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Association between various breathing indexes during sleep and the Epworth Sleepiness Scale score in adults

Pei-Shan Hsieh, Bachelor[a], Sheng-Wei Hwang, Student[b], Shang-Rung Hwang, Student[c], Juen-Haur Hwang, MD, PhD[d,e,f,*]

Abstract

Some breathing indexes during sleep, including the apnea-hypopnea index, oxygen desaturation index, and oxygen saturation during sleep, can be recorded by overnight polysomnography. We aimed to investigate the association of various breathing indexes during sleep with the Epworth Sleepiness Scale (ESS) score in adults. We retrospectively collected the clinical and overnight polysomnography data of 2829 adults aged 20 years or older from November 2011 to June 2017. The association of various breathing indexes during sleep and ESS score was analyzed using univariate and multivariate logistic regression analysis for all adults (20–91 years), and in each sex and of body mass index (<26 kg/m^2 vs ≥26 kg/m^2). The mean ESS score was 6.2 (standard deviation = 4.3; range = 0–24) for all adults. After adjustment for age, sex, many common diseases, and health-related habits, apnea-hypopnea index, oxygen desaturation index, percentage of oxygen saturation below 90% during sleep, and percentage of oxygen saturation below 85% during sleep were significantly positively associated with ESS score in all adults, whereas mean oxygen saturation during sleep, minimal oxygen saturation during sleep, and awake oxygen saturation during sleep were significantly negatively associated with ESS score in all adults. In subgroup analysis, we found that the association between breathing indexes during sleep and ESS score was similar in both sex, but was significant in subjects of body mass index ≥ 26 kg/m^2. All breathing indexes during sleep had significant positive or negative correlation with ESS score in all adults, especially in obese subjects.

Abbreviations: AHI = apnea-hyponea index, BMI = body mass index, EDS = Excessive daytime sleepiness, ESS = Epworth Sleepiness Scale, ODI = oxygen desaturation index, OSA = obstructive sleep apnea, PSG = polysomnography, RDI = respiratory distress index, SD = standard deviation.

Keywords: apnea-hyponea index, Epworth Sleepiness Scale, oxygen desaturation index, oxygen saturation, polysomnography

1. Introduction

Excessive daytime sleepiness (EDS) is a common symptom worldwide. EDS may reduce attention, decrease the ability to learn or work, and increase the risk of accidents.[1] The etiology of EDS might be idiopathic and it may be a symptom of certain diseases.[1,2] Among all evaluating tools for EDS, the Epworth Sleepiness Scale (ESS) is a questionnaire for assessing EDS commonly used in clinical practice. The Chinese version of the ESS was found to have good reliability and validity.[3] However, some studies have shown poor clinical effectiveness of the ESS due to its ambiguity of items and potentially limited cultural applicability.[4,5] Also, low test–retest reliability in ESS scores has been found, even when the test is repeated on the same day.[6] Alqurashi et al[4] claimed that, compared to ESS, Visual Analog Scale more easily detected a change in daytime sleepiness after continuous positive airway pressure treatment in patients with obstructive sleep apnea (OSA).

ESS scores are affected by many factors, including ethnicity, gender, and body morphometry.[7] Some breathing indexes during sleep, including the apnea-hypopnea index (AHI), oxygen desaturation index (ODI), mean oxygen saturation during sleep, minimal oxygen saturation during sleep, awake oxygen saturation during sleep, oxygen saturation below 90% during

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[a] Department of Medical Research, Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Chiayi, Taiwan, [b] Taichung First Senior High School, Taichung, Taiwan, [c] Taichung Girls Senior High School, Taichung, Taiwan, [d] Department of Otolaryngology-Head and Neck Surgery, Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Chiayi, Taiwan, [e] School of Medicine, Tzu Chi University, Hualien, Taiwan, [f] Department of Medical Research, China Medical University Hospital, China Medical University, Taichung, Taiwan.

* Correspondence: Juen-Haur Hwang, Department of Otolaryngology-Head and Neck Surgery, Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, No. 2, Minsheng Road, Dalin, Chiayi 62247, Taiwan (e-mail: g120796@tzuchi.com.tw).

