Self-evaluated and Close Relative-Evaluated Epworth Sleepiness Scale vs. Multiple Sleep Latency Test in Patients with Obstructive Sleep Apnea

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Objectives: The aims of this study were to determine (1) the agreement in Epworth Sleepiness Scale (ESS) evaluated by patients and their close relatives (CRs), and (2) the correlation of objective sleepiness as measured by multiple sleep latency test (MSLT) with self-evaluated and close relative-evaluated ESS.

Methods: A total of 85 consecutive patients with obstructive sleep apnea (OSA) (70 males, age 46.7 ± 12.9 years old) with an apnea-hypopnea index (AHI) > 5 events per hour (mean $38.9 \pm 26.8/h$) were recruited into this study. All participants underwent an overnight polysomnographic assessment (PSG), MSLT, and ESS rated by both patients and their CRs. Mean sleep latency < 8 min on MSLT was considered objective daytime sleepiness.

Results: Self-evaluated global ESS score (ESS_g) was closely correlated with evaluation by CRs ($r = 0.79$, $p < 0.001$); the mean ESS_g score evaluated by patients did not significantly differ from that evaluated by CRs ($p > 0.05$). However, Bland-

Altman plot showed individual differences between self-evaluated and CR-evaluated ESS scores, with a 95%CI of -9.3 to 7.0 . The mean sleep latency on MSLT was significantly associated with CR-evaluated ESS_g ($r = -0.23$, $p < 0.05$); significance of association with self-evaluated ESS_g was marginal ($r = -0.21$, $p = 0.05$).

Conclusions: CR-evaluated ESS has a good correlation but also significant individual disagreement with self-evaluated ESS in Chinese patients with OSA. CR-evaluated ESS performs as well as, if not better than, self-evaluated ESS in this population when referring to MSLT.

Keywords: Obstructive sleep apnea, excessive daytime sleepiness, Epworth Sleepiness Scale, multiple sleep latency test, close relatives

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Excessive daytime sleepiness (EDS) is one of the most common symptoms in patients suffering from obstructive sleep apnea (OSA). Four percent of men and 2% of women have OSA with symptoms of EDS.¹ EDS is known to be associated with reduced quality of life,²⁻⁵ impaired cognitive function,⁶ and increased risk of various accidents,⁷ as well as cardiovascular and cerebrovascular morbidities⁸ in patients with OSA.

As the degree of EDS is correlated with the severity of OSA, the determination of the severity of EDS in patients with OSA is important in the evaluation of disease progress and severity,⁹ prediction of outcomes,¹⁰⁻¹⁴ and indication of treatment response. Among the various methods to define the degree of EDS, the Epworth Sleepiness Scale (ESS) and the multiple sleep latency test (MSLT) are the most commonly used tools for evaluating subjective and objective daytime sleepiness in patients with OSA.^{15,16} A number of clinical studies have found that ESS score is closely associated with MSLT in individuals with OSA¹⁷⁻²⁰; however, some studies report no significant correlation between ESS and MSLT scores in subjects with OSA.^{18,20-22} This inconsistency might be due to the severity of OSA,²¹ age of participants,²³ and/or the sample size of the study.^{17,21} These findings

BRIEF SUMMARY

Current Knowledge/Study Rationale: To determine the agreements in Epworth Sleepiness Scale (ESS) evaluated by patients and their close relatives (CR) and the correlations of objective sleepiness as measured by multiple sleep latency test (MSLT) with self-evaluated and CR-evaluated ESS.

Study Impact: CR-evaluated ESS performs as well as self-evaluated ESS in patients with obstructive sleep apnea (OSA) when referring to MSLT. CR-evaluated ESS scores maybe a supplement for assessing daytime sleepiness in patients with OSA.

raise the concerns about the disagreement between objective and subjective sleepiness in patients with OSA.

