Research Article

Journal of Clinical Reviews & Case Reports

# Comparison between Epworth Sleepiness Scale and Polysomnographic Parameters in Patients with Obstructive Sleep Apnea Syndrome

**Daniela Vieira Martins*, Gabriel Liria Juares, Leticia Helena de Sousa Marques and Fábio Tadeu Moura Lorenzetti.**

*Department of Otolaryngology, Head and Neck Surgery – Banco de Olhos de Sorocaba Hospital. Sorocaba, Brazil.*

***Corresponding author**
Daniela Vieira Martins, Banco de Olhos de Sorocaba Hospital. Praça Nabek Shiroma, 210 – Jd Emilia – Sorocaba, São Paulo, Brazil, Tel: +55 15 32127077.

**Submitted**: 12 June 2017; **Accepted**: 18 June 2017; **Published**: 22 June 2017

## Abstract

***Introduction:*** *Obstructive sleep apnea syndrome (OSAS) is the most common sleep-related respiratory disorder. With the purpose of assisting in the screening or evaluation of OSAS patients, some scales and questionnaires were proposed. Objective: To evaluate and critically compare the relationship of excessive daytime sleepiness with the presence or absence of OSAS, in addition to other polysomnographic data. Material and method: Systematic review of the literature. Results: Six studies were included, with a total of 4258 patients; four studies demonstrate association between the Epworth sleepiness scale and the hypopnea apnea index (AIH); of those, two studies showed significant differences between ESS score and OSAS severity. Five studies (4233 patients) demonstrated lower minimum oxygen saturation in the group with excessive daytime sleepiness. There was an increase in sleep efficiency in in patients with excessive daytime sleepiness, as per the results of 3 studies (3002 patients). Discussion: The relationship between the presence of excessive daytime sleepiness and OSAS is still questioned, and its pathophysiological mechanism uncertain. Excessive daytime sleepiness secondary to OSAS seems to be an independent event, related to nocturnal hypoxemia and sleep fragmentation. Conclusion: The confidence intervals obtained from these studies do not provide clinical safety to use the Epworth sleepiness scale for screening or stratifying the risk of patients suspected of having sleep apnea.*

**Keywords:** Sleep apnea, OSAS, Epworth sleepiness scale, excessive daytime sleepiness, polysomnography.

## Introduction

The obstructive sleep apnea syndrome (OSAS) is the most common sleep-related respiratory disorder [1,2]. In the United States, the prevalence in individuals from 30 and 60 years is 9% in men and 4% in women, and is even higher among patients with a body mass index (BMI) above 30. In Brazil, it is estimated that 32.8% of adults between 20 and 80 years are affected by OSAS [3]. However, studies suggest that up to 95% of patients with sleep disorders are not correctly diagnosed, suggesting that the prevalence of OSAS may be even greater [4].

Clinically, OSAS is characterized by repeated episodes of airway obstruction during sleep, resulting in cyclic periods of hypoxemia and hypercapnia. Changes in blood oxygenation during sleep may, in the long term, increase the risk of developing cardiovascular diseases [1]. The typical symptoms of OSAS include snoring, apnea or hypopnea, awakening during sleep, fatigue, headaches, excessive daytime sleepiness, and disturbances of concentration [2].

Assisted polysomnography is considered the gold standard exam for the diagnosis of OSAS. In this test, electroencephalogram, electro-oculogram, electromyography, electrocardiogram, oximetry, airflow, and respiratory effort records provide reliable data on evaluating the severity of the disease [5]. However, it is a high-cost test, and is not always well tolerated by the patients [2]. In order to aid in the screening or evaluation of potential OSAS patients, several scales and questionnaires were proposed, one of which is the Epworth sleepiness scale (ESS). The ESS is a validated questionnaire, used to evaluate the presence or absence of daytime sleepiness - one of the cardinal symptoms for diagnosis of OSAS [6-8]. The publication of studies demonstrating an association between the presence of daytime sleepiness and OSAS raised the hypothesis that a positive ESS may suggest the presence of nocturnal apnea. However, subsequent studies that aimed to prove this association present conflicting results.

The aim of our study is to critically evaluate and compare the relationships between excessive daytime sleepiness with the presence or absence of OSAS, in addition to other polysomnographic data.