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sleep, and oxygen saturation below 85% during sleep, can be captured by overnight polysomnography (PSG). Basta et al[8] reported that mild/moderate daytime sleepiness could be predicted by AHI and depression in both sexes; severe daytime sleepiness could be predicted, in men, by minimum oxygen saturation during sleep, depression, and lack of regular exercise, and by AHI in women. In addition, Shao et al[9] found that mild to moderate daytime sleepiness was associated with waist circumference, memory loss, work/commute disturbances, sleep efficiency, arousal index, AHI, and percentage of oxygen saturation below 90% during sleep; severe daytime sleepiness was associated with age, neck circumference, memory loss, work/commute disturbances, sleep latency, gasping/choking, AHI, and mean oxygen saturation during sleep.

In the elderly, Sforza et al[10] found that only gender, body mass index (BMI), and depression score were significantly related with daytime sleepiness. The respiratory distress index (RDI) was weakly correlated with ESS scores.[7] ESS scores were negatively associated with mean sleep latency in the multiple sleep latency test, but no correlation was found with AHI or minimum oxygen saturation during sleep.[3] Previous reports of the association of various breathing indexes during sleep with ESS scores remain inconsistent. This discrepancy might be due to differences between studies in ethnicities selected, breathing indexes during sleep used, or variations in items selected for statistical adjustment. Thus, in this study, we aimed to investigate the detailed relationship between various breathing indexes during sleep and ESS score, after adjustment for important clinical factors, using a large clinical database in Taiwan.

2. Materials and methods

From November 2011 to June 2017, clinical and overnight PSG data of 2829 adults aged ≥ 20 years with sleep disturbances at Dalin Tzu Chi Hospital were collected retrospectively. This study was approved by the Institutional Review Board of Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation (no. B10604018). The requirement for informed consent was waived because the study was a retrospective data analysis.

The indication for PSG was complaint of sleep disturbance when the patient visited the outpatient department of Otolaryngology-Head and Neck Surgery. All patients who received PSG also filled out all ESS and sleep questionnaires on the same night, right before receiving PSG, and none of these patients was excluded from this study. Also, none of the patients received any kind of OSA treatment while enrolled in the study.

Clinical data, including ESS score, age, sex, BMI, hypertension, diabetes mellitus, dyslipidemia, acute myocardial infarction, stroke, chronic kidney disease, liver cirrhosis, cancers, depression, smoking, drinking alcohol, coffee consumption, and tea consumption were recorded. Also, AHI, ODI, mean oxygen saturation during sleep, minimal oxygen saturation during sleep, awake oxygen saturation during sleep, oxygen saturation below 90% during sleep, and oxygen saturation below 85% during sleep were acquired during PSG examination. Common systemic diseases and health-related habits were graded as "no" or "yes." The ESS score was treated as a continuous dependent variable during analysis.

2.1. Statistical analysis

First, numerical variables were shown descriptively as means ± standard deviation (SD) and category variables were shown as number and percentages. Then, univariate linear regression was used to test the associations of different breathing indexes during sleep with ESS scores. Multivariate linear regression was used to test the associations of each breathing index during sleep with ESS scores with adjustment for age, sex, many common diseases, and health-related habits. In addition, subgroup analysis was performed by sex and BMI (<26 kg/m^2 vs ≥26 kg/m^2). All analyses were performed using STATA 10.0 software (Stata Corp., College Station, TX). $P < .05$ was considered to be significant.

3. Results

Table 1 shows the basic characteristics of all adults. The mean ESS score was 6.2 (SD = 4.3; range = 0–24). The mean AHI was 28.1/hr (SD = 23.9). The mean ODI was 20.3/hr (SD = 23.7). The mean oxygen saturation during sleep was 94.8% (SD = 2.8). The minimal oxygen saturation during sleep was 82.9% (SD = 2.3). The awake oxygen saturation during sleep was 95.0% (SD = 2.5). By contrast, the percentage of those

Table 1

Basic characteristics of adults in different ages.