The ESS is a tool measuring how likely a patient estimates he/she is to doze off or fall asleep in eight different daily situations.¹⁶ However, if the patient has little awareness of his/her own daytime sleepiness or believes that his/her sleep patterns are normal, the ESS may give unreliable results.²³ Since a close relative (CR) of a patient can easily observe the patient's episodes of dozing off or falling asleep in these daily situations, CR might be a supplementary source in assessing patients' daytime sleepiness. However, previous studies have shown

contradictory results in agreement between self-evaluated and CR-evaluated ESS scores. Two studies found consistency between self-evaluated and CR-evaluated scores,^{24,25} while six others^{19,23,26-29} found some degree of disagreement despite moderate to high correlation. For example, CRs of patients with OSA tends to overestimate the severity of the patient's sleepiness, with a mean of difference in ESS ranging from 1.2 to 2.6 ($p < 0.05$).^{19,23,26-29} Several factors including age, relationship between patient and CR, and education level of patient and CR, might account for the inconsistent results. To our knowledge, no previous study has tested the correlations of self-evaluated ESS_G scores and CR-evaluated ESS_G with MSLT scores. We thus conducted this study to determine the agreement of ESS score evaluated by patients and their CRs. In particular, the present study was to determine whether witnessed sleepiness based on ESS_G evaluated by CR is closer than self-evaluated ESS_G score to the mean sleep latency in patients with OSA.

METHODS

Setting

This was a cross-sectional observational study and was conducted in Sleep Medicine Center, West China Hospital of Sichuan University, China. Informed consent was obtained from all subjects and CRs. This study was approved by the Research Ethics Board of the West China Hospital of Sichuan University.

Subjects

Eighty-five (15 female and 70 male, mean age $\pm$ SD 46.60 $\pm$ 12.85 years) consecutive Chinese patients admitted from July 2012 to September 2012 were recruited into current study. Inclusion criteria were (1) newly diagnosed OSA, defined by apnea-hypopnea index (AHI) > 5 according to overnight polysomnography (PSG); (2) patient and CR between 18 to 65 years of age; (3) living at home with a CR (spouse, partner, or a family member), with CR spending > 10 h/day with the patient during the previous 3 months; (4) patient and CR fluent Mandarin speakers; (5) patient and CR free of acute medical problems and mental diseases as determined by a physician. Exclusion criteria for both patients and CRs were (1) the presence of a major psychiatric disorder based on physician's diagnosis; (2) hearing loss; (3) visual loss; (4) acute illness; (5) inability to speak or understand Mandarin fluently. The patients who met MSLT diagnostic criteria of narcolepsy (MSL ≤ 8 min, ≥ 2 SOREMPs) based on ICSD-2 were also excluded from this study.

After undergoing an overnight PSG recording, MSLT and ESS data were collected. All patients and CRs were asked for their highest educational level.

Overnight Polysomnography (PSG)

The diagnosis of OSA (AHI > 5) was established by a standard overnight PSG. Overnight PSG recording techniques and standard parameters were performed according to the American Academy of Sleep Medicine (AASM) Manual for the Scoring of Sleep and Associated Events.³⁰ Sleep data were collected and scored via the Alice 5 Diagnostic Sleep System (Philips Respironics, Bend, OR, USA). The measures consisted of continuous recordings from 4 electroencephalographic (EEG)

leads (F4-M1, C4-M1, O2-M1, F3-M2, C3-M2, O1-M2), bilateral electro-oculography (EOG), electrocardiography (ECG), electromyography (EMG) (submental, anterior tibialis), oral airflow, rib cage and abdominal movements, and measures obtained from an arterial oxygen saturation sensor on the left index finger. The hours during which the subjects slept in the sleep medicine center were based on their habitual sleep schedule at home. All sleep parameters recorded by PSG were analyzed by a senior technician according to the criteria of the AASM.³⁰

Multiple Sleep Latency Test (MSLT)

