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Agreement between Epworth Sleepiness Scale and objective sleep parameters in patients with excessive daytime sleepiness

Analiza zgodności oceny nadmiernej senności dziennej w skali Epworth z obiektywnymi parametrami snu

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ABSTRACT:

Summary: Obstructive sleep apnea (OSA) is a disease with a broad social impact. Excessive daytime sleepiness raises suspicion of OSA and together with polysomnography (PSG) is the basis for diagnosis. The Epworth Sleepiness Scale (ESS) is used for objective assessment of daytime sleepiness. Many authors underline a high predictive value of this scale in selecting patients at risk of OSA. Moreover, there is a high agreement between the ESS and PSG. However, some authors oppose the use of this scale. We wanted to verify this issue based on our own data. We enrolled 120 patients who were referred to the Polysomnographic Laboratory, Department of Otolaryngology, Medical University of Warsaw with a suspicion of obstructive sleep apnea. All patients filled out the Epworth Sleepiness Scale. Overnight PSG was performed with 14-channel recordings (Grassm USA), including EEG, EMG, and recordings of the movements of the chest and abdomen. Airflow through the airways was recorded with a nasal-oral temperature probe. PSG was assessed automatically and manually; sleep stages were coded manually for each 30-second interval by a technician. Severity of OSA was assessed based on AHI. There were 96 patients with confirmed OSA and a control group of 24 patients with exclusion of OSA but with different disorders causing excessive daytime sleepiness. The average ESS scores were not significantly different between the subgroups, between genders, and in patients with different severity of OSA. ESS scores did not correlate significantly with any of the tested PSG parameters. In conclusion, the ESS should be used as an additional and only ancillary tool in assessing patients with suspected OSA.

KEYWORDS: obstructive sleep apnea, excessive daytime sleepiness, Epworth Sleepiness Scale, correlation with sleep parameters

STRESZCZENIE:

Obturacyjny bezdech senny (OBS) jest problemem medycznym o zasięgu społecznym. Nadmierna senność dzienna jest przyczynkiem do podejrzenia zespołu OBS, a łącznie z wynikiem polisomnografii (PSG) – stanowi podstawę do postawienia rozpoznania. Obiektywizacji nasilenia nadmiernej senności dziennej służy stosowana od kilkudziesięciu lat skala Epworth. Wielu autorów podkreśla jej istotną wartość predykcyjną, pozwalającą wyselekcjonować pacjentów podejrzanych o OBS, oraz jej dużą zgodność z wynikiem PSG. Wiele jest także głosów przeciwnych jej użyteczności. Postanowiono poddać weryfikacji te poglądy w oparciu o badania własne. Materiał stanowiło 120 pacjentów zgłaszających się do Pracowni Polisomnograficznej Katedry i Kliniki Otolaryngologii WUM z podejrzeniem obturacyjnego bezdechu sennego. Pacjenci rutynowo wypełniali kwestionariusz Epworth. Całonocna PSG była wykonywana na sprzęcie firmy Grassm (USA), z zapisem 14-kanałowym, obejmującym EEG, EMG oraz rejestrację ruchów klatki piersiowej i brzucha. Przepływ powietrza przez drogi oddechowe rejestrowano przy użyciu nosowo-ustnego czujnika termicznego. Ocena badania była dokonywana metodą automatyczno-manualną, przy czym stadia snu były kodowane manualnie przez technika, osobno dla każdej 30-sekundowej składki. Ciężkość OBS klasyfikowano na podstawie AHI. Utworzono grupę badawczą liczącą 96 chorych z rozpoznanym OBS oraz grupę kontrolną, którą stanowiło 24 pacjentów, u których wykluczono OBS, a ich zaburzenia snu oraz nadmierna senność dzienna wynikały z innych przyczyn.

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Średni wynik w skali senności dziennej Epworth nie różnił się istotnie w podgrupach według płci i ciężkości bezdechu, nie korelował także w sposób istotny statystycznie z żadnym z badanych rutynowo parametrów PSG. Wyciągnięto wniosek, według którego skala Epworth powinna być traktowana jako dodatkowy i wyłącznie pomocniczy element oceny pacjenta z podejrzeniem OBS.

