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The Impact of Age, Gender and Body Mass Index on the Polysomnography Variables

Yaş, Cinsiyet ve Vücut Kitle İndeksinin Polisomnografideki Değişkenlere Etkisi

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Abstract

Objective: This study aimed to analyse respiratory parameters in polysomnography, mean nocturnal pulse oxyhaemoglobin saturation (mean nocturnal SpO_2), minimum SpO_2, total sleep time with <90% oxyhaemoglobin saturation (TST90), Oxygen Desaturation index (ODI), apnoea duration, Sleep Arousal index in obstructive sleep apnoea (OSA) and their relationship with Apnoea-hypopnea index (AHI), Body Mass index (BMI), age and gender.

Materials and Methods: A total of 1.000 patients diagnosed with OSA using polysomnography between January 2018 and January 2019 were investigated retrospectively. All subjects underwent one night of laboratory-based polysomnography and were then classified in the polysomnography report as mild, moderate or severe OSA according to the AHI values.

Results: A significant relationship between AHI and BMI, the male gender and age ($p<0.01$) was noted. A strong negative correlation between mean nocturnal SpO_2 and TST90 was also recorded. In all the oxymetric parameters, ODI was found to have a strong relationship with AHI. To distinguish between patients with and without apnoea, the mean nocturnal SpO_2 cut-off point was found to be 93.6%.

Conclusion: A unit increase of BMI increases the OSA risk by 1.5 times and being male increases OSA risk by 7.6 times. Ageing is also associated with higher AHI. A mean nocturnal oxygen saturation of <93.6% is important in detecting apnoea in patients.

Keywords: Obstructive sleep apnoea, polysomnography, Body Mass index, males, oxygen

Öz

Amaç: Bu çalışmanın amacı, polisomnografideki solunum parametrelerini (ortalama noktürnal nabız oksihemoglobin satürasyonu (SpO_2), minimum SpO_2, toplam uyku süresinde %90 altında oksihemoglobin satürasyonu (TST90), Oksijen Desatürasyon indeksi (ODİ), apne süresi, Uyku Uyarılma indeksi) analiz ederek bu parametrelerin Apne-hipopne indeksi (AHİ), Vücut Kitle indeksi (VKİ), yaş ve cinsiyet ile ilişkisini araştırmaktır.

Gereç ve Yöntem: Ocak 2019 ve Ocak 2019 tarihleri arasında polisomnografi ile tanı alan 1,000 obstrüktif uyku apnesi (OUA) hastası retrospektif olarak incelendi. Tüm hastalara bir gece laboratuvar temelli polisomnografi yapıldı. Polisomnografi raporunda hastalar AHİ değerlerine göre hafif, orta ve şiddetli OUA olarak sınıflandırıldı.

Bulgular: AHİ ve VKİ, erkek cinsiyet ve yaş arasında anlamlı bir ilişki vardı ($p<0,01$). Ortalama noktürnal SpO_2 ve TST90 arasında güçlü bir negatif korelasyon vardı. Tüm oksimetrik parametreler içinde ODİ'nin AHİ ile güçlü bir ilişkisi olduğu bulunmuştur. Apnesi olan hastaları apne olmayan hastalardan ayırmak için ortalama noktürnal SpO_2 değeri için kesim (cut-off) noktası %93,6 olarak bulundu.

Sonuç: VKİ'nin 1 birim artışı obstrüktif uyku apne riskini 1,5 kat artırır, erkek olmak OSA riskini 7,6 kat artırır. Yaşlanma yüksek AHİ ile ilişkilidir. Polisomnografi için başvuranlarda ortalama noktürnal oksijen satürasyonunun %93,6'sının altında olması apne hastalarını saptamada önemlidir.

Anahtar Kelimeler: Obstrüktif uyku apnesi, polisomnografi, Vücut Kitle indeksi, erkekler, oksijen

Introduction

Obstructive sleep apnea (OSA) is a disorder that is characterized by obstructive apneas, hypopneas, and/or respiratory effort-related arousals caused by repetitive collapse of the upper airway during sleep. OSA is the most common sleep-related breathing disorder.