## Material and methods

We conducted a systematic review of the literature study, based on research in PubMed database between December 2016 and February 2017. The keywords used in the search were ("Obstructive Sleep apnea") AND ("Epworth Sleepiness Scale") NOT (CPAP) NOT (central). Additional filters were used: studies published in the last 10 years, in humans, in English, Spanish and Portuguese languages. The inclusion criteria were: original studies published in peer-reviewed journals comparing the results obtained with the application of the Epworth questionnaire to polysomnographic findings. We excluded studies including patients not subjected to polysomnography, case reports and series of cases, systematic reviews and meta-analyses. Initially, we proceeded to reading the titles and abstracts of the studies resulting from the bibliographic research; after preliminary selection, the articles were read in full. These articles were evaluated independently by 3 of the researchers. We only selected articles which inclusion was recommended by unanimity by the 3 researchers. In case of disagreement, the articles were re-evaluated, and the decision whether to include or exclude the study was made by mutual consent.

We made a table in the program Microsoft Excel (Microsoft, USA) containing all the relevant data extracted from the selected articles. We further classify studies according to the level of evidence, as proposed by "Oxford Centre for Evidence-based Medicine – Levels of Evidence" (http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/).

## Results

The database search resulted in 570 articles. After reading the title and the abstract, 89 articles were read in full. After selection, 6 articles fulfilled the inclusion and exclusion criteria and were selected for final analysis (Fig. 1).

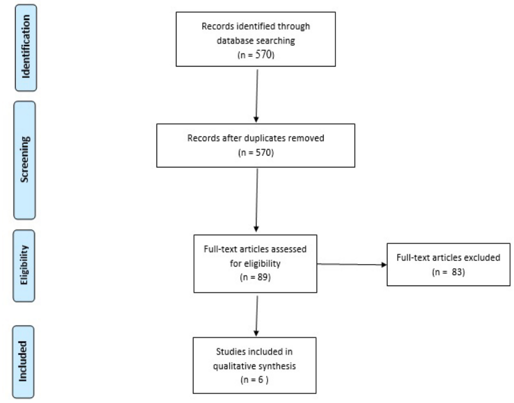


**Figure 1: Flowchart describing the process of the selection of the studies.**

The main reasons for excluding articles were, in descending order: (1) no description of polysomnographic data; (2) studies in non-OSAS patients; (3) studies that did not apply the ESS or did not describe its results; (4) studies in specific populations (truck drivers, elderly, children, and patients with narcolepsy or chronic diseases, and patients with psychiatric conditions and metabolic syndrome); and (5) studies aiming to describe therapeutic approaches to OSAS (use of positive pressure, nasal surgeries, palatal and maxillomandibular advancement). As per the criteria proposed by the Oxford Centre for Evidence-based Medicine-Levels of Evidence"), 2 (33.3%) of the selected articles were 2a (cohorts), and the other 4 (66.6%) were 2b (cross-sectional studies). (Table 1). Demographic data of selected papers were included in Table 1.

**Table 1: Demographic information and content of the selected studies.**

| Authors | Year | Study desing | Country | Epworth scale x polysomnography | Groups |
|---|---|---|---|---|---|
| Lee et al. (1) | 2012 | Cross-sectional | South Korea | Age, BMI, AHI, total sleep time, sleep efficiency, sleep latency, minimum SpO2, ODI, time length under SpO2 <90%, | Only patients with OSAS: with EDS and without EDS |
| Gondim et al. (15) | 2007 | Cohort | Brazil | Clinical condition (incluindo EDS and BMI) and AHI. | Included primary snory and patients with OSAS |
| Chen et al. (13) | 2010 | Cohort | China | Age, BMI, AHI, total sleep time, sleep efficiency, sleep latency, minimum SpO2, ODI, time length of SpO2 <90%, | Included primary snore and OSAS patients |
| Sun et al. (14) | 2012 | Cross-sectional | China | Age, BMI, AHI, total sleep time, sleep efficiency, sleep latency, minimum SpO2, ODI, time length of SpO2 <95%, | Only patients with OSAS: with EDS and without EDS |
| Roure et al. (12) | 2008 | Cross-sectional | Spain | Age, BMI, AHI, total sleep time, sleep efficiency, sleep latency, minimum SaO2 (%) and mean SaO2. | Only patients with OSAS: with EDS and without EDS |
| Mediano et al.(16) | 2007 | Cross-sectional | Spain | Age, BMI, AHI, total sleep time, sleep efficiency, sleep latency, minimum SaO2 (%) and mean SaO2. | Only patients with OSAS: with EDS and without EDS |

BMI: body mass index; AHI: apnea hypopnea index; ODI: oxygen desaturation index; EDS: excessive daytime sleepiness; OSAS: Obstructive sleep apnea syndrome.