SŁOWA KLUCZOWE: obturacyjny bezdech senny, nadmierna senność dzienna, skala Epworth, korelacja z parametrami snu

INTRODUCTION

Obstructive sleep apnea (OSA) is a disease with a broad social impact, affecting over a dozen percent of people in the developed world [1]. OSA significantly reduces quality of life, causes lower productivity and work absence [2, 3]. Moreover, increased sleepiness and disorders of attention that result from OSA contribute to a substantial number of car accidents [4]. OSA is one the treatable causes of morbidity and mortality related to cardiovascular diseases [5]. At the same time, awareness regarding OSA and its ramifications is much lower than that regarding other cardiovascular diseases or cancers and therefore OSA is underdiagnosed [6]. Symptoms of OSA can be ignored by patients and their relatives for many years, and they are not included in routine medical history [7]. Surveys conducted among physicians, including tests using exemplary cases, indicate that awareness of OSA is insufficient not only among beginning physicians but also among experienced family physicians [5].

Because the incidence of OSA is much larger than the capability to perform polysomnography (PSG), there is a need for screening tools to select patients with severe forms of the disease [8]. Patient's self-assessment with the use of questionnaires that can be filled out by patients themselves or by professional medical personnel is an initial step in the work-up for OSA. Such self-assessment plays an important role in diagnostic algorithms created for patients at risk of OSA [9-15]. To date, more than 100 tools have been developed [16], and there are over 4,000 articles on this issue in the Cochrane Library [8].

Insomnia and chronic daytime sleepiness are among the hallmarks of OSA. The Epworth Sleepiness Scale (ESS), which was developed in the Epworth Medical Center, Sydney, Australia, can be used for assessing excessive daytime sleepiness. In the EES, respondents are asked about the probability of falling asleep in eight different situations that are characterized by lack of physical activity during the day. They include lying on a couch at home or sitting in a car stopped at a red light or in a traffic jam. The ESS can be used for research purposes and in clinical practice. It has been validated for adults aged 18 to 78 years.

The psychometric characteristics of the ESS were evaluated by

Tab. I. Epworth Sleepiness Scale

NAME, SURNAME		DATE OF EXAMINATION:		
EPWORTH SLEEPINESS SCALE How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you haven't done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation: 0 = would never doze 1 = slight chance of dozing 2 = moderate chance of dozing 3 = high chance of dozing How likely are you to doze off or fall asleep in the following situations?				
1. Sitting and/or reading	0	1	2	3
2. Watching TV	0	1	2	3
3. Sitting, inactive in a public place (e.g. a theatre or a meeting)	0	1	2	3
4. As a passenger in a car for an hour without a break	0	1	2	3
5. Lying down to rest in the afternoon when circumstances permit	0	1	2	3
6. Sitting and talking to someone	0	1	2	3
7. Sitting quietly after a lunch without alcohol	0	1	2	3
8. In a car, while stopped for a few minutes in the traffic	0	1	2	3
Sum				

The sores should be interpreted as follows:

0-9 points: no excessive daytime sleepiness
10-15 points: excessive daytime sleepiness

16-24 points: severe excessive daytime sleepiness

Johns et al. just after the development of the scale [17]. With score range of 0 to 24 points, Johns and Hocking reported a mean score of 4.6 points ± 2.8 SD in healthy volunteers [18]. Based on that, Johns suggests to accept 10 points as a cut-off point for a significantly excessive and clinically relevant level of daytime sleepiness. The ESS has sensitivity of 94% and specificity of 100%.

The scale has been used extensively, and studies investigating its sensitivity and specificity confirm its clinical usefulness [20]. However, some authors think that the scale does not have sufficient probabilistic value, and point out that the scale selects preferentially patients with moderate and severe apnea (AHI≥15) [21, 22]. According to some authors, daytime sleepiness is a weak predictor of OSA, and only one in three patients with OSA diagnosed on PSG declares excessive daytime sleepiness [1, 22].

To aim of the study was to investigate the relationship between ESS scores and objective measures of sleep in our patients.