	All subjects (20–91 yr, N = 2829)	Young adults (20–45 yr, N = 967)	Old adults (46–91 yr, N = 1862)
Stroke	63	4	59
Mean age, y/o (SD)	50.8 (13.1)	36.3 (6.6)	58.3 (8.6)
Male/female	1851/978	710/257	1141/721
Waist, cm (SD)	91.4 (12.4)	93.2 (14.4)	90.5 (11.2)
BMI, kg/m^2 (SD)	26.5 (4.7)	27.7 (5.8)	25.9 (3.9)
HTN	913	165	748
DM	309	48	261
Dyslipidemia	454	90	364
Head injury	93	29	64
Menopause	606	30	576
HRT	71	6	65
Insomnia	608	296	312
Smoking	537	274	263
Drinking	1107	484	623
AHI/hr (SD)	28.1 (23.9)	28.4 (27.3)	27.9 (21.9)
ODI/hr (SD)	20.3 (23.7)	21.1 (27.3)	19.8 (21.7)
Mean O_2% (SD)	94.8 (2.8)	95.0 (3.5)	94.7 (2.3)
Minimal O_2% (SD)	82.9 (9.3)	82.9 (10.6)	82.9 (8.5)
O_2% awake during sleep (SD)	95.0 (2.5)	95.3 (3.2)	94.9 (2.1)
Percentage of O_2 below 90% (SD)	6.0 (13.9)	7.2 (16.5)	5.4 (12.2)
Percentage of O_2 below 85% (SD)	2.6 (9.2)	3.9 (12.1)	2.0 (7.1)

AHI = apnea-hyponea index, BMI = body mass index, DM = diabetes mellitus, HRT = hormone replacement therapy, HTN = hypertension, ODI = oxygen desaturation index.

with oxygen saturation below 90% during sleep was 6.0% (SD = 13.9). The percentage of those with oxygen saturation below 85% during sleep was 2.6% (SD = 9.2).

Table 2 shows the results of univariate linear regression analysis of the association of ESS scores with various breathing indexes during sleep and clinical factors. We found that AHI ($P < .001$), ODI ($P < .001$), percentage of oxygen saturation below 90% during sleep ($P < .001$), and percentage of oxygen saturation below 85% during sleep ($P < .001$) had a significantly positive association with ESS scores, whereas mean oxygen saturation during sleep ($P < .001$), minimal oxygen saturation during sleep ($P < .001$), and awake oxygen saturation during sleep ($P < .001$) had a significantly negative association with ESS scores in all adults. In addition, sex ($P < .001$), BMI ($P < .001$), hypertension ($P < .001$), diabetes mellitus ($P = .005$), dyslipidemia ($P < .001$), acute myocardial infarction ($P = .001$), chronic kidney disease ($P = .010$), liver cirrhosis ($P = .003$), smoking ($P < .001$), drinking alcohol ($P < .001$), coffee consumption ($P = .001$), and tea consumption ($P < .001$) were also significantly associated with ESS scores.

Table 3 shows the results of multivariate linear regression analysis of the association of various breathing indexes during sleep with ESS scores, after adjustment for related clinical factors. We found that AHI, ODI, percentage of oxygen saturation below 90% during sleep, and percentage of oxygen saturation below 85% during sleep had significantly positive association with ESS scores in all adults (all $P < .05$). Mean oxygen saturation during sleep, minimal oxygen saturation during sleep, and awake oxygen saturation during sleep all had significantly negative association with ESS scores in all adults after adjustment for other clinical factors.

Table 4 shows the results of multivariate linear regression analysis of the association of various breathing indexes during sleep with ESS scores by different sex and BMI. In males with BMI < 26 kg/m^2, AHI and ODI had significantly positive association with ESS scores after adjustment for other clinical factors. In males with BMI ≥ 26 kg/m^2, AHI, ODI, percentage of oxygen saturation below 90% during sleep, and percentage of oxygen saturation below 85% during sleep had significantly positive association with ESS scores. Mean oxygen saturation during sleep, minimal oxygen saturation during sleep, and awake oxygen saturation during sleep all had significantly negative association with ESS scores after adjustment for other clinical factors.

In females with BMI < 26 kg/m^2, ODI had significantly positive association with ESS scores after adjustment for other clinical factors. Minimal oxygen saturation during sleep had significantly negative association with ESS scores after adjustment for other clinical factors. In females with BMI ≥ 26 kg/m^2, AHI, ODI, percentage of oxygen saturation below 90% during sleep, and percentage of oxygen saturation below 85% during sleep had significantly positive association with ESS scores. Minimal oxygen saturation during sleep and awake oxygen saturation during sleep had significantly negative association with ESS scores after adjustment for other clinical factors (Table 4).