The studies included 4.258 patients, all adults, of both sexes. Only 306 of these patients did not have OSAS (AHI> 5). The studies showed results from several clinical evaluations and tests: all six articles (100%) correlated the results of the ESS with polysomnographic parameters. Among those articles, 2 (33.3%) included groups of non-apneic patients in the comparison of the results, while the other 4 (66.6%) only included patients with AHI> 5. Five (83.3%) studies associated polysomnographic data and ESS with clinical variables (BMI and age); one (16.6%) correlated the presence of daytime sleepiness with clinical symptoms. Only 2 (33.3%) studies evaluated the association between ESS scores and severity of OSAS. (Tables 1 and 2).

Regarding the association between ESS and AIH, 4 (66.6%) studies which involved a total of 4.093 patients demonstrated a significant association between positivity of the ESS and the presence of OSAS. Two out of those 4 (50%) also report significant direct association between ESS scores and severity of OSAS, while the other 2 studies did not.

Five studies aimed to evaluate the nocturnal oxygen saturation. Of those, 5 articles (100%) (4.233 patients), demonstrated lower minimum oxygen saturation levels in the group of patients with excessive daytime sleepiness compared to patients without such symptom. Among those five studies, one (20%) reported that the minimum oxygen saturation was progressively smaller as per the increase of the AHI and the score on the Epworth sleepiness scale; and 2 studies (40%) observed that nocturnal oxygen saturation was, on average, lower in apneic patients with excessive daytime sleepiness compared to apneic patients without excessive daytime sleepiness. Two out of those 5 studies (40%) report that nocturnal time with oxygen saturation below 90-95% was higher in the apneic group with excessive sleepiness compared to apneic patients without excessive daytime sleepiness.

Regarding other polysomnographic parameters, three studies (50%), which included 3002 patients, demonstrated an increase in the sleep efficiency in the group of apneic patients with excessive daytime sleepiness compared to the group without the symptom. Only one study (16.6%) evidenced an increase in total sleep time, and another study (16.6%) found an increase in BMI in the group of apneic patients complaining of excessive daytime sleepiness in relation to the group without excessive daytime sleepiness. (Table 2).

**Table 2: Data extracted from the selected studies.**

| Authors | N | Population | Variables | Outcomes (* = P>0.05) | Conclusions |
|---|---|---|---|---|---|
| Lee et al. (1) | 96 | OSAS patients who had daytime sleepiness vs OSAS patients without daytime sleepiness. | 1. ESS<br>2. Polysomnography results | No excessive daytime sleepiness group (n=37):<br>-BMI 24.68 ± 4.49*<br>- ESS:6.93 ± 2.43*<br>- AHI: 35.65±23.21*<br>- Total sleep time (min): 411.43±79.52<br>- Minimum Sp02(%): 82.53± 7.07*<br>- Time lengh of SpO2 < 90%(min): 17.04±25.92*<br>- Sleep efficiency (%): 86.24±7.73<br><br>Excessive daytime sleepiness group (n=59):<br>- BMI: 27.24± 3.90*<br>- ESS:14.19 ± 2.31*<br>- AHI: 47.29±23.76*<br>- Total sleep time (min): 397.96±62.18<br>- Minimum Sp02(%): 78.11±8.88*<br>- Time lengh of SpO2 < 90% (min): 39.26±60.08*<br>- Sleep efficiency (%): 87.18±8.56 | - Epworth sleepiness scale could be used as an indicator of excessive daytime sleepiness.<br>- Higher levels of apnea hypopnea index and hypoxemia associates with the degree of sleepiness and positivity in the Epworth sleepiness scale. |
| Gondim et al. (15) | 125 | Patients subjected to polysomnography | 1. AHI<br>2. ESS | No OSAS (n=57) or mild OSAHS (n=38) group:<br>- ESS negative in 49.5% and positive in 50.5% (p>0.05)<br><br>Moderate (n=19) or severe (n=11) OSAS group:<br>- ESS was positive in 70% and negative in 30% of patients (p>0.05)<br><br>There were no significant differences in the complaints of snoring, apnea, daytime sleepiness, dyspepsia, stress, lack of concentration, restless sleep, parasomnia, and morning headache between the groups | - ESS is not associated with the severity of OSAS.<br>- There were no significant differences in the clinical complaints among the different degrees of OSAS. |