MATERIALS AND METHODS

We enrolled 120 patients who were referred to the Polysomnographic Laboratory, Department of Otolaryngology, Medical University of Warsaw with a suspicion of obstructive sleep apnea. Based on PSG, there were 96 patients with confirmed OSA and a control group of 24 patients with exclusion of OSA but with different disorders causing excessive daytime sleepiness.

The severity of OSA was judged based on AHI. Overnight PSG was performed with 14-channel recordings (Grassm USA), including EEG, EMG, and recordings of the movements of the chest and abdomen. Airflow through the airways was recorded with a nasal-oral temperature probe. PSG was assessed automatically and manually; sleep stages were coded manually for each 30-second interval by a technician according to the criteria of the AASM (American Academy of Sleep Medicine).

The elementary matrix with 120 observations was preliminary recoded, specific codes were given to patients that described patients and sleep parameters. Preliminary calculations were performed with Excel, and all statistical analyses were conducted with Statistica 10. Based on the Shapiro-Wilk test, most of the variables were not distributed normally and therefore non-parametric analyses were performed for all data. For independent variables with two discrete values, the Man-Whitney test was used. If the independent variable had a different distribution, we used the median test and the Kruskal-Wallis test. Correlation analysis was performed with the Spearman correlation coefficient, with the t-Student test used for testing significance. Finally, we performed stepwise analysis of regression. The analyzed variables are presented in Table II.

Tab. II. List of analyzed variables with their codes (numbers).

VARIABLE CODE	VARIABLE DESCRIPTION
1	gender
2	age
3	BMI
4	Percentage of N1 phase of total sleep time
5	Percentage of N2 phase of total sleep time
6	Percentage of N3 phase of total sleep time
7	Percentage of REM phase of total sleep time
8	subgroups 1-4 according to AHI
9	subgroups 1-3, and 4 according to AHI
10	AHI
11	SO2nadir
12	Sleep latency
13	Full sleep latency
14	Latency of phase N2
15	Latency of phase REM
16	Sleep effectiveness
17	Arousal index
18	Awakening index
19	Total score in Epworth Sleepiness Scale

RESULTS

In Table III, we present sleep features and BMI for both genders separately. In our patients, we found several statistically significant differences between genders. BMI and the major PSG parameters such as AHI, SO_2nadir, and awakening index were significantly higher in men, which indicates a significantly more severe OSA in men.

In Table IV, we present sleep characteristics, age, and BMI for subgroups differentiated according to AHI. Based on those data, the AHI criterion significantly differentiated subgroups with respect to SO_2nadir, duration of REM, N1, and N3, awakening index, and BMI. This confirms the fact that AHI is a fundamental parameter that characterized sleep quality. Mean age did not differ between genders in the total sample. However, in 16 women with OSA (AHI<5), the mean age was 54.94 years, and in women without OSA (AHI<5) the mean age was 44.0 years. In 18 men with confirmed OSA, the mean age was 46.66 years, and in men with OSA (79 patients) it

Tab. III. Descriptive statistics for age, BMI, sleep quality parameters for all patients and separately for genders. Arithmetic means and standard deviations (in brackets) are written in bold letters; range of variability is presented below. Next to it, p value for the Mann-Whitney U-test. P values < 0.05 are heighted in bold letters.