OSA has a prevalence of no less than 2-4% of adults and is therefore frequently seen (1). 3.1-7.5% of men, and 2.1-4.5% of women have the disorder according to a number of epidemiological studies (2-8). Respiration ceases periodically during sleeping, leading to the signs and symptoms of the disorder and accounting for its sequelae, e.g. a heightened risk profile for circulatory disease. There are associations between OSA and numerous other conditions, such as high blood pressure, diabetes mellitus, obesity, gastroesophageal reflux,

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impotence, depression, and elevated levels of cardiovascular and cerebrovascular morbidity and mortality (9). Likewise in the study of Senel et al. (10) it was seen that metabolic syndrome components were clustered in OSA patients, therefore they should be followed closely and given high priority. Consequently, suspecting and diagnosing OSA is a key clinical imperative.

OSA prevalence appears to be increasing and may relate to the increasing rates of obesity or the increased detection rates of OSA. OSA severity varies with age, gender, and upper airway area (11). However, when we look at the literature the change in risk is variable. On the other hand, the prognosis for OSA could be improved by evaluating the major factors affecting OSA and treating OSA patients according to epidemiological characteristics and anatomical structures, but in our country the sleep medicine area is new and the studies with large patient populations from our country are few in number. The development of new techniques can provide additional data, but it is important to carefully analyze and apply the data to make an accurate diagnosis and plan the most effective treatment of the disease.

We aim to study 1.000 patients from our country investigating the risk factors of OSA and how much they add to the severity of the disease, analyze the respiratory parameters in the polysomnography (mean nocturnal pulse oxyhemoglobin saturation (mean nocturnal SpO_2), minimum SpO_2, total sleep time with oxyhemoglobin saturation <90% (TST90), Oxygen Desaturation index (ODI), apnea duration, and the Sleep Arousal index in OSA and their relationship with AHI, BMI, age and gender. We also we wanted to analyze all of the parameters to find one that could enable clinicians to predict OSA in patients admitted for polysomnography. In order to form a prediction model to screen patients who have high risk of OSA, we used cut-off values for patients with an AHI below 5 and patients with an AHI over 5. This predictive information relating SpO_2 to AHI could be used for screening or home-based testing of patients with complaints related to sleep disordered breathing or in phenotyping OSA.

Materials and Methods

Thousand OSA patients diagnosed with polysomnography between January 2018 and January 2019 were investigated retrospectively in this study. All the patients with a clinical indication for OSA were recruited. The study was approved by the local ethic commission. All subjects underwent one night of laboratory based polysomnography. All the recordings were made on a Grass-Comet Plus polysomnograph. The patients were classified according to the Apnea-hypopnea index (AHI) values in the polysomnography report. In accordance with the World Health Organization classification of OSA, patients with AHI<5 were considered as no/minimal OSA, AHI=5-15 as mild OSA, patients with AHI=16-30 as moderate OSA and patients with AH>30 were classed as severe OSA (12). The BMI of the patients were classified as BMI<18.5 kg/m^2 as underweight, 18.5-24.9 kg/m^2 as normal weight, 25-29.9 kg/m^2 as overweight, 30-34.9 kg/m^2 as 1st degree obese, 35-39.9 kg/m^2 as 2nd degree obese, and a BMI>40 kg/m^2 as 3rd degree obese. The ages of the patients were classified as 0-18, 18-65 and 65 and above.

Statistical Analysis

SPSS version 21 and Medicalc 19.1.3 packet programmes were used for the data analysis. Normality control of continuous variables were performed by the Shapiro Wilk test. Parametric methods were used since the variables were compatible with normal distribution. Student's t-test was used for the comparison of the mean of two independent groups, One-Way Analysis of Variance and the Tukey post-hoc tests were used for comparison of the mean of two groups. Pearson correlation coefficients were calculated in the linear relationship between two continuous variables. The effects of BMI, age and gender on AHI and mean nocturnal SpO_2 were examined with univariate and multiple linear regression analysis. ROC analysis was used to determine mean nocturnal SpO_2 cut-off point for AHI<5 and AHI≥5 patients. The statistical significance level was taken as 0.05.

Results

Two hundred thirty seven female and 763 male patients participated in the study and the mean age of the patients was 45.17±11.91. The demographic distribution of the patients are given in Table 1. The mean values of AHI, mean nocturnal SpO_2, minimum SpO_2, ODI, TST90, apnea duration and sleep arousal index are given in Table 2.