| | | | | | |
|---|---|---|---|---|---|
| Chen R (13) | 1035 | Patients who snored | 1. ESE<br>2. Polysomnography results | AHI< 5 per hour (n=249)<br>- ESS : 8.3±5.0*<br>- Total sleep time: 401.4 ± 85.5<br>- Time of Sp02 <90% min: 0.3 ±1.7<br>- Minimum O2 saturation: 83.2±23.6<br><br>AHI 5-15 per hour (n= 225):<br>-ESS 9.4±4.6*<br>- Total sleep time: 400.8± 74.4<br>- Time of Sp02 <90% min: 4.0 ±14.4<br>- Minimum O2 saturation: 82.5±9.4<br><br>AHI 15-30 per hour (n= 171)<br>- ESS: 10.4±4.6*<br>- Total sleep time: 405.6± 75.7<br>- Time of Sp02 <90%) min: 10.0 ±19.2<br>- Minimum O2 saturation: 77.3±8.3<br><br>AHI> 30 per hour (n=390):<br>- ESS: 13.0±5.0*<br>- Total sleep time: 428.7±76.9<br>- Time of Sp02 <90%) min: 147.4± 111.5<br>- Minimum O2 saturation: 65.6±12.7 | - ESS scores were progressively higher in more severe stages of OSAS.<br>- Higher scores in the ESS associated with more time of SpO2<90% and decreased levels of minimum O2 saturation. |
| Sun et al. (14) | 80 | Patients who had OSAS (AHI > 5) | 1. ESE<br>2. Polysomnographic results | No excessive daytime sleepiness group (n= 48):<br>- ESS: 5.29 ±3,15*<br>- AIH: 33.68 ± 22.71*<br>- Total mean SaO2: 94.54±4.15*<br>- Minimum SaO2: 73.10±14,97*<br>- Time length of Sa02 <95%: 146.41±143.91*<br>- Snoring time: 112.56±85,79 (p>0,05)<br>- Sleep efficiency 83.61±12,27*<br><br>Excessive daytime sleepiness group (n=32)<br>-ESS: 16.53±3,59*<br>- AHI: 60.92 ± 19.24*<br>- Total mean SaO2: 90.06 ±5.57*<br>- Minimum SaO2: 54.06%±21.22*<br>- Time length of Sa02 <95%: 286.95±128.67*<br>Snoring time: 88.98 ±71.33<br>- Sleep efficiency: 90.40 ±7.23* | - Positive ESS scores associate with excessive daytime sleepiness<br>- Excessive daytime sleepiness associate with severity of OSAS, lower SaO2 levels during sleep, and increased sleep efficiency. |
| Roure et al. (12) | 2882 | Patients who had OSAS (AHI > 5) | 1. ESE<br>2. Polysomnography results | No excessive daytime sleepiness group (n=1233)<br>- ESS: 7±3*<br>- AHI: 33±25 (p<0,05)<br>- Sleep efficiency: 72±31*<br>- Total sleep time: 325±65<br>- Minimum saturation of O2: 79±11*<br>- Mean saturation of O2: 92±4<br><br>Excessive daytime sleepiness group (n= 1649)<br>- ESS: 15±3*<br>- AHI: 36 ± 27*<br>- Sleep eficiency: 79±22*<br>- Total sleep time: 338±67<br>- Minimum saturation of O2: 78 ±12*<br>- Mean saturation of O2: 92±5 | - Positive ESS associates with excessive daytime sleepiness<br>- Excessive daytime sleepiness associate with OSAS, lower minimum SaO2 levels during sleep, and increased sleep efficiency. |