GROUP/PARAMETER	WOMEN (N=23)	MEN (N=97)	IN TOTAL (N=120)	P
Age	51.61 (10.6) 32-72	48.82 (12.25) 19-78	49.36 (12.00) 19-78	0.3131
BMI	27.14 (3.09) 22.27-36.98	28.52 (3.31) 19.05-47.34	28.25 (3.32) 19.05-47.34	0.0052
N1	9.47 (5.32) 3.0-27.0	15.34 (10.03) 0.7-58.3	14.21 (9.59) 0.7-58.3	0.0033
N2	67.02 (12.46) 34-84.3	68.43 (11.62) 40.2-88.4	68.16 (11.8) 34-88.4	0.7860
N3	15.77 (8.21) 2.9-35.3	11.31 (10.38) 0.0-40.9	12.7 (10.5) 0-40.9	0.0085
REM	7.11 (5.83) 0.0-26.6	4.93 (4.14) 0.0-16.0	5.35 (4.6) 0-26.6	0.1084
AHI	16.87 (15.42) 0.3-56.8	35.67 (28.1) 0.8-107.4	32.04 (27.17) 0.3-107.4	0.0028
SO2nadir	86.22 (5.11) 76.0-96.0	82.84 (6.9) 59.0-97.0	83.48 (6.73) 59-97	0.0428
Sleep latency	31.54 (40.05) 6.5-157.0	15.78 (13.76) 0.5-83.5	18.8 (22.34) 0.5-157	0.0257
Full sleep latency	48.91 (45.41) 7.0-175.0	41.61 (37.25) 0.0-240.0	43.01 (39.06) 0-240	0.7058
N2 latency	34.39 (40.46) 6.5-157.0	19.77 (18.11) 4.5-97.0	22.58 (24.74) 4.5-157	0.0706
REM latency	148.2 (95.0) 0.0-404.0	132.74 (84.38) 0.0-364.5	135.7 (86.73) 0-404	0.8219
Sleep effectiveness	76.64 (16.29) 21.8-94.3	77.94 (14.63) 19.9-96.1	77.69 (14.97) 19.9-96.1	0.8116
Awakening index	6.19 (6.42) 0.8-34.1	8.5 (8.57) 0.6-69.6	8.06 (8.25) 0.6-69.6	0.0842
Arousal index	7.75 (9.53) 0.0-38.3	11.3 (10.4) 0.0-44.7	10.2 (10.34) 0-44.7	0.0918

N1, N2, N3, REM – sleep phases as % sleep time, sleep effectiveness in % of study duration time, SO_2 nadir in % oxygen saturation, sleep latencies in minutes, arousal and awakening indices as incidences/ hour of sleep.

was 49.82 years. Among patients with confirmed OSA, women were significantly older than men (Mann-Whitney U-test, p<0.05).

Arithmetic means and standard deviations (in brackets) are written in bold letters; range of variability is presented below. Next to it, p value for the Mann-Whitney U-test. P values < 0.05 are heighted in bold letters.

Based on the results presented in Table V, the scores were either significant or close to significant for diagnosing excessive daytime sleepiness in all subgroups, but they did not differentiate significantly between the individual groups.

This observation is confirmed by correlation analysis (Spearman correlation coefficients) that is presented in Table VI, as ESS scores did not correlate significantly with any of the tested sleep parameters.

Tab V. Total scores on the ESS for all patients and subgroups differentiated based on gender and AHI. Arithmetic means and standard deviations (in brackets) are written in bold letters; range of variability is presented below. Next to it, p value for the Mann-Whitney U-test. P values < 0.05 are heighted in bold letters.

SUBGROUP	ESS SCORE	P FOR DIFFERENCE
Women (N=23)	10.52 (4.75) 2-20	0.3495
Men (N=97)	9.59 (6.18) 0-21	
AHI<5 (N=24)	9.38 (5.4) 0-20	0.4901
5≤AHI<15 (N=22)	9.95 (5.9) 1-21	
15≤AHI<30 (N=17)	7.88 (5.63) 1-19	
AHI≥30 (N=57)	10.42 (6.14) 0-20	
Total (N=120)	9.77 (5.95) 0-21	

Tab. IV. List of descriptive statistics for age, BMI, and sleep parameters for subgroups differentiated on the basis for AHI. Arithmetic means and standard deviations (in brackets) are written in bold letters; range of variability is presented below. Next to it, p value for the Kruskal-Wallis test. P values < 0.05 are heighted in bold letters.