There was a statistically significant difference between AHI and mean nocturnal SpO_2 values of underweight, normal, overweight, 1st, 2nd and 3rd degree obese groups ($p<0.001$). The p values of the differences between the groups (pairwise comparison) are given in Table 3. There was a statistically significant difference between AHI and the mean nocturnal SpO_2 values of age groups 0-18, 18-65 and 65 and above ($p<0.001$) (Table 4). There was a significant difference between

Table 1. The demographic distribution of patients

	Mean ± SD n (%)	Min-max
Age	45.17±11.91	5-80
0-18	12 (1.2%)	-
18-65	953 (95.3%)	-
65 and above	35 (3.5%)	-
Gender		
Female	237 (23.7%)	-
Male	763 (76.3%)	-
BMI	28.98±5.04	17.3-58
Underweight	3 (0.3%)	-
Normal	188 (18.8%)	-
Overweight	426 (42.6%)	-
1st degree obese	260 (26.0%)	-
2nd degree obese	84 (8.4%)	-
3rd degree obese	39 (3.9%)	-

SD: Standard deviation, BMI: Body Mass index

males and females in terms of AHI (p<0.001), but this difference was not observed in mean nocturnal SpO_2 (Table 5). According to OSA classification of patients, there was a statistically significant difference between the mean nocturnal SpO_2, apnea duration and sleep arousal index values of simple snoring, and mild, moderate and severe OSAS patients (p<0.001) (Table 6). There was a very weak positive linear relationship between age and AHI, ODI and SAT90. There was a weak negative linear relation between age, SpO_2, and minimum SpO_2. We did not find a direct relationship with age and apnea duration or arousal. We found a weak positive linear relationship between BMI, AHI and ODI. There was a weak positive linear relationship between BMI and SaO_2, minimum SaO_2, and apnea duration. We did not find a linear correlation between BMI and arousal (Table 7).

In the univariate analysis, BMI, age and gender were effective on SpO_2 but when evaluated together considering their combined interactions it was seen in multiple linear regression analysis that they were all effective on SpO_2.

In univariate analysis, 1 unit increase in BMI lead to an increase of 1.538 units in AHI. One unit increase of age caused an increase of 0.404 units in AHI. Being male caused an increase of 7.571 units in AHI. In multiple analysis, while one unit of BMI and age caused a 1.467 and 0.378 units increase, respectively, being male caused an increase of 9.949 units (Table 8).

In the univariate analysis, 1 unit increase in AHI lead to a 1.147 units decrease in the mean nocturnal SpO_2. Also 1 unit decrease in age caused a 0.05 decrease in the mean nocturnal SpO_2.

Table 2. Mean values of AHI, mean nocturnal SpO_2, minimum SpO_2, ODI, TST90, apnea duration and Sleep Arousal index

	Mean ± SD n (%)	Min-max
AHI	28.22±25.97	0.1-128.2
Mean nocturnal SpO_2	93.42±2.65	66.8-98.3
Minimum SpO_2	78.96±9.29	50-95
ODI	13.27±17.63	0-165.7
TST90	13.64±20.46	0-99.5
Apnea duration	23.78±8.05	0-60
Sleep Arousal index	0.53±1.52	0-29

SD: Standard deviation, AHI: Apnoea-hypopnea index, ODI: Oxygen Desaturation index

Table 3. AHI and mean nocturnal SpO_2 values of underweight, normal, overweight, 1st, 2nd and 3rd degree obese groups and pairwise comparisons

BMI	Underweight	Normal	Overweight	1st degree obese	2nd degree obese	3rd degree obese		
	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	p	Pairwise comparison
AHI	30.73±25.67 (1.7-50.4)	15.58±18.61 (0.1-89.2)	25.23±23.40 (0.1-104.8)	35.28±26.68 (0.2-110.1)	45.34±30.91 (0.4-128.2)	37.57±30.92 (0.7-105.6)	<0.001	2-3 (p<0.001) 2-4 (p<0.001) 2-5 (p<0.001) 2-6 (p<0.001) 3-4 (p<0.001) 3-5 (p<0.001) 3-6 (p=0.033) 4-5 (p=0.014)
Mean nocturnal SpO_2	94.23±1.77 (92.2-95.4)	94.30±2.20 (76.8-98.3)	93.74±2.14 (79.1-97.9)	92.88±3.16 (66.8-98.2)	92.11±2.39 (85.2-97.9)	91.97±4.05 (74.7-95.8)	<0.001	2-4 (p<0.001) 2-5 (p<0.001) 2-6 (p<0.001) 3-4 (p<0.001) 3-5 (p<0.001) 3-6 (p=0.001)

