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The relationship between the apnea-hypopnea index, oxygen desaturation index, average oxygen saturation, and body mass index in patients with obstructive sleep apnea

Odnos između indeksa apneja-hipopneja, indeksa desaturacije kiseonikom, prosečne saturacije kiseonikom i indeksa telesne mase kod bolesnika sa opstruktivnom apnejom tokom spavanja

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Abstract

Background/Aim. Obstructive sleep apnea (OSA) involves a range of conditions manifested as various forms of breathing disorders with intermittent complete breathing interruptions caused by obstruction in the upper airways. The disorder is more common in adult men, and obesity is a significant predisposing factor. The apnea-hypopnea index (AHI) is the main diagnostic criterion that reflects the frequency and duration of apneic phases. Besides the AHI, other parameters, such as the oxygen desaturation index (ODI), average oxygen saturation, and body mass index (BMI), may have diagnostic value. The aim of the study was to examine the correlation between AHI and ODI, AHI and average oxygen saturation, and AHI and BMI. **Methods.** A retrospective study included 200 patients, 166 men and 34 women, aged between 18 and 65, in whom OSA was proven by respiratory polygraphy. Depending on the AHI values, they were divided into three groups: Group I (AHI 5–15 events *per* hour), Group II (AHI 15–30 events *per* hour), and Group III (AHI > 30 events *per* hour). **Results.** There was a significant correlation between AHI and ODI in all groups, with the strongest correlation in Group III, where ODI also had predictive value for severe forms of apnea. Average oxygen saturation and BMI were significantly correlated with AHI only in Groups II and III. **Conclusion.** In addition to AHI, known as the main diagnostic parameter for OSA, ODI, average oxygen saturation, and BMI play a significant role in assessing apnea. With its strong correlation with AHI, as well as predictive value for more severe forms of apnea, ODI has the same importance as AHI in diagnosing and assessing the severity of this disorder.

Key words:
body mass index; oxygen saturation; prognosis; sleep apnea, obstructive.

Apstrakt

Uvod/Cilj. Opstruktivni poremećaj disanja tokom spavanja (*obstructive sleep apnea* – OSA) uključuje niz stanja koja se manifestuju raznim oblicima poremećaja disanja sa povremenim potpunim prekidima disanja, uzrokovanim opstrukcijom u gornjim disajnim putevima. Poremećaj je češći kod odraslih muškaraca, a gojaznost je značajan predisponirajući faktor. Indeks apneja-hipopneja (*apnea-hypopnea index* – AHI) glavni je dijagnostički kriterijum, koji govori o učestalosti i trajanju apneičnih faza. Osim AHI, i drugi parametri, kao što su indeks desaturacije kiseonikom (*oxygen desaturation index* – ODI), prosečno zasićenje (saturacija) kiseonikom (SK) i indeks telesne mase (ITM), mogu imati dijagnostičku vrednost. Cilj rada bio je da se ispita korelacija između AHI i ODI, AHI i prosečne SK kao i AHI i ITM. **Metode**. Retrospektivnom studijom obuhvaćeno je 200 bolesnika, 166 muškaraca i 34 žena, starosti između 18 i 65 godina, kod kojih je respiratornom poligrafijom dokazano postojanje OSA. U zavisnosti od vrednosti AHI, bolesnici su podeljeni u tri grupe: grupa I (AHI 5–15 prekida disanja na sat), grupa II (AHI 15–30 prekida disanja na sat) i grupa III (AHI > 30 prekida disanja na sat). **Rezultati.** Utvrđena je značajna korelacija između AHI i ODI u svim grupama, a najizrazitija korelacija ispoljena je u grupi III, gde je ODI imao i prediktivnu

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vrednost za teške oblike apneje. Prosečna SK i ITM bili su u značajnoj korelaciji sa AHI samo u grupama II i III. **Zaključak.** Pored AHI, koji je poznat kao glavni dijagnostički parametar za OSA, značajnu ulogu u proceni apneje imaju ODI, prosečna SK i ITM. Snažnom korelacijom sa AHI, kao i prediktivnom vrednošću za teže oblike apneje, ODI ima jednak značaj kao AHI u dijagnostikovanju i proceni težine tog poremećaja.

