcolepsy and IH, even if the latter is less well known.[47–49] Indeed, patients with IH were twice as prevalent, and NT2 patients were as numerous as NT1 patients. This may be explained by the fact that, when patients present with a suspicion of narcolepsy with highly suggestive symptoms, they benefit from PSG followed by MSLT only. The exhaustive evaluation including actigraphy, PSG, MSLT, and 24-hour bedrest is reserved for patients with a suspicion of IH or without a clear diagnosis orientation. Third, we decided to group different diagnoses (eg, hypersomnia due to substances, to psychiatric or medical conditions, sleep–wake rhythm disorder) into the same category in order not to increase the number of subgroups and as we wanted to study the most frequent causes of EDS (OSA and ISS) as well as the main group of our study, narcolepsy/IH. It is also important to note that the ODSI has not yet been specifically validated in a population other than elderly individuals with OSA. Finally, the gold standard for diagnosis of many causes of hypersomnolence is questionable; diagnostic criteria are evolving, and some are not clearly defined (such as ISS, which is a relative notion). We used *International Classification of Sleep Disorders, Third Edition*, criteria, but also, in many cases, pluri-disciplinary consensus of experts including neurologists, psychiatrists, and pneumologists, all of whom are specialized in sleep medicine.

CONCLUSIONS

In conclusion, the ODSI is a simple, easy-to-use, questionnaire correlated with the ESS in a population of young and middle-aged adults with hypersomnolence due to various sleep pathologies. The ODSI scores separately perceived duration of sleepiness, sleepiness in conditions where the individual should be active, and sleepiness in resting or passive conditions. In the context of narcolepsy/IH, the ODSI has a high sensitivity and a good negative-predictive value, which makes it a good screening test and a first step before scheduling further sleep evaluation, especially for patients with IH in whom prolonged bedrest recording is required for diagnosis.

ABBREVIATIONS

CI, confidence interval
EDS, excessive daytime sleepiness
ESS, Epworth Sleepiness Scale
ISS, insufficient sleep syndrome
IH, idiopathic hypersomnia
MSLT, Multiple Sleep Latency Test
ODSI, Observation and Interview-based Diurnal Sleepiness Inventory
OSA, obstructive sleep apnea
PSG, polysomnography
REM, rapid eye movement

REFERENCES

1. Ohayon MM. From wakefulness to excessive sleepiness: what we know and still need to know. *Sleep Med. Rev.* 2008;12(2):129–141.
2. Dinges DF. An overview of sleepiness and accidents. *J Sleep Res.* 1995;4(S2): 4–14.
3. Zhou J, Camacho M, Tang X, Kushida CA. A review of neurocognitive function and obstructive sleep apnea with or without daytime sleepiness. *Sleep Med.* 2016; 23:99–108.
4. Mazza S, Pepin JL, Naegele B, Plante J, Deschaux C, Levy P. Most obstructive sleep apnoea patients exhibit vigilance and attention deficits on an extended battery of tests. *Eur Respir J.* 2005;25(1):75–80.
5. Dauvilliers Y. Differential diagnosis in hypersomnia. *Curr Neurol Neurosci Rep.* 2006;6(2):156–162.
6. Cluydts R, De Valck E, Verstraeten E, Theys P. Daytime sleepiness and its evaluation. *Sleep Med Rev.* 2002;6(2):83–96.
7. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep.* 1991;14(6):540–545.
8. Åkerstedt T, Gillberg M. Subjective and objective sleepiness in the active individual. *Int J Neurosci.* 1990;52(1-2):29–37.
9. Hoddes E, Dement W, Zarcone V. The development and use of the Stanford Sleepiness Scale (SSS). *Psychophysiology.* 1972;9:150.
10. Bixler EO, Vgontzas AN, Lin HM, Calhoun SL, Vela-Bueno A, Kales A. Excessive daytime sleepiness in a general population sample: the role of sleep apnea, age, obesity, diabetes, and depression. *J Clin Endocrinol. Metab.* 2005; 90(8):4510–4515.
11. Schreier DR, Roth C, Mathis J. Subjective perception of sleepiness in a driving simulator is different from that in the Maintenance of Wakefulness Test. *Sleep Med.* 2015;16(8):994–998.
12. Richardson GS, Carskadon MA, Flagg W, Van den Hoed J, Dement WC, Mitler MM. Excessive daytime sleepiness in man: multiple sleep latency measurement in narcoleptic and control subjects. *Electroencephalogr Clin Neurophysiol.* 1978; 45(5):621–627.
13. Chervin RD, Aldrich MS. The Epworth Sleepiness Scale may not reflect objective measures of sleepiness or sleep apnea. *Neurology.* 1999;52(1): 125–131.
14. Littner MR, Kushida C, Wise M, et al. Practice parameters for clinical use of the multiple sleep latency test and the maintenance of wakefulness test. *Sleep*. 2005; 28(1):113–121.
15. Wise MS. Objective measures of sleepiness and wakefulness: application to the real world? *J Clin Neurophysiol.* 2006;23(1):39–49.
16. Bonnet MH. ACNS clinical controversy: MSLT and MWT have limited clinical utility. *J Clin Neurophysiol.* 2006;23(1):50–58.
17. Barateau L, Lopez R, Dauvilliers Y. Clinical neurophysiology of CNS hypersomnias. *Handb Clin Neurol.* 2019;161:353–367.
18. Bassetti CLA, Adamantidis A, Burdakov D, et al. Narcolepsy—clinical spectrum, aetiopathophysiology, diagnosis and treatment. *Nat Rev Neurol.* 2019;15(9): 519–539.
19. Onen F, Lalanne C, Pak VM, Gooneratne N, Falissard B, Onen S-H. A three-item instrument for measuring daytime sleepiness: the Observation and Interview Based Diurnal Sleepiness Inventory (ODSI). *J Clin Sleep Med.* 2016;12(4): 505–512.

