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Correlation of the Epworth Sleepiness Scale with Polysomnography Parameters in Obstructive Sleep Apnea Syndrome Patients

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BACKGROUND/AIMS
The aim of the present study was to find out whether Epworth Sleepiness Scale (ESS) is correlated with polysomnography (PSG) and which specific polysomnographic parameter is most closely associated with ESS scores and thus excessive daytime sleepiness.

MATERIAL and METHODS
The study included patients with an initial diagnosis of obstructive sleep apnea syndrome (OSAS). All patients completed a validated Turkish version of the ESS. Patients were divided into two groups based on their ESS scores as those with an ESS score below 10 and those scoring above 10. The differences in mean values of PSG parameters were compared between the two groups. Correlations between ESS scores and PSG parameters were investigated for all patients.

RESULTS
The study included 174 patients. The group with ESS scores above 10 was found to have significantly greater apnea-hypopnea index (AHI), arousal index, oxygen desaturation (ODI), and total sleep time spent with an oxygen saturation less than 90% in comparison to the group with ESS scores below 10. A moderate positive correlation between ESS scores and ODI and weak positive correlations between ESS scores and AHI and arousal index were found.

CONCLUSION
Given the finding that ODI had the strongest correlation with ESS, it can be concluded that as well as being closely related to the subjective symptoms of OSAS, ODI is the PSG parameter that best reflects excessive daytime sleepiness.

Keywords: Epworth Sleepiness Scale, excessive daytime sleepiness, obstructive sleep apnea, polysomnography

INTRODUCTION

Sleep is a critical component of our lives, and we spend about one-third of our life sleeping. Breathing problems during sleep and daytime sleepiness are prevalent complaints in modern societies. Sleep-related breathing disorders are the most common type of sleep disorders. Obstructive sleep apnea syndrome (OSAS) is the most frequent form of sleep related breathing disorder.[1] Obstructive sleep apnea is characterized by repetitive pharyngeal collapses during sleep. Complete or partial pharyngeal collapses result in oxygen desaturation, hypercapnia, and sleep fragmentation. Interruptions of breathing caused repeated pharyngeal collapses are associated with blood gas deterioration and arousals and disruption of sleep continuity.[2,3] Disrupted sleep continuity causes daytime sleepiness, which is a major symptom of OSAS. Several subjective and objective tests have been described to investigate daytime sleepiness of individuals. The Epworth Sleepiness Scale (ESS) is a simple, validated subjective tool, which was first developed in 1991. The ESS is a self-administered questionnaire in which respondents rate their usual chances of dozing off or falling asleep while engaged in different activities. Due to ease of use, the ESS is currently the most widely used subjective test for assessment of sleepiness.[4,5] Many studies exist in literature addressing the correlation of ESS with polysomnographic findings.

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However, to our best knowledge, there are no studies that focused on the correlation of the ESS with polysomnographic parameters and a specific polysomnographic parameter that is most closely associated with ESS scores and thus excessive daytime sleepiness (EDS). This study was designed to seek answer to the following question: "Which polysomnography parameter best reflects excessive daytime sleepiness?"

MATERIALS and METHODS

Approval from the institutional ethics committee was obtained before initiation of the study from Ankara Numune Training and Research Hospital Clinical Research Ethics Committee (Decision no: E-18-2127). Patients were informed, and their signed consents were taken. Medical records of patients presenting with complaints of snoring, witnessed apnea, and daytime sleepiness between January 2013 and June 2018 who underwent overnight polysomnography were reviewed retrospectively. Patients of both sexes with an apnea-hypopnea index (AHI) equal to or greater than 5 were included in the study. Patients with a sleep efficiency below 60% and total sleep duration less than 240 minutes, patients with suspected central sleep apnea, patients with a mental illness or neurological pathology, patients with a history of insomnia, narcolepsy, hypersomnia, and periodic limb movement disorder, and patients whose ESS questionnaires were not available were excluded.

At the time of initial examination, patients were asked to complete the validated Turkish version of the ESS.[6] The ESS is an instrument with eight questions that is used for assessment of daytime sleepiness. Respondents are asked to rate, on a 4-point scale (0-3), their usual chances of dozing off or falling asleep while engaged in eight different activities. The total ESS score is the sum of 8 item scores.