| | | | | | |
|---|---|---|---|---|---|
| Mediano et al. (16) | 40 | Patients who had OSAS (AHI > 20) | 1. ESE<br>2. Polysomnography results | No excessive daytime sleepiness group (n= 17)<br>- ESS: 5±2*<br>- AIH 60±20 (p>0.05)<br>- Minimum O2 saturation: 79±8*<br>- Mean O2 saturation: 90±5*<br>- Sleep efficiency: 82%*<br>- Sleep latency (min): 18±18<br><br>Excessive daytime sleepiness group (n=23):<br>- ESS: 17±3*<br>- AIH 62±18 (p>0,05)<br>- Minimum O2 saturation: 69±12*<br>- Mean O2 saturation: 87 ±6*<br>- Sleep efficiency: 90%*<br>- Sleep latency (min): 11±16 | - Positive ESS significantly associates with excessive daytime sleepiness.<br>- AIH levels do not associate with presence or not of excessive daytime sleepiness.<br>- Excessive daytime sleepiness associates with lower nocturnal O2 saturation levels and increased sleep efficiency. |

## Discussion

Excessive daytime sleepiness is one of the most prevalent symptoms in both men (16%) and women (23%) with OSAS, and also a common symptom in the general population (3% and 10% in men and women, respectively) [9,10]. The ESS is a validated questionnaire used to evaluate the presence of excessive daytime sleepiness, constituting a cheap, easy-to-perform analysis with highly reliable results [11]. The high prevalence of excessive daytime sleepiness in patients with OSAS raised the hypothesis that ESS could become an alternative screening method for patients at risk of OSAS, considering the low availability and high cost of polysomnography in some countries. However, studies aiming to associate ESS with polysomnographic parameters are scarce, with conflicting results.

### Epworth sleepiness scale (ESS) and apnea-hypopnea index (AHI)

Among the selected studies, most of the authors agree to observe a statistically significant association between scores of ESS and AHI. Roure, et al., Chen, et al, Lee, et al., and Sun et al., in studies involving 4093 patients, were unanimous in demonstrating a positive association between the presence or severity of OSAS and the values obtained with ESS [1,12,13].

Chen, et al. and Sun, et al. conclude the relationship between higher values obtained in ESS with higher OSA severity: Chen, et al. observed a gradual increase in ESS score in the more severe degrees of OSAS, and Sun et al. demonstrated that apneic patients with excessive daytime sleepiness had AHI scores almost twice as high as in apneic patients without daytime sleepiness [13,14]. The studies that did not show the association between the AHI and ESS totaled 165 patients [15,16]. However, even among the studies that corroborate such association, there are questions about the clinical validity of the results obtained. In most of those studies, a significant portion of sleep apnea patients had ESS <10, a result considered negative for daytime sleepiness. Even in studies that included many patients, ESS values varied significantly even in patients with severe apnea, with confidence intervals that were well beyond or below the cut-point score of 10. The study by Chen et al.(13), for example, reports significantly higher values of ESS according to the degree of OSAS; however, the large standard deviations obtained in the (mild OSAS= 9.4±4.6; moderate OSAS = 10.4±4.6; severe OSAS= 13±5) do not provide a safe clinical margin to diagnose of OSAS without the association with polysomnography. Considering the clinical criterion of the presence of daytime sleepiness as the presence of ESS scores> 10, the results obtained by the selected studies suggest that the simple application of ESS does not constitute a safe method of screening for patients in risk of sleep apnea.

The relationship between the presence of excessive daytime sleepiness and OSAS is still questioned, and the pathophysiological mechanism still uncertain. Some authors justify excessive daytime sleepiness secondary to OSAS as an independent event related to nocturnal hypoxemia and sleep fragmentation in apneic patients [17-19]. Although the hypothesis seems quite plausible, studies for this purpose obtained conflicting results: a randomized clinical trial demonstrated a strong relationship between sleep fragmentation and excessive daytime sleepiness, but large cohorts demonstrated that sleep-disordered breathing, sleep fragmentation, and hypoxemia do not correlate with excessive daytime sleepiness [20,21].