According to the AASM Practice Parameters for Clinical Use of the MSLT,³¹ the MSLT was performed during daytime on the day following the overnight PSG recording and comprised four 20-min nap trials at intervals of 2 h. The first 30-s epoch of stage 1 or one epoch of any other sleep stage was required to establish sleep onset. When a subject did not fall asleep during the 20 min allowed, a score of 20 min was assigned to that nap. Mean sleep latency was calculated using MSLT data from all 4 tests. We used a score ≤ 8 in MSLT as the "gold standard" for the diagnosis of EDS.³¹

Epworth Sleepiness Scale (ESS)

Subjective daytime sleepiness was measured with the Chinese version of ESS.³² This is an 8-item self-administered questionnaire asking the subject how likely he/she is to doze off or fall asleep in different situations of daily life. This questionnaire was filled out by both patients and CRs between nap times in the morning during the MSLT. The patients and their CRs were asked to complete the questionnaire separately in order to prevent discussion between patients and CRs. Both subjects and CRs were allowed to interact with the technicians to clarify the doubts about the instructions and items on the ESS. The difference between self-reported and CR-evaluated ESS_G scores was calculated as the pair of ESS_G scores in self-evaluated minus that in CR-evaluated.

Statistical Analysis

Data were analyzed using SPSS 17.0 software. As MSLT and ESS scores cannot be assumed to follow normal distributions, we performed nonparametric analyses using the Spearman rank correlation, χ^2 test, or Fisher exact test, wherever appropriate. Agreement between patient and CR ESS_G score was assessed graphically according to the Bland and Altman method. The Y-axis indicates the difference between self-evaluated and CR-evaluated ESS_G, which is plotted against the mean of scores of each pair.³³ Using scores < 8 on MSLT as the gold standard for diagnosis of EDS, ESS_G > 10 as the test variable for assessing sensitivity, specificity, positive predictive value (PV+), and negative predictive value (PV-) in self-evaluated, CR-evaluated, both self- and CR-evaluated, and self- or CR-evaluated ESS_G > 10 , respectively. Data were considered significant when p-values were less than 0.05.

RESULTS

Eight-five patients' data were obtained (Table 1). The mean $\pm$ SD of AHI in all patients was 38.9 $\pm$ 26.8 events/hour.

Table 1—General information and PSG parameters in patients.

Variables	Mean	SD
Male gender [n (%), n = 85]	70 (82.4%)	
Age (years)	46.60	12.85
BMI (kg/m ²)	26.51	3.53
Sleep latency (min)	12.52	12.67
Total sleep time (min)	415.08	80.25
Stage REM (%)	16.20	6.86
Stage N1 (%)	38.31	19.16
Stage N2 (%)	37.52	16.04
Stage N3 (%)	7.96	7.47
Sleep efficiency (%)	82.19	13.03
AHI (/h)	38.87	26.84
ODI (/h)	38.29	27.38
Lowest SaO ₂ (%)	74.53	14.12
MSLT (min)	9.07	5.11
Self-evaluated ESS _G scores	9.81	6.12
CR-evaluated ESS _G scores	10.99	6.62
Difference in ESS _G scores	-1.18	4.15

BMI, body mass index; AHI, apnea-hypopnea index; ODI, oxygen desaturation index.

Among them, 21.2% had mild OSA, 29.4% had moderate OSA, and 49.4% had severe OSA. In this study, the educational level of most patients (81.2%) and CRs (92.1%) were above junior high school degree, so we believed that they could fully understand each item of the ESS.

There was no difference between patient-evaluated ESS_G and CR-evaluated ESS_G (9.81 ± 6.12 vs. 10.99 ± 6.62 , $p > 0.05$). As shown in **Figure 1**, the correlation between ESS_G scores evaluated by patient and CR was close, with a Spearman coefficient of 0.79 ($p < 0.001$). Agreement between subjects' self-evaluated and CR-evaluated ESS_G scores is shown in **Figure 2** (Bland-Altman plot). As shown in **Figure 2**, CR-evaluated ESS_G scores were larger than self-evaluated scores in 54.1% ($n = 46$), remained the same in 14.1% ($n = 12$), and were lower in 31.8% ($n = 27$) of cases. The mean of the difference between the ESS_G scores evaluated by patients and CR was -1.18 ± 4.15 ($p > 0.05$), and the 95% upper and lower limits of the corresponding interval of variation were 7.0 and -9.3, as shown on **Figure 2**. This implies that on average, CR evaluation of ESS_G was about 1 point higher than patient self-evaluation. Moreover, most of the differences were contained between 7.0 and -9.3. This demonstrates a large variability in the ESS_G scores evaluated by patients and CRs. Visual inspection of the graph suggested no systematic variation in the disagreement as the mean values increased, and this trend was also confirmed by Spearman correlation analysis ($r = -0.04$, $p = 0.75$).