Polysomnography was conducted overnight during spontaneous sleep of patients under the supervision of a sleep technician in a single room at our hospital's sleep center. Audio monitoring and digital video recording were performed all through the night. During polysomnography, data from four-channel electroencephalogram, electromyogram (EMG-submental), EMG (right-left tibialis), two-channel electrooculogram (right-left), electrocardiography, nasal airflow, thoracic, and abdominal breathing movements, blood oxygen saturation by pulse oximetry, and body position were recorded overnight. Manual scoring was performed by an otorhinolaryngologist with special knowledge on sleep disturbance and polysomnography certificate using the criteria established by the American Academy of Sleep Medicine. Apnea was scored when there was a drop in the peak signal excursion by ≥90% of the pre-event baseline and the duration of the ≥90% drop in sensor signal was ≥10 seconds. The respiratory event to be defined as apnea as per the criteria was scored as obstructive when it was accompanied by a sustained or increasing inspiratory effort during the whole period without airflow, or as central when no inspiratory effort was present. The event was scored as mixed type apnea when an inspiratory effort was absent in the beginning but started later on. Hypopnea was scored when the peak signal excursions dropped by ≥30% of pre-event baseline using nasal pressure (diagnostic study) for ≥10 seconds in association with ≥3% arterial oxygen desaturation or an arousal.[7]

Main Points

- The Epworth Sleepiness Scale is a useful tool for assessing excessive daytime sleepiness.
- Oxygen desaturation index is the most strongly correlated polysomnography parameter with Epworth sleepiness scale.
- High oxygen desaturation index values may have the potential to predict increased daytime sleepiness.

Patients were divided into two groups based on their ESS scores as those with an ESS score below 10 and those scoring above 10. The differences in mean values of polysomnography parameters were compared between the two groups including AHI, sleep latency, sleep efficiency, the percentages of non-rapid eye movement (REM) stage 1 sleep (NREM1%), non-REM stage 2 sleep (NREM2%), non-REM stage 3 sleep (NREM3%) and REM sleep (REM%), arousal index, oxygen desaturation index (ODI), total sleep time spent with an oxygen saturation less than 90% (TST < 90%), mean oxygen saturation, minimum oxygen saturation. Correlations between ESS scores and age, body mass index and polysomnography parameters were investigated for all patients.

Statistical Analysis

Kolmogorov–Smirnov test was used to analyze the distribution of the data. Mean values were provided with their standard deviations. The significance of difference between means was tested with the T-test when data were normally distributed and with the Mann–Whitney U test when data were non-normally distributed. Spearman correlation analysis was used to test correlations between ESS and polysomnography (PSG) parameters. A *P* value less than .05 was considered significant. Statistical Package for the Social Sciences (SPSS) version 21.0 (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analyses.

RESULTS

A total of 174 patients (132 males and 42 females) were included in the study. The mean age of the patients was 47.8 years. Polysomnographic parameters for the two groups with ESS scores below or above 10 were as follows: AHI, 29.95 ± 23.56 and 48.14 ± 30.16; sleep latency, 17.94 ± 12.73 and 18.25 ± 13.02; sleep efficiency %, 83.37 ± 9.52 and 82.43 ± 10.21; NREM1%, 8.26 ± 5.61 and 11.34 ± 9.18; NREM2%, 51.6 ± 10.9 and 53.94 ± 13.95; NREM3%, 23.81 ± 10.06 and 19.83 ± 11.81; REM%, 15.21 ± 6.03 and 14.15 ± 6.21; arousal index, 15.8 ± 16 and 28.25 ± 22.54; ODI, 22.75 ± 23.41 and 48.96 ± 34.67; TST <90%, 7.56 ± 14.42 and 18.48 ± 24.33; mean oxygen saturation, 93.41 ± 2.54 and 91.62 ± 5.25; minimum oxygen saturation, 78.66 ± 12.08 and 72.59 ± 17.35, respectively (*P* values < .001, .909, .660, .062, .257, .043, .443, <.001, <.001, .007, .049, and .048, respectively). Statistically significant differences were found between the two groups in the mean values of AHI, NREM3%, arousal index, ODI, TST < 90%, mean oxygen saturation, and minimum oxygen saturation (Table 1).