### Epworth sleepiness scale (ESS) and oxygen saturation

Some authors compared the presence of excessive daytime sleepiness with the behavior of oxygen saturation during polysomnography: Lee, et al., Sun, et al., Chen, et al. and Mediano, et al. demonstrated that apneic patients with excessive daytime sleepiness had increased sleep time with nocturnal oxygen saturation below 90% when compared to apneic patients without excessive daytime sleepiness [1,13,14]. Chen, et al. and Sun concluded that lower oxygen saturation indexes correlated positively with OSAS severity and with higher ESS scores. Chen et al. also conclude that hypoxemia was the strongest determinant of the positive score [13,14].

The pathogenesis of excessive daytime sleepiness with OSAS, as well as its association with hypoxemia, is unclear. The mechanisms that lead some patients with OSAS to complain of excessive daytime sleepiness while others do not also lack pathophysiological bases. From the studies by Chen, et al. and Mediano, et al., it was hypothesized that nocturnal hypoxemia plays an important role in determining excessive daytime sleepiness and OSAS [13,16]. In an attempt to confirm this hypothesis, animal studies have demonstrated a significant association between chronic intermittent hypoxemia and the development of excessive daytime sleepiness [22,23]. Hypothetically, intermittent chronic hypoxemia during sleep can trigger neural damage, with deleterious effects in specific brain regions that promote the control of vigil through a convergence of oxidative and inflammatory events; Ultimately, such events can lead to neuronal cell injury and apoptosis [22,23]. Although these mechanisms still require studies in human subjects, to date, there is clinical evidence of increased levels of tumor necrosis factor in the blood circulation of apneic patients with excessive daytime sleepiness when compared with apneic individuals without excessive daytime sleepiness [24].

**Epworth sleepiness scale (ESS) and other polysomnographic data**

In relation to other polysomnographic parameters, Mediano, et al. conclude that patients classified as excessive daytime sleepiness had lower sleep latency and greater sleep efficiency. This conclusion resembles those found in the study of Roure, et al., in which there was an association between OSAS and excessive daytime sleepiness with increased sleep time and better sleep efficiency compared to the apneic group without the symptom, suggesting that excessive daytime sleepiness relates to the degree of hypoxemia. Sun, et al. also found greater sleep efficiency in apneic patients with excessive daytime sleepiness [12-14]. The finding of increased efficiency in apneic patients with excessive daytime sleepiness seems, at first glance, paradoxical. However, taking into account that sleep efficiency is determined by dividing the N1, N2, N3 and REM stages by the total time that the patient lies in bed, patients with greater daytime sleepiness have lower latency for sleep, and may present better sleep efficiency without necessarily presenting better sleep quality [25].

## Conclusion

Although many studies demonstrate a statistically significant association between the ESS score and the presence or severity of OSAS, the confidence intervals obtained in these studies do not provide clinical safety to use the Epworth sleepiness scale as screening or stratification tools in patients with suspected sleep apnea. There was a statistically significant association between ESS positivity and higher sleep efficiency and lower minimum oxygen saturation during sleep.

## Acknowledgements

We acknowledge Rafael da Costa Monsanto, M.D., Ph.D. Student, for critically analyzing the manuscript and great support.