GROUP/PARAMETER	AHI<5 (N=24)	5≤AHI<15 (N=22)	15≤AHI<30 (N=17)	AHI≥30 (N=57)	P
Age	45.42 (11.73) 29-65	64.32 (11.15) 19-66	52.18 (11.78) 33-72	51.35 (11.81) 29-78	0.1335
BMI	26.08 (2.34) 19.05-29.92	26.85 (2.28) 21.1-31.07	30.68 (5.16) 25.3-47.34	28.98 (2.42) 24.49-36.11	0.0000
N1	10.34 (6.22) 0.7-28.7	9.88 (5.66) 3.1-27.0	11.53 (5.87) 1.3-22.0	18.32 (11.06) 2.9-58.3	0.0002
N2	64.72 (12.11) 42.1-86.7	65.36 (14.36) 34.0-88.4	68.33 (10.18) 49.0-84.3	70.65 (10.33) 41.1-88.2	0.1936
N3	17.32 (10.33) 0.0-38.8	17.61 (11.27) 3.0-40.9	14.84 (10.07) 4.2-39.7	7.1 (6.51) 0.0-24.2	0.0000
REM	7.03 (6.15) 0.0-26.6	7.17 (4.5) 0.4-16.0	5.31 (3.97) 0.0-13.6	3.95 (3.41) 0.0-15.1	0.0166
AHI	2.48 (1.47) 0.3-4.7	9.9 (2.35) 5.6-14.1	21.15 (4.06) 15.0-29.3	55.89 (19.5) 30.0-107.4	
SO2nadir	89.96 (3.28) 84.0-97.0	86.5 (3.81) 76.0-93.0	81.71 (7.33) 59.0-89.0	80.12 (5.98) 65.0-89.0	0.0000
Sleep latency	15.45 (11.96) 3.3-44.0	19.8 (13.44) 0.5-50.5	13.86 (9.53) 5.5-42.5	21.29 (29.58) 2.5-157.0	0.5184
Full sleep latency	31.71 (20.55) 5.0-68.0	42.34 (23.58) 6.5-98.0	31.62 (30.34) 0.0-107.0	51.43 (48.79) 5.0-240.0	0.1751
N2 latency	19.99 (17.57) 4.8-68.5	21.3 (13.55) 5.0-50.5	15.65 (11.02) 7.0-45.0	26.22 (31.94) 4.5-157.0	0.5286
REM latency	116.35 (69.13) 0.0-279.5	134.59 (66.28) 24.5-317.0	133.97 (80.94) 0.0-275.0	144.79 (99.67) 0.0-404.0	0.7055
Sleep effectiveness	81.85 (9.63) 59.8-94.3	78.43 (11.89) 54.0-96.1	75.44 (16.5) 26.2-95.3	76.32 (16.91) 19.9-96.1	0.6719
Awakening index	8.62 (13.74) 0.6-69.6	5.71 (2.62) 1.2-14.1	7.31 (5.54) 1.2-24.9	8.96 (6.98) 1.4-34.1	0.1310
Arousal index	5.28 (7.81) 0.0-28.5	5.6 (6.7) 0.0-22.6	5.34 (5.12) 0.0-17.7	16.38 (10.53) 2.3-44.7	0.0000

N1, N2, N3, REM – Legend: N1, N2, N3, REM – sleep phases as % sleep time, sleep effectiveness in % of study duration time, SO_2 nadir in % oxygen saturation, sleep latencies in minutes, arousal and awakening indices as incidences/ hour of sleep. For the mean AHI value, based on which the subgroups were differentiated, the Kruskal-Wallis test was not performed.

Based on a regression model with the total ESS score as the dependent variable, only the arousal index was found to be a significant predictor (p=0.0257), accounting for approximately 20% of the variance (20.34%).

DISCUSSION

In principle, our results are in line with previous studies, but there are also some differences.

The mean apnea index was higher for men than women, which is in line with the majority of published studies, possibly due to the fact that women are diagnosed with OSA after menopause [23]. Although there was a significant difference in BMI between genders, it was rather small in absolute values. Both genders had mean BMI values that indicated overweight but not obesity.

The percentage of duration of particular sleep phases did not clearly differ between genders, and the significant differences seem to be due to chance. Sleep latency and N1 and N3 latencies were significantly different between genders – N1 latency being longer in men and N3 latency in women. Based on these data, one cannot state that there are evident differences in sleep quality or sleep macroarchitecture between genders. However, in terms of respiratory events, men had less favorable results – the mean AHI value was over 2 times greater than in women (statistically significant difference), and men had lower mean

Tab. VI. Spearman's rank correlation coefficients for the analyzed variables. Significant correlation are shown in bold letters.

VARIABLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1.00	0.09	-0.25	-0.27	-0.03	0.24	0.15	-0.21	-0.21	-0.27	0.19	0.20	0.03	0.17	0.02	-0.02	-0.16	-0.15	0.09
2	0.09	1.00	0.21	0.17	0.21	-0.35	-0.01	0.19	0.14	0.12	-0.25	0.25	0.22	0.19	0.02	-0.46	0.24	-0.07	-0.10
3	-0.25	0.21	1.00	0.21	0.15	-0.34	-0.11	0.43	0.32	0.44	-0.46	0.00	0.01	-0.05	-0.02	-0.16	0.28	0.15	-0.11
4	-0.27	0.17	0.21	1.00	-0.32	-0.47	-0.13	0.38	0.40	0.41	-0.26	0.19	0.32	0.32	-0.00	-0.33	0.33	0.31	-0.09
5	-0.03	0.21	0.15	-0.32	1.00	-0.53	-0.38	0.20	0.18	0.20	-0.20	-0.08	-0.07	-0.15	0.00	-0.06	0.12	0.18	0.14
6	0.24	-0.35	-0.34	-0.47	-0.53	1.00	0.17	-0.47	-0.48	-0.49	0.39	-0.04	-0.18	-0.07	-0.02	0.26	-0.35	-0.35	-0.08
7	0.15	-0.01	-0.11	-0.13	-0.38	0.17	1.00	-0.27	-0.27	-0.31	0.15	0.01	-0.07	-0.03	-0.05	0.24	-0.28	-0.34	-0.09
8	-0.21	0.19	0.43	0.38	0.20	-0.47	-0.27	1.00	0.92	0.94	-0.64	-0.00	0.10	0.05	0.09	-0.07	0.22	0.59	0.06
9	-0.21	0.14	0.32	0.40	0.18	-0.48	-0.27	0.92	1.00	0.86	-0.54	-0.01	0.12	0.06	0.07	-0.03	0.20	0.60	0.10
10	-0.27	0.12	0.44	0.41	0.20	-0.49	-0.31	0.94	0.86	1.00	-0.64	-0.05	0.04	0.01	0.07	-0.03	0.23	0.65	0.09
11	0.19	-0.25	-0.46	-0.26	-0.20	0.39	0.15	-0.64	-0.54	-0.64	1.00	0.04	0.07	0.03	-0.03	0.09	-0.22	-0.33	0.08
12	0.20	0.25	0.00	0.19	-0.08	-0.04	0.01	-0.00	-0.01	-0.05	0.04	1.00	0.56	0.89	0.12	-0.60	0.10	-0.05	-0.01
13	0.03	0.22	0.01	0.32	-0.07	-0.18	-0.07	0.10	0.12	0.04	0.07	0.56	1.00	0.63	0.13	-0.58	0.29	0.11	0.11
14	0.17	0.19	-0.05	0.32	-0.15	-0.07	-0.03	0.05	0.06	0.01	0.03	0.89	0.63	1.00	0.18	-0.57	0.05	0.05	0.03
15	0.02	0.02	-0.02	-0.00	0.00	-0.02	-0.05	0.09	0.07	0.07	-0.03	0.12	0.13	0.18	1.00	-0.04	-0.04	0.02	-0.06
16	-0.02	-0.46	-0.16	-0.33	-0.06	0.26	0.24	-0.07	-0.03	-0.03	0.09	-0.60	-0.58	-0.57	-0.04	1.00	-0.52	0.10	0.05
17	-0.16	0.24	0.28	0.33	0.12	-0.35	-0.28	0.22	0.20	0.23	-0.22	0.10	0.29	0.05	-0.04	-0.52	1.00	-0.04	0.07
18	-0.15	-0.07	0.15	0.31	0.18	-0.35	-0.34	0.59	0.60	0.65	-0.33	-0.05	0.11	0.05	0.02	0.10	-0.04	1.00	0.17
19	0.09	-0.10	-0.11	-0.09	0.14	-0.08	-0.09	0.06	0.10	0.09	0.08	-0.01	0.11	0.03	-0.06	0.05	0.07	0.17	1.00

minimal oxygen saturation during sleep and arousal index. These data are in line with prior observations made by other authors, which indicate that OSA has more severe symptoms in men.