Table 2 shows correlation of mean sleep latency with self-evaluated and CR-evaluated ESS_G scores. Among the 85 patients and CRs in this study, higher scores on ESS_G were associated with shorter mean sleep latency. We found there was a significant but weak correlation between CR-evaluated ESS_G score and mean sleep latency of MSLT ($r = -0.23$, $p < 0.05$); significance of this association between self-evaluated ESS_G score and mean sleep latency was marginal ($r = -0.21$, $p = 0.05$).

Figure 1—Correlation between patient's self-evaluated ESS_G and CR-evaluated ESS_G scores **Figure 2**—Bland-Altman plot: ESS scores of patients and their CRs estimating the patients' sleepiness.

The mean of the patients' and CRs' ESS_G scores are plotted against the difference between the patients' and the CRs' ESS_G scores. The lines are at the mean difference and 2 SD above and below the mean.

The mean sleep latency of MSLT was found significantly correlated with item 1 (sitting and reading, $r = -0.23$, $p < 0.05$) and item 4 (as a passenger in a car for an hour without a break, $r = -0.26$, $p < 0.05$) in self-evaluated ESS_G, and only item 3 (sitting, inactive in a public place, $r = -0.27$, $p < 0.05$) in CRs-evaluated ESS_G. The results suggested that most of the items of ESS evaluated by patient and CR had weak correlation with mean sleep latency.

Thirty-eight self-evaluated, 43 CR-evaluated, 33 both self- and CR-evaluated, and 43 self- or CR-evaluated ESS_G scores were 11 (the lower limit of the abnormal range) or higher.^{16,25} Self- and CR-evaluated ESS_G were both ≥ 11 and had a significant association with MSLT < 8 ($p < 0.05$); none of the others had a significant association ($p > 0.05$). The sensitivity and specificity of self-evaluated, CR-evaluated,

Table 2—Correlations between mean sleep latency of MSLT, self-evaluated and CR-evaluated ESS score, and individual ESS sub items.

ESS items	Correlation with MSL			
	Self-reported		CR-evaluated	
	r	p	r	p
(1) Sitting and reading	-0.230*	0.034	-0.207	0.057
(2) Watching TV	-0.170	0.120	-0.171	0.117
(3) Sitting, inactive in a public place	-0.117	0.286	-0.269*	0.013
(4) As a passenger in a car for an hour without a break	-0.256*	0.018	-0.206	0.059
(5) Lying down to rest in the afternoon when circumstances permit	-0.200	0.066	-0.120	0.274
(6) Sitting and talking to someone	-0.129	0.239	-0.197	0.071
(7) Sitting quietly after a lunch without alcohol	-0.123	0.262	-0.027	0.808
(8) In a car, while stopped for a few minutes in a traffic	-0.020	0.855	-0.144	0.189
ESS _G score	-0.213	0.050	-0.234*	0.031

*Statistically significant at $p < 0.05$.**Table 3**—ESS_G > 10 for “abnormal” ESS scores and resulting sensitivity, specificity, p value, positive predictive value (PV+), and negative predictive value (PV-) for mean sleep latency < 8 min.

	n	Sensitivity	Specificity	p	PV+	PV-
Self	38	0.54	0.64	> 0.05	0.61	0.57
CR	43	0.56	0.55	> 0.05	0.56	0.55
Self and CR	33	0.49	0.71	< 0.05	0.64	0.58
Self or CR	43	0.51	0.49	> 0.05	0.57	0.44

Table 4—Spearman correlation coefficient (r) among MSL, ESS_G evaluated by patients, and CRs, and PSG parameters measured.