4. Discussion

This cross-sectional study with in a large consecutive population of patients with clinical and overnight PSG data showed that all breathing indexes during sleep had a significantly positive or negative association with ESS scores individually in all adults after adjustment for age, sex, many common diseases, and health-related habits. In addition, the association between breathing indexes during sleep and ESS score was similar in both sex, but was significant in subjects of BMI ≥ 26 kg/m^2.

Both EDS and OSA are well known to be common complex diseases with diverse etiology. In the literature, the risk factors for OSA and its related breathing indexes have been widely reported. The relationship between ESS scores and OSA has also been reported, but the results are inconsistent. For example, ESS scores were not a good predictor of OSA in patients with chronic obstructive pulmonary disease.[11] Otherwise, the STOP-BANG questionnaire performed better than ESS in predicting OSA in patients with chronic obstructive pulmonary disease.[12] ESS scores were weakly correlated with RDI. The sensitivity of ESS score in identifying OSA was 54% and the specificity was 57%. The positive and negative predictive values for OSA were 64% and 47%, respectively.[7] Among the morbidly obese, ESS score was a poor predictor of OSA. Otherwise, moderate-to-severe OSA can be predicted if age, gender, and BMI are taken into consideration.[13]

Table 2

Univariate logistic regression for each clinical variables on stroke.

	All subjects (20–91 yr, N = 2829)	Young adults (20–45 yr, N = 967)	Old adults (46–91 yr, N = 1862)
Age	0.0016 ± 0.0002 (<.001)	0.0002 ± 0.0003 (.553)	0.0027 ± 0.0005 (<.001)
Sex	0.0122 ± 0.0059 (.037)	0.0056 ± 0.0047 (.229)	0.0202 ± 0.0084 (.016)
Waist	0.0006 ± 0.0002 (.006)	0.0004 ± 0.0001 (.008)	0.0010 ± 0.0004 (.005)
BMI	0.000006 ± 0.0006 (.991)	0.0007 ± 0.0004 (.053)	0.0003 ± 0.0010 (.750)
HTN	0.0417 ± 0.0059 (<.001)	0.0096 ± 0.0055 (.081)	0.0456 ± 0.0083 (<.001)
DM	0.0447 ± 0.0089 (<.001)	–0.0044 ± 0.0095 (.647)	0.0487 ± 0.0118 (<.001)
Dyslipidemia	0.0396 ± 0.0076 (<.001)	–0.0046 ± 0.0072 (.518)	0.0468 ± 0.0104 (<.001)
Head injury	0.0105 ± 0.0157 (.502)	0.0313 ± 0.0121 (.010)	–0.0002 ± 0.0226 (.993)
Menopause	0.0150 ± 0.0087 (.086)	Omitted	0.0091 ± 0.0145 (.531)
HRT	–0.0030 ± 0.0156 (.846)	Omitted	–0.0074 ± 0.0188 (.694)
Insomnia	0.0034 ± 0.0022 (.124)	–0.00002 ± 0.0018 (.989)	0.0022 ± 0.0032 (.498)
Smoking	0.0001 ± 0.0071 (.991)	–0.0007 ± 0.0046 (.880)	0.0120 ± 0.01170 (.307)
Drinking	–0.0053 ± 0.0057 (.353)	0.000009 ± 0.0041 (.998)	–0.0015 ± 0.0087 (.861)
AHI	0.0001 ± 0.0001 (.226)	0.0001 ± 0.0001 (.150)	0.0002 ± 0.0002 (.335)
ODI	0.0002 ± 0.0001 (.051)	0.0001 ± 0.0001 (.058)	0.0003 ± 0.0002 (.080)
Mean O_2%	–0.0025 ± 0.0010 (.012)	–0.0013 ± 0.0006 (.027)	–0.0033 ± 0.0018 (.058)
Minimal O_2%	–0.0005 ± 0.0003 (.102)	–0.0002 ± 0.0002 (.228)	–0.0007 ± 0.0005 (.141)
O_2% awake during sleep	–0.0027 ± 0.0011 (.013)	–0.0016 ± 0.0007 (.016)	–0.0033 ± 0.0019 (.088
O_2 below 90%	0.0004 ± 0.0002 (.046)	0.0003 ± 0.0001 (.008)	0.0006 ± 0.0003 (.079)
O_2 below 85%	0.0001 ± 0.0003 (.635)	0.0003 ± 0.0002 (.069)	0.0003 ± 0.0006 (.644)

AHI = apnea-hyponea index, BMI = body mass index, DM = diabetes mellitus, HRT = hormone replacement therapy, HTN = hypertension, ODI = oxygen desaturation index.
The data in each cell was shown as cofficient ± standar error (P value).