SD: Standard deviation, AHI: Apnoea-hypopnea index, BMI: Body Mass index

Table 4. AHI and the mean nocturnal SpO_2 values of age groups 0-18, 18-65 and 65 and above

Age	0-18	18-65	65 and above		
	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	p	Pairwise comparison
AHI	7.10±13.43 (0.2-48.8)	28.28±26.09 (0.1-128.2)	33.81±22.55 (1.3-74.4)	0.008	1-2 (p=0.014) 1-3 (p=0.006)
SaO_2	96.34±1.20 (93.8-97.6)	93.43±2.66 (66.8-98.3)	92.13±1.87 (86.9-94.7)	<0.001	1-2 (p<0.001) 1-3 (p<0.001) 2-3 (p=0.012)

SD: Standard deviation, AHI: Apnoea-hypopnea index

There was no significant difference in being male in terms of mean nocturnal SpO_2 (Table 8).

When we calculated the relationships between the polysomnography parameters with the pearson correlation coefficient analysis, we found a negative strong linear correlation between mean nocturnal SpO_2 and the TST90 (r=0.836, p<0.001). There was also a positive strong linear relationship between AHI and ODI (r=0.781, p<0.001) (Table 9).

Table 5. AHI and mean nocturnal SpO_2 values of males and females

	Male	Female	
	Mean ± SD (min-max)	Mean ± SD (min-max)	p
AHI	30.01±26.48 (0.1-128.2)	22.44±23.39 (0.1-103.2)	<0.001
Mean nocturnal SpO_2	93.38±2.56 (66.8-98.2)	93.55±2.93 (74.7-98.3)	0.391

Student's t-test, SD: Standard deviation, AHI: Apnoea-hypopnea index

Table 6. The mean nocturnal SpO_2, apnea duration and sleep arousal index values of simple snoring, mild, moderate and severe OSAS patients

OSA	No/minimal	Mild	Moderate	Severe		
	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	p	Pairwise comparison
Mean nocturnal SpO_2	94.65±1.67 (88.6-98.3)	94.16±1.82 (86.3-98.2)	93.82±1.69 (85-97.6)	92.05±3.29 (66.8-97)	<0.001	1-3 (p=0.005) 1-4 (p<0.001) 2-4 (p<0.001)
Apnea duration	23.73±11.66 (0-60)	21.08±6.17 (0-48.9)	22.98±7.22 (0-42.4)	26.12±6.52 (12.6-58.3)	<0.001	1-2 (p=0.002) 1-3 (p=0.003) 2-4 (p<0.001) 3-4 (p<0.001)
Sleep Arousal index	0.20±0.56 (0-3.9)	0.41±0.99 (0-6.6)	0.42±0.96 (0-6)	0.86±2.19 (0-29)	<0.001	1-4 (p<0.001) 2-4 (p<0.001) 3-4 (p<0.001)

SD: Standard deviation, OSA: Obstructive sleep apnea

Table 7. The linear relations of age and BMI with AHI, SpO_2, minimum SpO_2, apnea duration and arousal

		AHI	SpO_2	Minimum SpO_2	ODI	SAT 90	Apnea duration	Arousal
Age	r	0.185	-0.226	-0.205	0.135	0.155	-0.007	0.056
	p	<0.001	<0.001	<0.001	<0.001	<0.001	0.832	0.078
BMI	r	0.298	-0.279	-0.241	0.265	0.254	-0.117	0.024
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.450

Pearson Correlation Coefficient, BMI: Body Mass index, AHI: Apnoea-hypopnea index, ODI: Oxygen Desaturation index

Table 8. The univariate and multipl linear regression analysis of AHI, SpO_2, BMI, age and gender