ESS scores were not correlated with age or body mass index. ESS scores were positively correlated with AHI, arousal index, ODI, and TST < 90% and negatively correlated with NREM3%, mean oxygen saturation, and minimum oxygen saturation (*P* and r values: <.001 and 0.265, .001, and 0.256, <.001 and 0.416, .002, and 0.228, .036 and –0.159, .049 and –0.144, .006 and –0.208, respectively). A moderate positive correlation between ESS scores and ODI, weak correlations between ESS scores and AHI, arousal index, TST < 90% and minimum oxygen saturation

TABLE 1. Mean Values of Polysomnography Parameters for Groups Stratified by ESS Scores

	Group with ESS scores below 10 (n = 112)	Group with ESS scores above 10 (n = 62)	*P* value
AHI	29.95 ± 23.56	48.14 ± 30.16	<.001
Sleep latency (minutes)	17.94 ± 12.73	18.25 ± 13.02	.909
Sleep efficiency (%)	83.37 ± 9.52	82.43 ± 10.21	.660
NREM1%	8.26 ± 5.61	11.34 ± 9.18	.062
NREM2%	51.6 ± 10.9	53.94 ± 13.95	.257
NREM3%	23.81 ± 10.06	19.83 ± 11.81	.043
REM%	15.21 ± 6.03	14.15 ± 6.21	.443
Arousal index	15.8 ± 16	28.25 ± 22.54	<.001
ODI	22.75 ± 23.41	48.96 ± 34.67	<.001
TST < 90%	7.56 ± 14.42	18.48 ± 24.33	.007
Mean oxygen saturation	93.41 ± 2.54	91.62 ± 5.25	.049
Minimum oxygen saturation	78.66 ± 12.08	72.59 ± 17.35	.048

All values are provided as means with standard deviations.
ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index; NREM1%, non-REM stage 1 sleep percentage; NREM2%, non-REM stage 2 sleep percentage; NREM3%, non-REM stage 3 sleep percentage; REM%, REM sleep percentage; ODI, oxygen desaturation index; TST < 90%, total sleep time spent with an oxygen saturation less than 90%.

TABLE 2. Correlations of ESS Scores with Age, Body Mass Index, and Polysomnographic Parameters

	P value	r
Age	.468	
Body mass index	.193	
AHI	<.001	0.265
Sleep latency (minutes)	.263	
Sleep efficiency (%)	.203	
NREM1%	.387	
NREM2%	.436	
NREM3%	.036	−0.159
REM%	.313	
Arousal index	.001	0.256
ODI	<.001	0.416
TST < 90%	.002	0.228
Mean oxygen saturation	.049	−0.144
Minimum oxygen saturation	.006	−0.208

ESS, Epworth Sleepiness Scale; AHI, apnea-hypopnea index; NREM1%, non-REM stage 1 sleep percentage; NREM2%, non-REM stage 2 sleep percentage; NREM3%, non-REM stage 3 sleep percentage; REM%, REM sleep percentage; ODI, oxygen desaturation index; TST < 90%, total sleep time spent with an oxygen saturation less than 90%.

and very weak correlations between ESS scores and NREM3% and mean oxygen saturation were found (Table 2) (Figure 1).

DISCUSSION

In this study, AHI, arousal index, ODI, and TST < 90% were significantly greater in the group with ESS scores above 10 compared to the group with ESS scores below 10. NREM3%, mean oxygen saturation, and minimum oxygen saturation were significantly lower in the group with ESS scores above 10 compared to the group with ESS scores below 10. ESS scores were positively correlated with AHI, arousal index, ODI, and TST < 90% and negatively correlated with NREM3%, mean oxygen saturation, and minimum oxygen saturation. A moderate correlation between ESS scores and ODI, weak correlations between ESS scores and AHI, arousal index, TST < 90% and minimum oxygen saturation and very weak correlations between ESS scores and NREM3%, mean oxygen saturation were found.

Discordant results have been reported in literature on the correlation of the ESS with polysomnographic parameters, with some studies showing positive correlations whereas others reporting none.[1,2,8] In their study, Ozcan et al.[2] investigated the consistency of ESS results with polysomnographic findings and reported no statistically significant associations between patient ESS scores and AHI, TST < 90% and arousal index values. A separate study found slightly greater AHI and arousal index in patients with EDS than those without EDS.[8] In our study, the group of patients with EDS showed highly significantly greater mean values of AHI, ODI, and arousal index in comparison to the group without EDS.