Table 3

Effects of variable breathing indexes during sleep on ESS after adjusting for other clinical variables by multivariate linear regression.

Coefficient ± SE (*P*)	All subjects (20–91 yr, N = 2829)
AHI	0.030 ± 0.004 (<.001)
ODI	0.035 ± 0.004 (<.001)
Mean O_2% during sleep	−0.174 ± 0.035 (<.001)
Minimal O_2% during sleep	−0.073 ± 0.010 (<.001)
Awake O_2% during sleep	−0.215 ± 0.038 (<.001)
Percentage of O_2 below 90% during sleep	0.041 ± 0.006 (<.001)
Percentage of O_2 below 85% during sleep	0.055 ± 0.009 (<.001)

AHI = apnea-hypopnea index, ESS = Epworth Sleepiness Scale, ODI = oxygen desaturation index, SE = standard error.
*The data in each cell was acquired after adjustment for age, sex, body mass index, hypertension, diabetes mellitus, dyslipidemia, acute myocardial infarction, stroke, chronic kidney disease, liver cirrhosis, cancers, depression, smoking, drinking alcohol, coffee consumption, and tea consumption.

Furthermore, most subjects underestimated their ESS scores compared to their partner. Using an ESS score of ≥10 as abnormal, self-evaluated ESS scores did not correlate well with the presence OSA. However, partner-evaluated and consensus ESS scores did.[14] Li et al[15] reported that, compared to self-evaluated ESS scores, ESS scores from a close relative correlated better with OSA in Chinese patients. However, neither patient-completed nor partner-completed ESS scores showed great utility in predicting OSA and its severity.[16]

On the other hand, the risk factors for EDS have been rarely discussed and the results were inconsistent. Previous studies reported that ESS scores might be affected by ethnicity, gender, obesity, OSA, depression, or lack of regular exercise.[7–9] In addition, age, memory loss, work disturbances, sleep latency, sleep efficiency, gasping/choking, arousal index, AHI, mean oxygen saturation during sleep, and percentage of oxygen saturation below 90% during sleep had differential impact on daytime sleepiness.[9] However, Sforza et al[10] found that, in the elderly, only gender, BMI, and depression were significantly related with daytime sleepiness. The correlation between RDI and ESS scores was weak.[7] Another study found no correlation between ESS scores and either AHI or minimum oxygen saturation during sleep.[3]

The preferred breathing index during sleep was not consistent across researchers. AHI was commonly used in many studies. However, oxygen saturation or desaturation data were also regarded as simple and reliable indicators for sleep apnea-related conditions by some researchers.[17–19] We here found that, after taking into consideration many important clinical variables, all breathing indexes have a significantly positive or negative association with ESS scores in adults, except for mean oxygen saturation in older adults. We suppose that OSA might lead to EDS directly via poor sleep quality, tissue hypoxia, neuroinflammation,[20,21] or impaired macrovascular and microvascular endothelial function,[22] as well as indirectly via tissue damage from its related metabolic syndrome,[23] although sympathetic tone was elevated during sleep.[24]

This study had both strengths and weaknesses. First, our analysis included a large number of cases and significant *P* value within a wide age range with detailed clinical and PSG information. Second, analyses included statistical adjustment for many important confounding factors to determine the effect of various breathing indexes during sleep on ESS scores. Third, wide ranges of ESS scores and various breathing indexes during sleep, which ranged from normal to severe conditions, were collected. Thus, our results could be used properly in all adults with sleep disturbances, including non-OSA and OSA. The potential weak points of this study include, first, that ESS might not perfectly represent daytime sleepiness and that other unknown clinical factors might also have affected our results. Second, our results may not be applicable to subjects without sleep disturbances, who were not included in this study. Thus, a larger study might be needed in the future to address this issue.

