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Original Article

Importance of Anthropometric Measurements to Determine Cardiometabolic Diseases in Obstructive Sleep Apnea Syndrome

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Abstract

OBJECTIVE: Obesity is considered a major risk factor for obstructive sleep apnea syndrome (OSAS). This study aimed to examine the correlation between anthropometric measurements, which have been recently defined and are indicative of abdominal obesity and cardiometabolic diseases, OSAS severity, and polysomnography (PSG) parameters in patients with OSAS.

MATERIAL AND METHODS: This retrospective cohort study included patients who underwent all-night polysomnography with a prediagnosis of OSAS. These patients were categorized as having mild (5-15), moderate (15-30), and severe (>30) OSAS according to the apnea-hypopnea index (AHI). The anthropometric measurements used in the study consisted of waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), (waist/hip)-to-height ratio (WHHR), a body shape index (ABSI), body adiposity index (BAI), abdominal volume index (AVI), and conicity index (CI).

RESULTS: A total of 410 individuals were enrolled in the study (31 control subjects and 129 with mild, 101 with moderate, and 149 with severe OSAS). A significant difference was observed between groups in terms of all anthropometric measurements ($p<0.05$). The difference between the groups was significant in terms of diabetes mellitus, hypertension, and cardiovascular disease ($p<0.05$). There was a significant correlation between each of the anthropometric measurements and the PSG parameters. In the receiver operating characteristic analysis, cutoff values that predicted severe OSAS were ABSI>0.08, BAI>28.29, AVI>25.54, and CI>1.37. Multiple regression analyses demonstrated that age, sex, and AVI were independent predictors that determine OSAS presence.

CONCLUSION: Anthropometric parameters that are indicators of abdominal obesity were found to be robustly correlated with cardiometabolic diseases and the severity of OSAS.

KEYWORDS: Abdominal obesity, anthropometric measurement, cardiometabolic disease, obstructive sleep apnea syndrome, polysomnography

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INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is characterized by recurrent episodes of obstruction within the upper respiratory tract, often accompanied by oxygen desaturation and systemic complications, such as stroke, arrhythmia, hypertension (HT), coronary artery disease, heart failure, and diabetes mellitus (DM) with consequences, including higher mortality and morbidity [1]. Obesity is a substantial component, contributing to the development and progression of OSAS [2]. In recent years, the focus has been on the importance of the region and distribution of fat in the body rather than the total amount of fat in the body. It has been emphasized that abdominal type obesity is a more important indicator in terms of morbidity and mortality [3]. An increasing number of studies have investigated the correlation between cardiometabolic diseases (CMDs) and the parameters demonstrating central body fat in the general population, including measurements of waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), (waist/hip)-to-height ratio (WHHR), and a body shape index (ABSI) [4-6].

In this study, we examined the correlation between disease severity of OSAS, polysomnographic parameters, and CMD using traditional indices and the recently defined anthropometric measurements whose correlation with OSAS have not yet been investigated; these measurements include ABSI, WHtR, body adiposity index (BAI), abdominal volume index (AVI), and conicity index (CI) [7, 8]. We believe that these measurements, which are not used frequently and are rather unknown, can predict CMD and may help determine the severity of the OSAS.

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MATERIAL AND METHODS

Study Population

Our study was a retrospective study that included patients who had undergone a sleep study in the sleep study center of Gaziosmanpaşa University School of Medicine between June 2013 and December 2015 for the clinical suspicion of OSAS. Polysomnographic evaluation of all the patients was performed. On the basis of their AHI scores, the patients were classified as OSAS negative (control) (AHI <5) or categorized as having mild (AHI 5-15), moderate (AHI 15-30), and severe OSAS (AHI >30) per the American Academy of Sleep Medicine (AASM) task force criteria [9]. Patients who were younger than 18 years of age, with central sleep apnea syndrome, upper airway resistance syndrome, narcolepsy, movement disorders, and hypoxemic lung disease including asthma, chronic obstructive pulmonary disease, or interstitial lung disease were excluded from the study. The demographic characteristics, medical history inclusive of cardiovascular and metabolic diseases, medication use, habits, and sleep patterns of all the patients were obtained using a standardized questionnaire before the sleep study. The phrase cardiovascular diseases (CVDs) included only the presence of arrhythmia, coronary artery disease, or heart failure in the context of this study. The diagnosis of CVD was made by an expert cardiologist with medical treatment and history, electrocardiogram, echocardiography, and coronary angiography.