	Univariate			Multiple		
	B	p	R^2	B	p	R^2
AHI						
BMI	1.538	<0.001	0.089	1.467	<0.001	0.136
Age	0.404	<0.001	0.034	0.378	<0.001	
Gender (male)	7.571	<0.001	0.015	9.494	<0.001	
SpO_2						
BMI	-0.147	0.016	0.078	-0.136	<0.001	-
Age	-0.050	0.007	0.051	-0.046	<0.001	0.120
Gender (male)	-0.169	0.391	0.001	-0.386	0.039	-

p: Linear regression, dependent variable in model 1: AHI, dependent variable in model2: SpO_2, BMI: Body Mass index, AHI: Apnoea-hypopnea index

According to AHI classification there was a statistically significant difference between the mean nocturnal SpO_2 of AHI<5 and AHI≥5 (p<0.001) (Table 10). To detect the cut-off point we analyzed the data by using ROC analysis. The cut-off point of mean nocturnal SpO_2 was determined as 93.6 to distinguish apneic and non-apneic patients (p<0.001) (Table 11). According to this value, SpO_2's success in distinguishing those with snoring (mild, moderate and severe) was 52.35%, and the normal separation success rate was 77.08% (Figure 1).

Discussion

When we look at the literature, several clinical risk factors are associated with OSA; including age, the male gender and BMI. However, how much these factors effect OSA risk is not clear. The prevalence of OSA increases from young adulthood through the sixth to seventh decade, then it appears to plateau (13). 95.3% of our patients were between 18-65 years of age. There was a statistically significant difference between AHI and age. In addition, there was a significant difference between the mean nocturnal SpO_2 and age, but this was a weak negative linear relationship (r=-0.226, p<0.001).

According to Fietze et al.'s (14) study, the prevalence of OSA increases with age for both men and women, but women are diagnosed with OSA at a later age than men. Also Fietze et al. (14) reported that gender, age, Body Mass index (BMI), waist-to-hip ratio, snoring, alcohol consumption (for women only) and cardiovascular diseases were positively associated with obstructive sleep apnea, but daytime sleepiness was not. Diabetes, hypertension and metabolic syndrome were positively associated with severe OSA. According to their study the clinical values of the female population was more strongly associated with OSA than in men. In their study, half of the patients had OSA, which was a very high prevalence. Furthermore, the OSA increase with age and presence of comorbid cardiovascular disease, was found to increase the mortality rate (14). Moreover, Hongyo et al.'s (15) findings suggest that the severity of OSA increase with age. Hongyo et al. (15) also reported that in the elderly patient group, male gender, BMI and age were independent risk factors of severe OSA.

The study of Bostanci et al. (16) provides evidence that elderly patients exhibit more severe and deeper nocturnal intermittent hypoxia than younger adults; independent of the severity of OSA, BMI, gender, and neck circumference. Hypoxia-related polysomnographic variables in geriatric patients may in fact reflect a physiological aging process rather than the severity of sleep disordered breathing (16).

Table 9. The relation of SpO_2, minimum SpO_2, ODI, SAT 90, apnea duration, arousal with AHI and SpO_2

		AHI	SpO_2
SpO_2	r	-0.470	-
	p	<0.001	-
Minimum SpO_2	r	-0.482	0.566
	p	<0.001	<0.001
ODI	r	0.781	-0.533
	p	<0.001	<0.001
SAT90	r	0.537	-0.836
	p	<0.001	<0.001
Apne duration	r	0.198	-0.108
	p	<0.001	0.001
Arousal	r	0.170	-0.087
	p	<0.001	0.006

Pearson correlation coefficient, AHI: Apnoea-hypopnea index, ODI: Oxygen Desaturation index

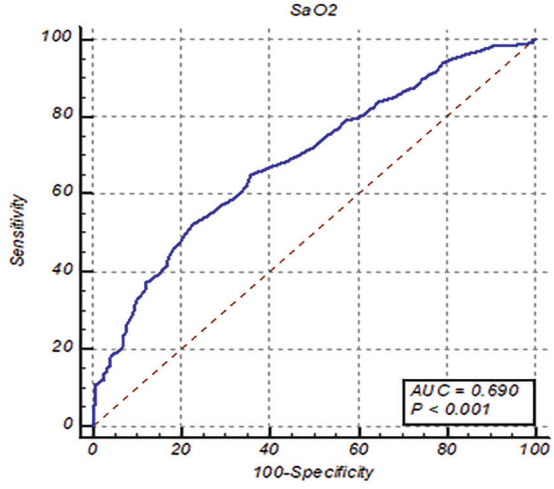

Figure 1. SpO_2's performance to detect mild, moderate and severe apnea patients

AUC: Area under the curve

Table 10. The comparison of SpO_2 values of AHI<5 and AHI ≥5 groups

	AHI<5 (n=192)		AHI≥5 (n=808)		
	Mean ± SD	Min-max	Mean ± SD	Min-max	p
SpO_2	93.13±2.76	66.8-98.2	94.66±1.67	88.6-98.3	<0.001