5. Conclusion

EDS is a common complex disease with a varied etiology. After accounting for age, sex, many common diseases, and health-related habits, we found that almost all breathing indexes during sleep had a significantly positive or negative association with ESS scores individually in all adults, especially in obese subjects.

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Author contributions

JHH wrote the initial manuscript. PSH, SRH, and SWH data acquisition. PSH, SRH, and SWH analyzed data. JHH and PSH wrote – review & editing. JHH conception and design, analysis and interpretation of data, and final approval of the version to be published.
Conceptualization: Juen-Haur Hwang.
Data curation: Pei-Shan Hsieh, Sheng-Wei Hwang, Shang-Rung Hwang.
Formal analysis: Pei-Shan Hsieh, Sheng-Wei Hwang, Shang-Rung Hwang.
Methodology: Juen-Haur Hwang.

Table 4

Effects of variable breathing indexes during sleep on ESS after adjusting for other clinical variables by multivariate linear regression by different sex and BMI.

	Males		Females	
Coefficient ± SE (*P*)	BMI < 26 kg/m²	BMI ≥ 26 kg/m²	BMI < 26 kg/m²	Females, BMI ≥ 26 kg/m²
AHI	0.016 ± 0.008 (.037)	0.040 ± 0.005 (<.001)	0.014 ± 0.012 (.253)	0.025 ± 0.010 (.013)
ODI	0.017 ± 0.009 (.050)	0.041 ± 0.005 (<.001)	0.032 ± 0.016 (.044)	0.032 ± 0.010 (.002)
Mean O_2% during sleep	0.074 ± 0.087 (.396)	−0.255 ± 0.043 (<.001)	−0.163 ± 0.112 (.144)	−0.157 ± 0.091 (.086)
Minimal O_2% during sleep	−0.052 ± 0.019 (.006)	−0.090 ± 0.015 (<.001)	−0.072 ± 0.028 (.011)	−0.073 ± 0.025 (.004)
Awake O_2% during sleep	0.083 ± 0.095 (.384)	−0.301 ± 0.047 (<.001)	−0.219 ± 0.119 (.067)	−0.208 ± 0.103 (.045)
Percentage of O_2 below 90% during sleep	0.016 ± 0.018 (.355)	0.047 ± 0.008 (<.001)	0.025 ± 0.034 (.460)	0.044 ± 0.018 (.014)
Percentage of O_2 below 85% during sleep	−0.005 ± 0.031 (.881)	0.068 ± 0.011 (<.001)	0.014 ± 0.037 (.700)	0.068 ± 0.028 (.017)

AHI = apnea-hypopnea index; BMI = body mass index; ESS = Epworth Sleepiness Scale; ODI = oxygen desaturation index; SE = standard error.
*The data in each cell was acquired after adjustment for age, hypertension, diabetes mellitus, dyslipidemia, acute myocardial infarction, stroke, chronic kidney disease, liver cirrhosis, cancers, depression, smoking, drinking alcohol, coffee consumption, and tea consumption.