Ključne reči:
telesna masa, indeks; kiseonik, zasićenost; prognoza; apneja u snu, opstruktivna.

Introduction

Obstructive sleep apnea (OSA) encompasses a range of conditions, from simple snoring to hypoventilation and apnea. Even though sleep breathing disorders (SBD) were identified much earlier, the first studies in this field began in the 1970s [1]. Depending on the pathophysiological cause and clinical manifestations, central, obstructive, and mixed types of apnea are distinguished. Although today this disorder is diagnosed in 6% of men and 4% of women, the prevalence in the general adult population is estimated to be significantly higher, ranging from 9% to 38% [2, 3].

In terms of frequency, the most common clinical form of apnea is OSA, which constitutes 90–95% of all breathing disorders during sleep [4].

OSA is a condition characterized by repeated episodes of partial or complete cessation of breathing during sleep. These episodes cause a series of adverse effects on the respiratory, digestive, cardiovascular, nervous, and endocrine systems. OSA occurs due to relaxation of the throat muscles during sleep, leading to a reduction or cessation of airflow through the upper airways [5].

Despite the epidemiological data mentioned, the number of diagnosed and confirmed cases of OSA is significantly lower. It is estimated that 75% of people with SBD with suspected sleep apnea remain undiagnosed for various reasons [6].

OSA is confirmed by using polysomnography (PSG), which represents the "gold standard" for diagnosing this disorder. Depending on the number of registered signals, there are various levels of testing. Limited PSG, or respiratory polygraphy (RP), is a level III diagnostic method that is simpler, more accessible, and sufficient for accurately recording obstructive SBD [7].

Episodes of hypopnea and apnea in OSA last from 10 to even 60 seconds or more. It is said that individuals with more than 5 hypopnea/apnea episodes *per* hour have sleep apnea, which is determined using the apnea-hypopnea (AH) index – AHI. In severe forms of OSA, AHI can be as high as 100 episodes *per* hour (100/hr) [8].

OSA is significantly associated with excessive body weight, which is an independent risk factor for this disorder. When talking about the impact of obesity, it primarily refers to central obesity and obesity characterized by an increased body mass index (BMI) [9].

In addition to obesity, tongue hypertrophy, short lower jaw, and short neck represent key risk factors for upper airway collapse in OSA.

Upper airway obstruction in OSA causes several critical pathophysiological conditions, such as decreased blood oxygen saturation, increased carbon dioxide concentration, changes in intrathoracic pressure, and increased sympathetic activity.

The main disorder in OSA is intermittent hypoxia, which triggers a cascade of events responsible for worsening cardiovascular diseases [10]. By using PSG and RP, we obtained information about the frequency and duration of AH episodes (AHI) while learning about the severity of the respiratory disorder caused by these episodes from the oxygen saturation or oxygen desaturation index (ODI).

ODI is defined as the average number of desaturation episodes *per* recording hour, where blood oxygen saturation is decreased by at least 3% from the basal value [11].

Given the facts stated, there is a need to consider other parameters that will indicate a disorder in oxygenation levels or hypoxemia caused by OSA.

The aim of the study was to examine the relationship between AHI and ODI, AHI and average oxygen saturation, and AHI and BMI in individuals with OSA.

Methods

Our retrospective study included 200 patients, 18 to 65 years old. Among those patients, 166 were male and 34 were female, with OSA diagnosed by RP. All patients predominantly had OSA and an AHI greater than 5/hr. In all patients, ODI, AHI, BMI, and average blood oxygen saturation, expressed in percentages, were measured during an overnight RP. Depending on the AHI, patients were classified into three groups: Group I (AHI 5–15/hr), Group II (AHI 15–30/hr), and Group III (AHI more than 30/hr). ODI was considered significant if desaturation was > 3% from the basal value. Descriptive methods expressed through frequency and percentage were used to present demographic and anthropometric data.

The relationship between AHI and ODI, AHI and BMI, and AHI and average saturation was analyzed using Spearman and Pearson correlation coefficients. Receiver operating characteristic (ROC) curves were used to determine the existence of threshold values (cut-offs) between the given parameters.