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.

20. Pak VM, Onen SH, Gooneratne NS, Falissard B, Onen F. Observation and Interview-based Diurnal Sleepiness Inventory for measurement of sleepiness in older adults. *Nat Sci Sleep*. 2017;9:241–247.
21. Smith MT, McCrae CS, Cheung J, et al. Use of actigraphy for the evaluation of sleep disorders and circadian rhythm sleep-wake disorders: an American Academy of Sleep Medicine systematic review, meta-analysis, and GRADE assessment. *J Clin Sleep Med.* 2018;14(7):1209–1230.
22. Kapur VK, Auckley DH, Chowdhuri S, et al. Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: an American Academy of Sleep Medicine Clinical Practice Guideline. *J Clin Sleep Med.* 2017;13(3): 479–504.
23. Vernet C, Arnulf I. Idiopathic hypersomnia with and without long sleep time: a controlled series of 75 patients. *Sleep*. 2009;32(6):753–759.
24. Bassetti C, Aldrich MS. Idiopathic hypersomnia: a series of 42 patients. *Brain*. 1997;120(Pt 8):1423–1435.
25. Peter-Derex L, Perrin F, Petitjean T, Garcia-Larrea L, Bastuji H. Discriminating neurological from psychiatric hypersomnia using the forced awakening test. *Neurophysiol Clin.* 2013;43(3):171–179.
26. Claustrat B, Brun J, Chazot G. The basic physiology and pathophysiology of melatonin. *Sleep Med Rev.* 2005;9(1):11–24.
27. American Academy of Sleep Medicine. *International Classification of Sleep Disorders*. 3rd ed. Darien, IL: American Academy of Sleep Medicine; 2014.
28. Pichot P, Brun JP. [Brief self-evaluation questionnaire for depressive, asthenic and anxious dimensions.] *Ann Med Psychol*. 1984;142(6):862–865. In French.
29. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry.* 1961;4(6):561–571.
30. Flores NM, Villa KF, Black J, Chervin RD, Witt EA. The humanistic and economic burden of narcolepsy. *J Clin Sleep Med.* 2016;12(3):401–407.
31. Thorpy M, Morse AM. Reducing the clinical and socioeconomic burden of narcolepsy by earlier diagnosis and effective treatment. *Sleep Med Clin.* 2017; 12(1):61–71.
32. Onen F, Moreau T, Gooneratne NS, Petit C, Falissard B, Onen SH. Limits of the Epworth Sleepiness Scale in older adults. *Sleep Breath.* 2013;17(1):343–350.
33. Billiard M, Sonka K. Idiopathic hypersomnia. *Sleep Med Rev.* 2016;29:23–33.
34. Evangelista E, Lopez R, Barateau L, et al. Alternative diagnostic criteria for idiopathic hypersomnia: a 32-hour protocol. *Ann Neurol.* 2018;83(2):235–247.
35. Rosenberg RP. Clinical assessment of excessive daytime sleepiness in the diagnosis of sleep disorders. *J Clin Psychiatry.* 2015;76(12):e1602.
36. Monderer R, Ahmed IM, Thorpy M. Evaluation of the sleepy patient: differential diagnosis. *Sleep Med Clin.* 2017;12(3):301–312.
37. Murray BJ. A practical approach to excessive daytime sleepiness: a focused review. *Can Respir J* 2016;2016:4215938.