Sleep Study

Polysomnography (PSG) was performed for all the patients using a 55-channel polysomnography unit (Alice Sleepware; Philips Respironics, Pennsylvania). The standard criteria of AASM were used to score all the patient recordings. Apnea was described as a ≥90% decline in the airflow amplitude for at least 10 seconds relative to the baseline amplitude, and hypopnea was a ≥ 30% decline in the airflow amplitude relative to the baseline values associated with ≥3% oxygen desaturation or arousal from sleep, all sustained for at least 10 seconds [9]. The AHI was calculated as the number of apneic plus hypopneic episodes per hour of sleep. An AHI ≥5 events/hour was diagnosed as OSAS. The oxygen desaturation index (ODI) was described as the total number of measurements of oxyhemoglobin desaturation of ≥4% within ≥10 seconds to <3 minutes from the baseline, divided by the total sleep time.

MAIN POINTS

- Abdominal obesity is significantly associated with the presence and severity of obstructive sleep apnea syndrome (OSAS) and cardiometabolic diseases (CMD) in patients with OSAS.
- The anthropometric evaluation and measurements showing abdominal obesity can be used as a biomarker to predict CMD in patients with OSAS. Patients with abdominal obesity, even if asymptomatic, should be investigated for the presence of OSAS.
- The treatment approach should not only achieve weight loss in patients but also contribute to health with exercise programs and lifestyle changes targeting correction of abdominal obesity.

Anthropometric Measurements

The anthropometric parameters calculated from the measurements of height, weight, waist circumference, and hip circumference are given below:

- Body mass index (BMI)=weight (kg)/height $(m)^2$ [7].
- Waist-to-hip ratio (WHR)=waist (m)/hip (m) [7].
- Waist-to-height ratio (WHtR)=waist (m)/height (m) [7].
- (Waist/hip)-to-height ratio (WHHR)=WHR/height (m) [7].
- Body adiposity index (BAI)=hip (cm)/height $(m)^{1.5}$ –18 [7].
- A body shape index (ABSI)=WC (m)/($BMI^{2/3}$ × height $[m]^{1/2}$) [7].
- Abdominal volume index (AVI)=2×waist $(cm)^2$ +0.7×(waist [cm]-hip $[cm])^2$/1000 [8].
- Conicity index (CI)=waist (m)/(0.109×√weight [kg]/height [m]) [8].

Statistical Analysis

The Statistical Package for Social Sciences version 19 software (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analysis. Continuous variables were stated as means±standard deviation (SD), and qualitative variables as frequency (n) and percentages (%). When the difference between the 2 groups was sought for continuous variables, the independent samples *t* test was used. One-way analysis of variance or the Welch test was used to evaluate for the difference in continuous variables among more than 2 groups.

The Tukey HSD or Tamhane T2 test was used for multiple comparisons. The correlation between qualitative variables was examined with the chi-square test. Receiver operating characteristic (ROC) analysis was used to state the cutoff points that identify the presence of disease. Pearson's correlation coefficient was used for the relationship between continuous variables. A value of $p<0.05$ was considered statistically significant.

The study was done in observance of the principles defined in the Declaration of Helsinki and confirmed by the local ethics committee (Project number: 16-KAEK-001).