Student's t-test, SD: Standard deviation, AHI: Apnoea-hypopnea index

Table 11. ROC analysis to determine cut-off point of the mean nocturnal SpO_2

AUC (95% CI)	Cut-off	Sensitivity (95% CI)	Specificity (95% CI)	p
0.690 (0.660-0.718)	≤93.6	52.35 (48.8-55.8)	77.08 (70.5-82.8)	<0.001

ROC analysis AUC: Area under the curve, CI: Confidence interval

OSA is approximately two to three times more common in males than females, although the risk appears to be similar once women are postmenopausal (17). In our study, 76.3% of our patients were male, approximately three times more than females. Being male causes an increase of 7.71 units in AHI.

The risk of OSA correlates well with BMI. In one study, a 10% increase in weight was associated with a six-fold increase in the risk of OSA (14). In another study, moderate to severe OSA (AHI≥15) was present in 11% of men who were normal weight, in 21% who were overweight (BMI: 25 to 30 kg/m^2), and in 63% of those who were obese (BMI>30 kg/m^2) (18). Similarly, in women, OSA was present in 3% of patients who were normal weight, in 9% who were overweight, and in 22% who were obese (19). In our study 42.6% of OSA patients were overweight and 26% of the patients had 1st degree obesity. According to our study, 1 unit increase in BMI leads to an increase of 1.538 units in AHI. There was a statistically significant difference between AHI and BMI, and also between mean nocturnal SpO_2 and BMI.

According to the OSA classification of patients, there was a statistically significant difference between the mean nocturnal SpO_2, apnea duration and Sleep Arousal index values of simple snoring, mild, moderate and severe OSA patients (20). Kwubara suggests that the severity and frequency of decrease in SpO_2 would be important indicators in identifying high-risk patients who are likely to develop cardiovascular events, specifically during sleep (21).

The study results of Bostanci et al. (22) provides supporting evidence that patients with similar AHI may have different ST90 values, which is the duration of hypoxia. Bostanci et al. (22) reports that the evaluation of OSA patients with both AHI and ST90 values together, gives more information about the prognosis of the patient. There was a strong negative correlation between mean nocturnal SpO_2 and ST90 in this study also.

According to Xu et al. (23) in severe OSA, nocturnal and awake blood pressures are associated more with the hypoxic duration than with AHI. Nocturnal blood pressure fluctuation can be induced by hypoxia and arousal, especially by the hypoxia (23). The effect of sleep fragmentation on sympathetic discharge during wakefulness could contribute to intersubjective variability, age-related increases in muscle sympathetic nerve activity, associations between sleep deprivation and insulin resistance or insomnia and future cardiovascular events. Poor sleep behaviors have been found to be associated with metabolic dysfunction (21). Also the parameters from PSG or overnight oximetry such as AHI, ODI, ST90, mean and minimal SpO_2, and longest apnea duration can be associated with postoperative complications, and may provide additional value in risk stratification and minimization (24).

Study Limitations

Being a retrospective study from a single center and the lack of data are the limitations of study. Also, except from BMI, the absence of important anthropometric measures such as neck circumference or waist-hip ratio measurements, are other limitations. Prospective multicenter studies with more data will help to reveal cause-effect relationships more clearly.

Conclusion

There is a significant relationship between AHI and BMI, the male gender and age. One unit increase of BMI increases the OSA risk by 1.5 times, and being male increases OSA risk 7.6 times. In all the oxymetric parameters of PSG, ODI was found to have a strong relationship with AHI. The mean nocturnal SpO_2 cut-off point was found to be 93.6%, and this cut-off value can be used to distinguish apneic patients from non-apneic. Further studies are necessary for the general applicability of our results.

Ethics

Ethics Committee Approval: The study was approved by the local ethic commission (date: 18.12.2019, no: 642).
Informed Consent: Informed consent was obtained.
Peer-review: Internally peer-reviewed.
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