	Self-evaluated ESS _G		CR-evaluated ESS _G		MSL	
	r	p	r	p	r	p
REM latency	-0.09	0.401	-0.23*	0.039	-0.13	0.241
Sleep latency	-0.11	0.313	-0.08	0.443	0.21	0.055
Total sleep time	0.028*	0.010	0.30**	0.006	-0.22*	0.042
WASO min	-0.32**	0.003	-0.31**	0.004	0.27*	0.011
Stage REM(%)	0.02	0.887	0.15	0.160	-0.03	0.814
Stage N1(%)	0.26*	0.017	0.22*	0.047	-0.13	0.250
Stage N2(%)	-0.27*	0.013	-0.26*	0.016	0.16	0.150
Stage N3(%)	-0.19	0.075	-0.25*	0.024	0.03	0.771
Sleep efficiency	0.33**	0.002	0.30**	0.006	-0.29**	0.007
Arousal Index	0.49**	0.000	0.44**	0.000	-0.26*	0.019
AHI	0.34**	0.002	0.28*	0.011	-0.17	0.117
Longest apnea duration	0.34**	0.001	0.37**	0.000	-0.11	0.328
ODI	0.33**	0.002	0.29**	0.007	-0.16	0.153
Lowest SpO ₂	-0.39**	0.000	-0.40**	0.000	0.19	0.082

WASO, wake after sleep onset; AHI, apnea-hypopnea index; ODI, oxygen desaturation index *Statistically significant at $p < 0.05$. **Statistically significant at $p < 0.01$.

both self- and CR-evaluated, and self- or CR-evaluated ESS_G scores > 10 in detecting MSLT < 8 were low. We found that the specificity in self-evaluated ESS_G (0.64) was higher than CR-evaluated ESS_G (0.55), which suggested self-evaluated ESS_G > 10 was better than that of CR-evaluated ESS_G > 10 in preventing missed detection of mean sleep latency < 8. The optimal ESS_G for predicting mean sleep latency < 8 was in both self- and CR-evaluated ESS_G > 10 (sensitivity 0.49,

specificity 0.71). All of the positive and negative predictive values were low (**Table 3**).

Table 4 shows the correlation of sleep parameters with ESS_G scores evaluated by patients and CRs, and the mean sleep latency on MSLT. Self-evaluated ESS_G score, CR-evaluated ESS_G score, and mean sleep latency were found significantly correlated with total sleep time, the time of wake after sleep onset, sleep efficiency, and arousal index. Self-evaluated or

CR-evaluated score was significantly correlated with AHI, longest apnea duration, oxygen desaturation index (ODI), and lowest SpO₂; it was not significantly correlated with mean sleep latency. These findings suggested that nocturnal hypoxia had greater effect on subjective daytime sleepiness than objective daytime sleepiness. Moreover, only the CR-evaluated ESS_G score was significantly correlated with REM latency and percentage of stage N3.

DISCUSSION

In the current study, we found that (1) there was highly significant correlation but also significant individual disagreement in ESS_G score between patient report and CR report; (2) ESS_G was negatively correlated with mean sleep latency on MSLT. These results indicated that CR-evaluated ESS is as good as that evaluated by patients themselves. In this regard, CR might be a supplementary source for the assessment of subjective sleepiness in Chinese patients with OSA.