RESULTS

A total of 410 patients (267 men [65%] and 143 women [35%]) were enrolled in the study. The mean age of the patients was 49±12 years, and the mean BMI was 31.53±5.56 kg/m^2. The patients were divided into 4 groups based on their AHIs (Table 1). Statistically significant intergroup differences were found with respect to all anthropometric parameters ($p<0.05$). The patients were further divided into 2 groups as those with OSAS (n=379) and those without OSAS (n=31). With the exception of BAI, all other anthropometric measurements were significantly higher in the patients with OSAS (Table 2). Correlation analyses revealed a significant relationship between each anthropometric measurement and all the PSG parameters (Table 3, Figure 1, 2). Anthropometric parameters were significantly higher in patients with DM, HT, and CVD than in those without them (Table 4). ROC analyses were performed to estimate cutoff values, which could predict severe OSAS. The cutoff values for different parameters were determined as follows: ABSI>0.08; BAI>28.29; AVI>25.54, and CI>1.37 (Table 5). In logistic regression analysis performed to determine the

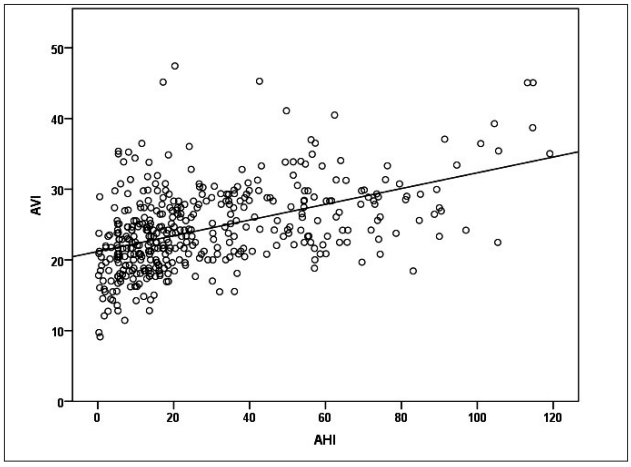

Figure 1. Correlation between the abdominal volume index and the apnea hypopnea index

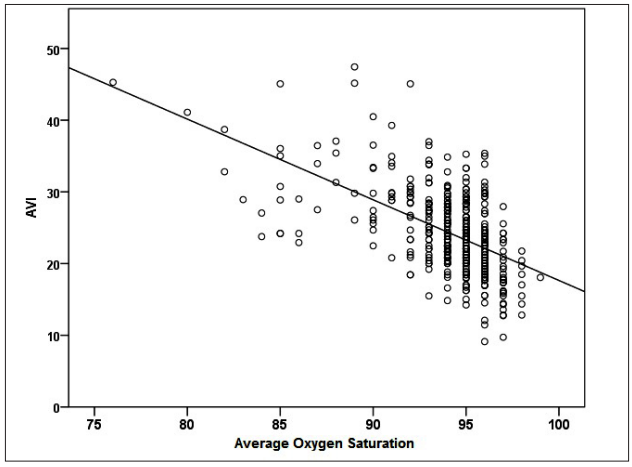

Figure 2. Correlation between the abdominal volume index and average oxygen saturation

Table 1. Demographic, clinical, polysomnographic findings and anthropometric measurements of the study population