Results

The study included 200 subjects, 166 men and 34 women. Group I consisted of 57 respondents, Group II of 52 respondents, and Group III of 91 respondents. The average age for men was 52.15 years, and for women, it was 52.75 years. The results of the study showed that in the first group of subjects, only ODI showed a statistically significant correlation with AHI ($p < 0.05$, $r = 0.320$), while the other parameters

were not significantly correlated. In the second group, only ODI maintained a statistically significant positive correlation with AHI, which was stronger than in the previous group (p = 0.01, r = 0.453). In the last group, the third one, ODI showed a strong, positive correlation with AHI (p < 0.01, r = 0.842) (Figure 1).

In this group, which had the highest AHI, average oxygen saturation showed a statistically significant negative correlation with AHI (p < 0.01, r = 0.375, n = 91) (Figure 2). In contrast, BMI showed a statistically significant positive correlation with AHI (p < 0.01, r = 0.470, n = 91) (Figure 3).

Further analysis revealed that ODI has a predictive value for AHI in the group with AHI > 30/hr, a determined cut-off value ≥ 21, and a sensitivity of 92% and specificity of 88% (Figure 4).

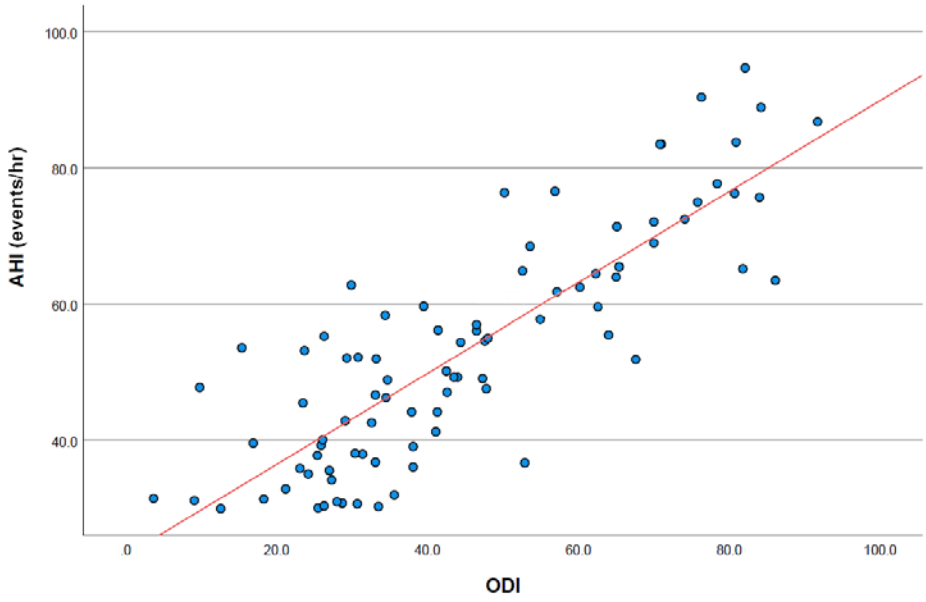

Fig. 1 – Correlation between AHI greater than 30/hr and ODI in patients with OSA (p < 0.01, r = 0.842, n = 91). AHI – apnea-hypopnea index; ODI – oxygen desaturation index; OSA – obstructive sleep apnea; n – number of respondents. Note: on the abscissa, ODI represents the number of times desaturation events occur *per* hour of sleep.