Since ESS relies on subject's retrospective subjective reports, the main disadvantage of ESS is its reliance on the subjective reports rather than objective measurements. Therefore, some factors might influence the ESS scores, such as patients' cognitive level,²³ age,²³ the time of evaluating ESS,²⁹ and awareness of excessive daytime sleepiness. Due to the psychological factors and the lack of self-awareness of EDS, a self-evaluated ESS score below 10 might not necessarily indicate the absence of sleepiness. Thus, a supplementary informant might provide additional information on patient sleepiness. Previous studies have tried to analyze the difference between ESS evaluated by patients and their CRs; the result of our present study was in line with most previous studies.^{19,23-29} The individual agreement between patients and CRs was not good (**Figure 2**). The individual disagreement was notable for about 40% of couples with three or more points of difference. Moreover, the CR frequently identified higher sleepiness levels than the patients themselves, with an average difference of 1.2 points on mean ESS_G score (**Figure 2**). This result was in line with findings of previous studies in young and elder patients and their CRs.^{23,27,28} However, the difference between ESS_G scores evaluated by patient and by CR varies significantly, which indicate the agreement in ESS_G score is modest between these two informants.

To the best of our knowledge, there has been no previous study focusing on the different accuracy in association of OSA patient's objective EDS (mean sleep latency < 8 min on MSLT) with ESS_G score evaluated by patient and CR. In previous studies, the findings in the association between ESS_G score and mean MSLT score was contradictory, with a correlation coefficient ranging from -0.51 to -0.15.^{18,20-22} One study has suggested that the correlation between ESS_G score and mean sleep latency increased with increasing severity of OSA.²¹ In our study, regardless of whether the ESS was completed by the patient or CR, the correlation between ESS_G score and mean sleep latency of MSLT was weak. The weak correlation between ESS_G score and mean sleep latency may be due to the fact that we recruited a whole spectrum of patients with OSA but did not have enough sample size to stratify the sample.

The ESS was often the only tool to determine EDS in both population-based and hospital-based studies in patients with OSA.³⁴⁻³⁷ In population-based studies, EDS determined by ESS_G score was independently associated with AHI and snoring.^{34,35} Hospital-based studies have suggested that hypoxemia, autonomic arousal,^{36,37} and sleep fragmentation²¹ might be the main causes of EDS. A recent study among 787 consecutive Chinese patients with OSAS showed that ESS score was significantly associated with AHI, BMI, and oxygen desaturation index.³⁶ In the current study, our results were in line with the previous findings (**Table 4**).^{21,34-38} Thus, the degree of EDS judged by ESS_G scores in patients with OSA might be an effective predictor for the severity level of OSA but not for their objective sleepiness.

Is it adequate to evaluate the ESS by CR? From our results in a sleep laboratory population, the answer is yes. First of all, it does not change the properties of the ESS. Further, the ESS evaluated by CR performed as well as that evaluated by patients themselves when referring to MSLT results. Since the ESS scores can be affected by a variety of factors, such as personality traits, cognitive function, time of day, medication effect, quality and duration of sleep in the preceding night, and the one's insight into the state of pathological sleepiness,¹⁶ we speculate the CR-evaluated approach could eliminate the above influencing factors. Therefore, our results suggested ESS scores evaluated by CRs were better—or at least no worse—than subject's self-evaluated ESS score in correlation with objective EDS.

There were several limitations in the present study. First, the relatively small sample in this study limited further stratification of the patients according to the severity of OSA. According to the previous studies,²¹ patients with more severe OSAS have much more agreement between ESS_G scores and the mean sleep latency. Thus, we speculated that different severity level groups might also have different agreement between ESS_G evaluated by patient and CR and meant sleep latency on MSLT. Further studies with larger samples size are warranted to address this issue. Second, all the patients in this study were selected from a sleep laboratory in a sleep medicine center; therefore, the results might not be generalized to the persons from community.

Clinical Implications

In this study, we found ESS scores evaluated by self and CR was significantly correlated. Thus, the ESS assessed by CRs can serve as supplementary information for OSA patient's sleepiness when the patient's information is not accessible (such as due to language, cognitive and somatic problems). Moreover, we found that both self-reported and CR-reported ESS_G groups had higher specificity ($p < 0.05$) in detecting MSL < 8 min when the ESS_G was > 10. In this regard, we speculate that the combination of both self-reported and CR-reported ESS might have better consistency with MSLT results.

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