	Control group, non-OSAS (n=31)	Mild OSAS (n=129)	Moderate OSAS (n=101)	Severe OSAS (n=149)	p
Age (year)	36.97±12.3[a]	47.2±10.31[b]	51.13±11.04[c]	51.7±11.65[c]	<0.001
Sex, male, n (%)	11 (35.5)	84 (65.1)	62 (61.4)	110 (73.8)	<0.001
Hypertension, n (%)	2 (6.5)	22 (17.1)	38 (37.6)	59 (39.6)	<0.001
Diabetes mellitus, n (%)	0 (0)	13 (10.1)	24 (23.8)	39 (26.2)	<0.001
CVD, n (%)	2 (6.5)	12 (9.3)	15 (14.9)	33 (22.1)	0.012
Anthropometric measurements					
BMI (kg/m^2)	27.39±5.78[a]	29.77±5.05[b]	31.63±4.47[b]	33.85±5.59[c]	<0.001
NC (cm)	36.77±3.97[a]	39.26±3.51[a]	40.27±3.37[c]	42.58±3.37[d]	<0.001
WC (cm)	95.68±13.5[a]	104.74±11.73[b]	110.16±11.28[c]	116.17±11.8[d]	<0.001
HC (cm)	104.58±11[a]	107.81±10.32[b]	111.08±9.73[b]	113.63±13.16[c]	<0.001
WHR	0.92±0.1[a]	0.97±0.06[a]	0.99±0.06[a]	1.03±0.07[b]	<0.001
WHtR	0.58±0.09[a]	0.63±0.08[b]	0.66±0.08[c]	0.7±0.08[d]	<0.001
WHHR	0.55±0.06[a]	0.58±0.04[b]	0.6±0.04[c]	0.61±0.05[d]	<0.001
ABSI	0.08±0.01[a]	0.08±0.01[ab]	0.09±0.01[b]	0.09±0.005[b]	<0.001
BAI	31.63±7.7[a]	32.15±6.82[b]	34.15±6.82[b]	34.75±8.03[c]	<0.001
AVI	18.79±5.06[a]	22.25±5.01[b]	24.55±5.24[c]	27.32±5.63[d]	<0.001
CI	1.31±0.1[a]	1.36±0.08[ab]	1.4±0.09[bc]	1.42±0.08[c]	<0.001
Polysomnographic findings					
Stage 1 (%)	6.45±2.85[a]	7.18±4.6[a]	7.35±3.82[a]	11.28±7.6[b]	<0.001
Stage 2 (%)	39.45±8.55[a]	39.82±9.22[a]	39.3±8.38[a]	51.77±12.58[b]	<0.001
Stage 3 (%)	35.69±8.1[a]	34.23±9.73[a]	33.31±8.97[a]	21.37±11.81[b]	<0.001
REM (%)	18.43±6.32[ab]	19.08±6.11[a]	19.84±6.68[a]	15.09±7.11[b]	<0.001
SE (%)	82.9±11.19	84.81±9.61	83.36±12.17	81.94±12.11	0.184
AHI events/hour	1.99±1.37[a]	9.54±3.15[b]	20.48±3.95[c]	56.67±21.1[d]	<0.001
Average O2 sat (%)	96.29±1.32[a]	95.19±1.57[b]	94.34±2.25[c]	92.25±3.49[d]	<0.001
Minimum O2 sat (%)	90.94±3.08[a]	86.09±5.43[b]	80.24±8.71[c]	72.5±11.78[d]	<0.001
Desaturation (%)	0.01±0.04[a]	1.22±7.23[ab]	4.53±13.74[b]	17.3±21.93[c]	<0.001
ODI	1.56±1.49[a]	6.69±4.78[b]	18.33±10.93[c]	58.39±28.43[d]	<0.001

Each different superscript letter (a, b, c, d) indicates statistical significance; significant values are given in bold; sleep stages are given as % of total sleep time; OSAS: obstructive sleep apnea syndrome; CVD: cardiovascular disease; BMI: body mass index; NC: neck circumference; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; WHHR: (waist/hip)-to-height ratio; ABSI: a body shape index; BAI: body adiposity index; AVI: abdominal volume index; CI: conicity index; REM: rapid eye movement; SE: sleep efficiency; AHI: apnea hypopnea index; Desaturation (%): Sleep time of SpO_2< 90%; O_2 sat: oxygen saturation; ODI: oxygen desaturation index

presence of OSAS, all potential factors for OSAS were further searched in a univariate screening procedure. All the parameters that correlated with OSAS, with a significance level below 0.1, were introduced in a stepwise multiple regression analysis. The final regression model included age, sex, BMI, BAI, and AVI; the independent predictors of OSAS were exacted to be age, gender, and AVI (Table 6).

DISCUSSION

The values of parameters that are indicative of abdominal obesity such as WHR, WHtR, WHHR, ABSI, AVI, and CI were observed to be higher in patients with OSAS than in those without OSAS. These parameters are related to the severity of OSAS and the grade of night oxygen desaturation. The anthropometric parameters were significantly higher in patients with OSAS and CMD than in those with OSAS and without CMD. AVI is an independent predictor for the presence of OSAS.