A cut-off of 10 points is recommended for ESS scoring.[9] Patients with an ESS score above this cut-off may be considered to have EDS. In a study in which patients were considered to have EDS if the ESS was >10, sleep latency was found to be shorter in the group with EDS.[8] In the same study, patients with EDS were found to have less NREM sleep in stages 1 and 2 and greater sleep efficiency and longer NREM sleep in stage 3 than those without EDS. In light of these data, the authors concluded that EDS was not associated poor sleep quality.[8] We found no significant differences between the groups with an ESS score below or above 10 with respect to sleep latency, sleep efficiency, and NREM sleep in stages 1 and 2. The group with an ESS score below 10 had longer NREM sleep in stage 3. Thus, EDS was not considered to be directly associated with sleep quality.

While the exact mechanisms of sleepiness have not been fully elucidated, EDS attributed to nocturnal hypoxemia, sleep fragmentation, or both in OSAS patients.[10–15] Roure et al.[8] stated that nocturnal hypoxemia might be a contributing factor to the development of EDS. Additionally, they found higher arousal index values in patients with EDS, which led them to suggest that sleep fragmentation may also have a role in EDS. Temirbekov et al.[1] examined the correlation of ESS scores with AHI and ODI values and found a stronger correlation of ESS with ODI than that with AHI and also suggested that the subjective symptoms of OSAS were closely related to ODI. When we examined the correlation of ESS scores with PSG parameters, ODI was most strongly correlated with ESS scores.

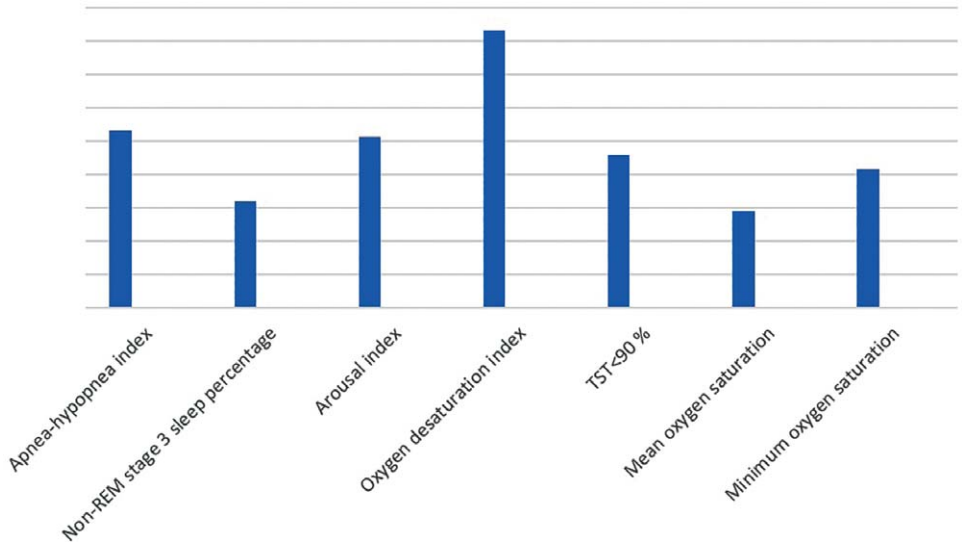

Figure 1. Correlation levels between polysomnography parameters and Epworth Sleepiness Scale scores according to correlation coefficient (r)

Positive correlations were also found between the parameters of nocturnal hypoxemia other than ODI (TST < 90%, meanoxygen saturation, minimum oxygen saturation) and ESS scores. Considering the correlations of ESS scores with polysomnographic parameters that indicate sleep fragmentation and sleep quality, we did not find any correlations between ESS scores and sleep latency, sleep efficiency, NREM1%, NREM2%, and REM% but observed a very weak negative correlation of ESS scores with NREM3% and a weak positive correlation of ESS scores with arousal index. Based on these results, it may be suggested that nocturnal hypoxemia plays a more prominent role in the development of EDS in comparison to sleep fragmentation.

As a conclusion, while the ESS is a subjective tool that does not take into account cognitive function, work conditions, and sociocultural status of individuals, it has the potential to indicate the severity of OSAS and disrupted nocturnal oxygenation. Given the finding that ODI had the strongest correlation with ESS, it can be concluded that as well as being closely related to the subjective symptoms of OSAS, ODI is the PSG parameter that best reflects EDS. Higher ODI values may predict EDS in OSAS patients.

Ethics Committee Approval: Ethical committee approval was received from Ankara Numune Training and Research Hospital Clinical Research Ethics Committee (Decision no: E-18-2127).

Informed Consent: Written or verbal informed consent was obtained from all participants who participated in this study.

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