38. Guilleminault C, Brooks SN. Excessive daytime sleepiness: a challenge for the practising neurologist. *Brain*. 2001;124(Pt 8):1482–1491.
39. Escourrou P, Grote L, Penzel T, et al. The diagnostic method has a strong influence on classification of obstructive sleep apnea. *J. Sleep Res.* 2015;24(6): 730–738.
40. Thurman SM, Wasylyshyn N, Roy H, et al. Individual differences in compliance and agreement for sleep logs and wrist actigraphy: a longitudinal study of naturalistic sleep in healthy adults. *PLoS One*. 2018;13(1):e0191883.
41. Mignot E, Lin L, Finn L, et al. Correlates of sleep-onset REM periods during the Multiple Sleep Latency Test in community adults. *Brain*. 2006;129(Pt 6): 1609–1623.
42. Aldrich MS, Chervin RD, Malow BA. Value of the Multiple Sleep Latency Test (MSLT) for the diagnosis of narcolepsy. *Sleep*. 1997;20(8):620–629.
43. Johns MW. Sensitivity and specificity of the Multiple Sleep Latency Test (MSLT), the Maintenance of Wakefulness Test and the Epworth Sleepiness Scale: failure of the MSLT as a gold standard. *J Sleep Res.* 2000;9(1):5–11.
44. Fong SY, Ho CK, Wing YK. Comparing MSLT and ESS in the measurement of excessive daytime sleepiness in obstructive sleep apnoea syndrome. *J Psychosom Res.* 2005;58(1):55–60.
45. Olson LG, Cole MF, Ambrogetti A. Correlations among Epworth Sleepiness Scale scores, multiple sleep latency tests and psychological symptoms. *J Sleep Res.* 1998;7(4):248–253.
46. Tyser AR, Abtahi AM, McFadden M, Presson AP. Evidence of non-response bias in the Press-Ganey patient satisfaction survey. *BMC Health Serv Res.* 2016; 16(a):350.
47. Ohayon MM, Priest RG, Zulley J, Smirne S, Paiva T. Prevalence of narcolepsy symptomatology and diagnosis in the European general population. *Neurology.* 2002;58(12):1826–1833.
48. Dauvilliers Y, Paquereau J, Bastuji H, Drouot X, Weil JS, Viot-Blanc V. Psychological health in central hypersomnias: the French Harmony study. *J Neurol Neurosurg Psychiatry.* 2009;80(6):636–641.
49. Roth B. Narcolepsy and hypersomnia: review and classification of 642 personally observed cases. *Schweiz Arch Neurol Neurochir Psychiatr.* 1976; 119(1):31–41.

SUBMISSION & CORRESPONDENCE INFORMATION

Submitted for publication December 23, 2019
Submitted in final revised form May 11, 2020
Accepted for publication May 11, 2020
Address correspondence to: Laure Peter-Derex, MD, PhD, Center for Sleep Medicine and Respiratory Diseases, Croix-Rousse Hospital, 103 Grande Rue de la Croix-Rousse, 69004 Lyon, France; Tel: (33) +4 72 07 17 69, Fax (33) + 4 72 07 28 08; Email: laure.peter-derex@chu-lyon.fr

DISCLOSURE STATEMENT

All authors have seen and approved the manuscript. The authors report no conflicts of interest.

Downloaded from jcsm.aasm.org by 49.145.234.186 on March 17, 2022. For personal use only. No other uses without permission.
Copyright 2022 American Academy of Sleep Medicine. All rights reserved.