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References

[1] Maestri M, Romigi A, Schirru A, et al. Excessive daytime sleepiness and fatigue in neurological disorders. Sleep Breath. 2020;24:413–24.
[2] Trimmel K, Zebrowska M, Bock M, et al. Wanted: a better cut-off value for the Epworth sleepiness scale. Wien Klin Wochenschr. 2018;130:349–55.
[3] Chung KF. Use of the Epworth sleepiness scale in Chinese patients with obstructive sleep apnea and normal hospital employees. J Psychosom Res. 2000;49:367–72.
[4] Alqurashi YD, Dawidziuk A, Alqarni A, et al. A visual analog scale for the assessment of mild sleepiness in patients with obstructive sleep apnea and healthy participants. Ann. Thorac Med. 2021;16:141–7.
[5] Campbell AJ, Neill AM, Scott DAR. Clinical reproducibility of the Epworth sleepiness scale for patients with suspected sleep apnea. J Clin Sleep Med. 2018;14:791–5.
[6] Grewe FA, Roeder M, Bradicich M, et al. Low repeatability of Epworth sleepiness Scale after short intervals in a sleep clinic population. J Clin Sleep Med. 2020;16:757–64.
[7] Hesselbacher S, Subramanian S, Allen J, et al. Body mass index, gender, and ethnic variations alter the clinical implications of the Epworth sleepiness scale in patients with suspected obstructive sleep apnea. Open Respir Med J. 2012;6:20–7.
[8] Basta M, Lin HM, Pejovic S, et al. Lack of regular exercise, depression, and degree of apnea are predictors of excessive daytime sleepiness in patients with sleep apnea: sex differences. J Clin Sleep Med. 2008;4:19–25.
[9] Shao C, Qi H, Lang R, et al. Clinical features and contributing factors of excessive daytime sleepiness in Chinese obstructive sleep apnea patients: the role of comorbid symptoms and polysomnographic variables. Can Respir J. 2019;2019:5476372.
[10] Sforza E, Pichot V, Martin MS, et al. Prevalence and determinants of subjective sleepiness in healthy elderly with unrecognized obstructive sleep apnea. Sleep Med. 2015;16:981–6.
[11] Soler X, Liao SY, Marin JM, et al. Age, gender, neck circumference, and Epworth sleepiness scale do not predict obstructive sleep apnea (OSA) in moderate to severe chronic obstructive pulmonary disease (COPD): the challenge to predict OSA in advanced COPD. PLOS One. 2017;12:e0177289. eCollection 2017.
[12] Xiong M, Hu W, Dong M, et al. The screening value of ESS, SACS, BQ, And SBQ on obstructive sleep apnea in patients with chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis. 2019;14:2497–505.
[13] Singla V, Gattu T, Aggarwal S, et al. Evaluation of Epworth sleepiness scale to predict obstructive sleep apnea in morbidly obese patients and increasing its utility. J Laparoendosc Adv Surg Tech A. 2019;29:298–302.
[14] Bonzelaar LB, Salapatas AM, Yang J, et al. Validity of the Epworth sleepiness scale as a screening tool for obstructive sleep apnea. Laryngoscope. 2017;127:525–31.
[15] Li Y, Zhang J, Lei F, et al. Self-evaluated and close relative-evaluated Epworth sleepiness scale vs. multiple sleep latency test in patients with obstructive sleep apnea. J Clin Sleep Med. 2014;10:171–6.
[16] Bhat S, Upadhyay H, DeBari VA, et al. The utility of patient-completed and partner-completed Epworth sleepiness scale scores in the evaluation of obstructive sleep apnea. Sleep Breath. 2016;20:1347–54.
[17] Del Campo F, Crespo A, Cerezo-Hernandez A, et al. Oximetry use in obstructive sleep apnea. Expert Rev Respir Med. 2018;12:665–81.
[18] Li Q, Jin XJ. Correlations between the duration and frequency of sleep apnea episode and hypoxemia in patients with obstructive sleep apnea syndrome [Chinese]. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2009;44:825–30.
[19] Pataka A, Zarogoulidis P, Hohenforst-Schmidt W, et al. During economic crisis can sleep questionnaires improve the value of oximetry for assessing sleep apnea? Ann Transl. 2016;4:443.
[20] Xu LF, Cai YF, Hu K, et al. Effects of chronic intermittent hypoxia on left ventricular myocardial contractibility in a rabbit model of obstructive sleep apnea [Chinese]. Zhonghua Yi Xue Za Zhi. 2017;97:2528–32.
[21] Yilmaz Avci A, Avci S, Lakadamyali H, et al. Hypoxia and inflammation indicate significant differences in the severity of obstructive sleep apnea within similar apnea-hypopnea index groups. Sleep Breath. 2017;21:703–11.
[22] Farooqui FA, Sharma SK, Kumar A, et al. Endothelial function and carotid intima media thickness in obstructive sleep apnea without comorbidity. Sleep Breath. 2017;21:69–76.
[23] Punjabi NM, Ahmed MM, Polotsky VY, et al. Sleep-disordered breathing, glucose intolerance, and insulin resistance. Respir Physiol Neurobiol. 2003;136:167–78.
[24] Bisogni V, Pengo MF, Maiolino G, et al. The sympathetic nervous system and catecholamines metabolism in obstructive sleep apnoea. J Thorac Dis. 2016;8:243–54.