We found several statistically significant differences between patient subgroups differentiated on the basis of AHI. They included BMI, percentage of duration of phases N1, N3, and REM, SO_2nadir, and arousal index. On post-hoc analysis, after performing the Kruskal-Wallis test, a significant difference with respect to BMI was found between patients with moderate or severe sleep apnea in comparison to the remaining groups. Patients with moderate or severe sleep apnea had higher BMI than the remaining patients, which confirms the well-known fact that OSA is associated with overweight and obesity. A similar pattern was seen with respect to SO_2nadir and the mean percentage duration of the N1 phase in relation to total sleep time. Obviously, a relative extension of the N1 sleep phase is related to a shallow sleep in patients with more than 15 episodes of apnea per hour of sleep. This value is also the basis for diagnosing clinically relevant OSA by many authors [9, 24, 25]. In patients with severe apnea, we also found a significant shortening of the relative duration of the N3 phase, and in patients with moderate OSA such relative shortening was found with respect to the REM phase. The arousal index was highest in patients with severe apnea, being almost 3 times greater than that of the remaining patients. This means that patients with severe apnea experience the greatest amount of sleep fragmentation. That and the relative shortening of the N3 phase, during which the organism regenerates itself in terms, for instance, of the function of the cardiovascular system, unfavorably influence sleep quality.

We also found a statistically significant negative correlation between age, the percentage duration of the N3 phase, sleep effectiveness, and SO_2nadir. With age, the total sleep time decreases, sleep latency increases, the amount of slow-wave (N3) sleep and REM sleep are reduced, and sleep fragmentation and arousal index increase [26-29]. We did not find all of these relationships, but one should take into account that our group consisted of patients with various diseases, whereas the above-mentioned relationships have been described in healthy subjects. A decreased SO_2nadir in older age can indicate a lower capacity to compensate for apnea.

The mean total ESS score (9.77 points) indicates that patients, on the whole, were below the level of excessive daytime sleepiness (10 points). Surprisingly, the lowest scores were seen in patients with moderate apnea (mean score of 7.88 points), which was within the normal range. However, there were no significant differences between patients differentiated on the basis of AHI. Moreover, there

were no significant differences between genders. Our study does not unequivocally confirm that there is a relationship between the frequency of apnea and respiratory events with excessive daytime sleepiness assessed on the Epworth Sleepiness Scale.

These results were in line with further correlation analysis in which the rank correlation coefficient between AHI and total ESS score was only 0.09 and was not statistically significant. Similarly, there were no significant difference in the mean ESS score between subgroups of patients differentiated on the basis of AHI (Kruskal-Wallis test). In regression analysis, only the arousal index was a significant predictor of the total ESS score, despite the fact that there was no first-order correlation between these two variables (Spearman's coefficient). This indicates that patients gave consistent answers to questions on both scales of daytime sleepiness and insomnia; however, this was not reflected by AHI. This observation is in line with views of several authors who do not hold the ESS as a valid screening tool. They emphasize that the ESS has only a weak, if any, relationship with the severity of apnea assessed with AHI [30, [23, 30-35]. Our results do not confirm earlier observations by those authors who see the ESS as a valid screening tool for OSA [36]. Also, we did not find any difference between men and women in total ESS sores, which is in line with previous studies (Shepertycki). This can suggest that excessive daytime sleepiness is caused by factors other than AHI, for instance, arousal index or SO_2 nadir [37-40].

Despite the lack of a clear relationship between subjective assessments (e.g., the ESS) and excessive daytime sleepiness in some studies, patients with OSA do have objectively determined excessive daytime sleepiness. Multiple sleep latency test (MSLT) is correlated with forced sleep restriction in healthy individuals and with the severity of OSA [38, 41-43]. However, not all MSLT-based studies have found a clear relation between sleep latency and the severity of OSA, especially in patients with mild OSA [42, 44, 45].

In conclusion, we state that patients with OSA form such a heterogeneous groups with regard to age, disease severity, general health condition, and other than AHI sleep parameters that the responses to the questions of the Epworth Sleepiness Scale have a large variability. The way in which the questions have been constructed can cause some interpretation difficulties for patients, which can lead to inadequate answers [46].

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