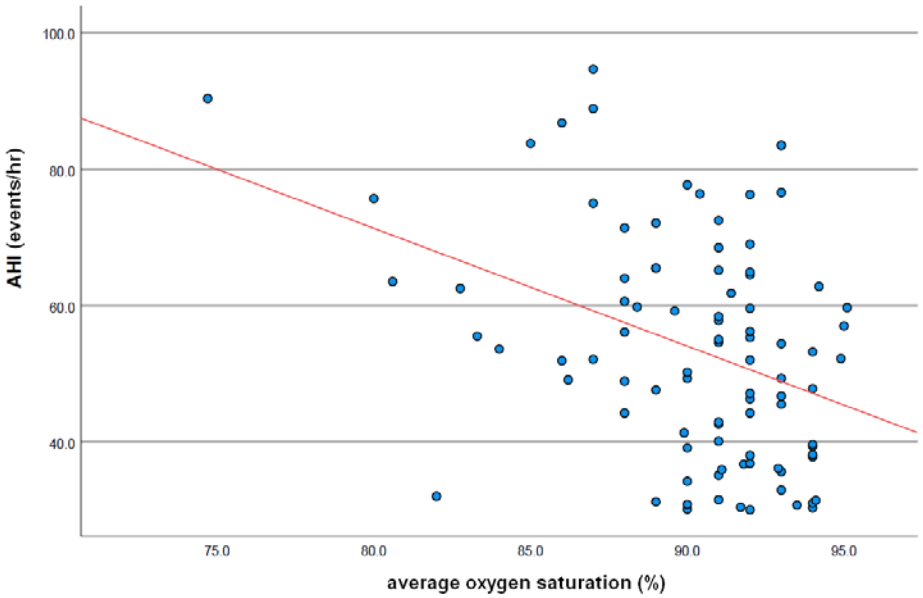

Fig. 2 – Correlation between AHI greater than 30/hr and average oxygen saturation in patients with OSA (p < 0.01, r = 0.375, n = 91). For abbreviations, see Figure 1.

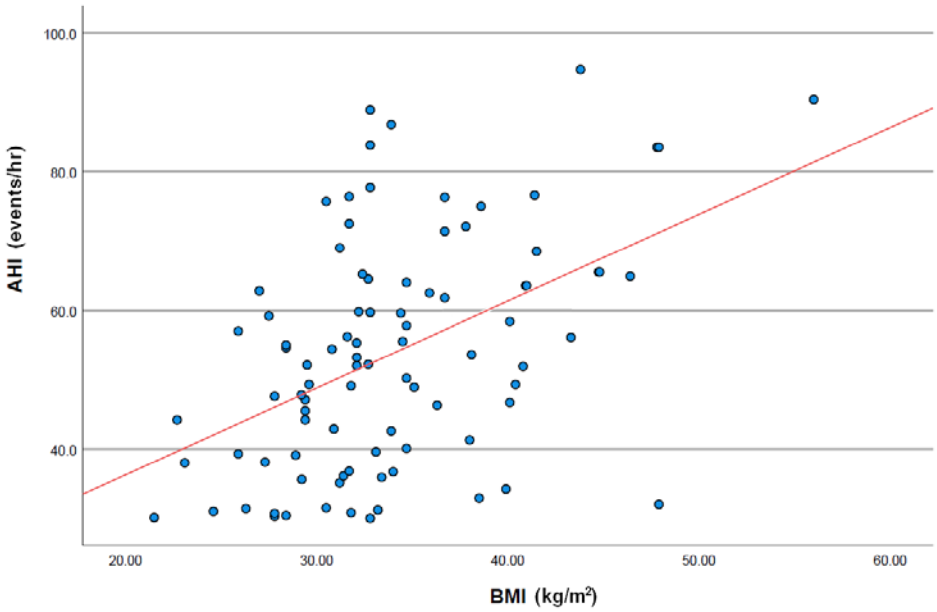

Fig. 3 – Correlation between AHI greater than 30/hr and BMI in patients with OSA ($p < 0.01$, $r = 0.470$, n = 91).
BMI – body mass index.
For other abbreviations, see Figure 1.

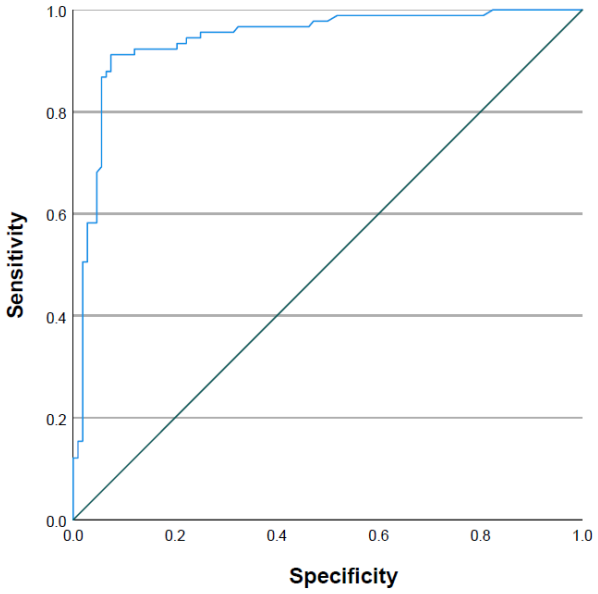

Fig. 4 – Cut-off value for ODI in the group with AHI > 30/hr
For abbreviations, see Figure 1.