## References

1. Lee SJ, Kang HW, Lee LH (2012) The relationship between the Epworth Sleepiness Scale and polysomnographic parameters in obstructive sleep apnea patients. Eur Arch Oto-Rhino-Laryngol Off J Eur Fed Oto-Rhino-Laryngol Soc EUFOS Affil Ger Soc Oto-Rhino-Laryngol - Head Neck Surg 269: 1143-1147.
2. Giorelli AS, Gomes M da M, Carnaval T, Santos PP dos (2017) Sonolência excessiva diurna: aspectos clínicos, diagnósticos e terapêuticos. Rev Bras Neurol [Internet] 48.
3. Tufik S, Santos-Silva R, Taddei JA, Bittencourt LRA (2010) Obstructive sleep apnea syndrome in the Sao Paulo Epidemiologic Sleep Study. Sleep Med 11:441-446.
4. Mercado JC (2003) Identifying Obstructive Sleep Apnea: A Highly Prevalent and Underdiagnosed Disease. Physician Assist 27: 39-45.
5. Thorpy MJ (2012) Classification of Sleep Disorders. Neurotherapeutics 9: 687-701.
6. Gelaye B, Lohsoonthorn V, Lertmeharit S, Pensuksan WC, Sanchez SE, et al. (2014) Construct validity and factor structure of the pittsburgh sleep quality index and epworth sleepiness scale in a multi-national study of African, South East Asian and South American college students. PloS One 9:e116383.
7. Johns MW (1993) Daytime sleepiness, snoring, and obstructive sleep apnea. The Epworth Sleepiness Scale. Chest 103: 30-36.
8. Togeiro SMGP, Smith AK (2005) Diagnostics methods for sleep disorders. Rev Bras Psiquiatr 27: 8-15.
9. Ryu HS, Lee SA, Lee GH, Chung YS, Kim WS (2016) Subjective apnoea symptoms are associated with daytime sleepiness in patients with moderate and severe obstructive sleep apnoea: a retrospective study. Clin Otolaryngol Off J ENT-UK Off J Neth Soc Oto-Rhino-Laryngol Cervico-Facial Surg 41:395-401.
10. Young T, Palta M, Dempsey J, Skatrud J, Weber S, et al. (1993) The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 328: 1230-1235.
11. Johns MW (1992) Reliability and factor analysis of the Epworth Sleepiness Scale. Sleep 15: 376-381.
12. Roure N, Gomez S, Mediano O, Duran J, Peña M de la, et al. (2008) Daytime sleepiness and polysomnography in obstructive sleep apnea patients. Sleep Med 9: 727-731.
13. Chen R, Xiong K, Lian Y, Huang J, Zhao M, et al. (2011) Daytime sleepiness and its determining factors in Chinese obstructive sleep apnea patients. Sleep Breath Schlaf Atm 15:129-35.
14. Sun Y, Ning Y, Huang L, Lei F, Li Z, et al. (2012) Polysomnographic characteristics of daytime sleepiness in obstructive sleep apnea syndrome. Sleep Breath Schlaf Atm 16: 375-381.
15. Gondim LMA, Matumoto LM, Júnior M, De MAC, Bittencourt S, et al. (2007) Comparative study between clinical history and polysomnogram in the obstructive sleep apnea/ hypopnea syndrome. Rev Bras Otorrinolaringol 73: 733-737.
16. Mediano O, Barceló A, de la Peña M, Gozal D, Agusti A, et al. (2007) Daytime sleepiness and polysomnographic variables in sleep apnoea patients. Rev Port Pneumol 13: 896-898.
17. Ciftci TU, Kokturk O, Ozkan S (2004) Apnea-hypopnea indexes calculated using different hypopnea definitions and their relation to major symptoms. Sleep Breath Schlaf Atm 8: 141-146.
18. Miliauskas S, Sakalauskas R (2005) [Peculiarities of nocturnal oxygen saturation in obstructive sleep apnea]. Med Kaunas Lith 41: 217-220.
19. Punjabi NM, O'hearn DJ, Neubauer DN, Nieto FJ, Schwartz AR, et al. (1999) Modeling hypersomnolence in sleep-disordered breathing. A novel approach using survival analysis. Am J Respir Crit Care Med 159: 1703-1709.
20. Colt HG, Haas H, Rich GB (1991) Hypoxemia vs sleep fragmentation as cause of excessive daytime sleepiness in obstructive sleep apnea. Chest 100: 1542-1548.
21. Guilleminault C, Partinen M, Quera-Salva MA, Hayes B, Dement WC, et al. (1988) Determinants of daytime sleepiness in obstructive sleep apnea. Chest 94: 32-37.
22. Zhan G, Fenik P, Pratico D, Veasey SC (2005) Inducible nitric oxide synthase in long-term intermittent hypoxia: hypersomnolence and brain injury. Am J Respir Crit Care Med 171: 1414-1420.
23. Zhan G, Serrano F, Fenik P, Hsu R, Kong L, et al. (2005) NADPH Oxidase Mediates Hypersomnolence and Brain Oxidative Injury in a Murine Model of Sleep Apnea. Am J Respir Crit Care Med 172: 921-929.
24. Ryan S, Taylor CT, McNicholas WT (2006) Predictors of elevated nuclear factor-kappaB-dependent genes in obstructive sleep apnea syndrome. Am J Respir Crit Care Med 174: 824-830.
25. 25. Shrivastava D, Jung S, Saadat M, Sirohi R, Crewson K (2014) How to interpret the results of a sleep study. J Community Hosp Intern Med Perspect [Internet] 4.