Discussion

Previous studies have shown that the harmful effects of OSA were more pronounced in individuals who had a more severe form of this disorder, i.e., where AHI was greater than 15/hr or 30/hr. In recent years, the number of newly revealed patients with severe forms of the disease has been steadily increasing. Recent data indicate that over 400 million people worldwide between 30 and 70 years of age with OSA have a moderate to severe form of the disease [12]. Although blood oxygenation disorders are more pronounced in severe forms of apnea with higher AHI, this parameter does not provide enough information to indicate how OSA causes harmful effects on systems and organs. Chronic intermittent hypoxia, interrupted sleep, and initiation of inflammation are the main pathophysiological mechanisms in OSA [13]. These conditions are also associated with the appearance of cognitive and neurological symptoms such as reduced attention, poor concentration, irritability, anxiety, and depression [14].

In our study, we examined the correlation between AHI and ODI, AHI and average oxygen saturation, and AHI and BMI in patients with OSA. Among the 200 subjects in our study, we found a statistically significant positive correlation between AHI and ODI, as well as between AHI and BMI. On the other hand, we found a negative correlation between AHI and average oxygen saturation. When we analyzed the correlation of these parameters by groups that we formed according to the AHI amount, we found that in groups with AHI from 5–15/hr and 15–30/hr, only ODI showed a significant positive correlation, while average oxygen saturation and BMI did not significantly correlate with AHI. Since the groups in question had mild and moderate forms of the disorder, the results we obtained were expected. After all, the results are in accordance with the authors' previous study [8].

Unlike the previous groups, a significant positive correlation was observed in the group with AHI greater than 30/hr between AHI and ODI, as well as between AHI and BMI. In contrast, a significant negative correlation was found between AHI and average oxygen saturation, which is in line with basic pathophysiological mechanisms.

In addition, Temirbekov et al. [15] indicated the importance of the parameters we examined and their mutual correlation. They found that hypoxia during the apnea period is closely related to oxygen desaturation and suggested that ODI has the same value as AHI in diagnosing and evaluating OSA syndrome.

Further analysis revealed that ODI in the group AHI > 30/hr also has predictive value for assessing the severity of apnea, indicating that this parameter can have the same role as AHI. The diagnostic predictive significance of ODI has also been suggested in papers by Chung et al. [8], whose conclusions were confirmed in our research.

In addition to ODI indicating hypoxia during apnea or the severity of this disorder, studies have shown that this parameter also plays a role as a predictor of the success of other therapeutic procedures in the treatment of OSA [16]. This primarily refers to surgical methods such as uvulopalatopharyngoplasty or velopharyngoplasty. In this sense, Davanian et al. [17] found in their research that the degree of desaturation has a more accurate prognostic value than AHI in individuals who are candidates for surgical treatment methods.

The facts about ODI indicate that this parameter is gaining increasing importance, both in the diagnosis and assessment of the severity of obstructive apnea and in choosing an appropriate therapeutic approach to OSA.

Conclusion

As the most significant parameter in individuals with obstructive sleep apnea, the apnea-hypopnea index positively correlates with oxygen desaturation index and body constitution, expressed through body mass index or obesity. The apnea-hypopnea index is in a significant negative correlation with average oxygen saturation, because a higher apnea-hypopnea index, i.e., a more severe form of obstructive sleep apnea, causes lower saturation. In severe forms of obstructive sleep apnea characterized by an apnea-hypopnea index greater than 30/hr, in addition to a strong positive correlation, the oxygen desaturation index also has predictive significance for the apnea-hypopnea index. This study provides valuable insights, but the gender balance limitations of the sample indicate the need for additional research with more balanced samples.

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