Table 2. Anthropometric measurements of patients with and without OSAS

	Control group, non-OSAS (n=31)	OSAS (n=379)	p
BMI (kg/m^2)	27.39±5.78	31.87±5.41	<0.001
NC (cm)	36.77±3.97	40.83±3.71	<0.001
WC (cm)	95.68±13.5	110.68±12.6	<0.001
HC (cm)	104.58±11	110.97±11.62	0.003
WHR	0.92±0.1	1±0.07	<0.001
WHtR	0.58±0.09	0.66±0.08	<0.001
WHHR	0.55±0.06	0.6±0.05	<0.001
ABSI	0.08±0.01	0.09±0.01	0.002
BAI	31.63±7.7	33.71±7.39	0.135
AVI	18.79±5.06	24.86±5.74	<0.001
CI	1.31±0.1	1.39±0.08	<0.001

Significant values are given in bold; BMI: body mass index; NC: neck circumference; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; WHHR: (waist/hip)-to-height ratio; ABSI: a body shape index; BAI: body adiposity index; AVI: abdominal volume index; CI: conicity index

There is crucial evidence that suggests an increased risk for metabolic diseases and CVDs in patients with OSAS [10-12]. Intermittent episodes of hypoxia as a result of temporary disruption of breathing during sleep are major physiological features of OSAS, which also seem similar to symptoms of an ischemia-reperfusion injury. Intermittent attacks of nocturnal hypoxemia mediate the formation of oxygen-free radicals and sympathetic activity leading to low-grade circulatory and inflammatory conditions [13]. There are numerous known risk factors, such as advanced age, smoking, and obesity that can explain the relationship between OSAS and CMD. Of these, 1 of the most important preventable factors is obesity, which is of importance because it contributes to the development and progression of OSAS. The correlation between obesity and OSAS is explained by many complex mechanisms, such as local and systemic inflammatory responses and humoral effects, the disruption of neuromuscular control in the upper airway (UA), increase in UA resistance, and increase in respiratory muscle workload [14]. In recent years, studies have focused on the region and distribution of fat in the body rather than the total amount of fat in the body. New anthropometric parameters indicative of central obesity known as BMI give no indication of muscle and fat accumulation or the distribution in the body. Hip circumference (HC), WHR, WHtR, WHHR, ABSI, BAI, AVI, and CI are the newly defined indices of abdominal obesity that are used to predict cardiovascular risks [7, 8]. Janssen et al. [15] emphasized a direct correlation between waist circumference (WC) and mortality and an inverse correlation between BMI and mortality. It was stated that HC has been an alternative measure that predicts mortality better than BMI [16, 17]. It has been suggested that fat in the gluteofemoral region may have a positive effect on health by removing free fatty acids from the bloodstream. In a recent prospective analysis, higher WC and lower HC correlated well with the risk of mortality, but BMI did not [18]. Moreover, there are many studies supporting the ability of WHtR to predict cardiometabolic risk factors and mortality risk [19-22]. Mortality analysis was not performed in the

Table 3. Correlation between polysomnographic parameters and anthropometric measurements

		BMI	NC	WC	HC	WHR	WHtR	WHHR	ABSI	BAI	AVI	CI	
AHI	r	0.413	0.429	0.476	0.352	0.294	0.437	0.272	0.164	0.262	0.477	0.345	
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	
Desaturation %	r	0.436	0.338	0.460	0.379	0.217	0.437	0.223	0.116	0.297	0.482	0.302	
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.019	<0.001	<0.001	<0.001	
Average O_2 sat (%)	r	-0.486	-0.395	-0.541	-0.412	-0.306	-0.512	-0.305	-0.177	-0.322	-0.556	-0.388	
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
ODI	r	0.495	0.415	0.517	0.425	0.259	0.503	0.284	0.127	0.354	0.523	0.342	
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	<0.001	<0.001	<0.001	
Minimum O_2 sat (%)	r	-0.481	-0.365	-0.530	-0.409	-0.294	-0.538	-0.351	-0.197	-0.373	-0.537	-0.401	
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	

Significant values are given in bold; BMI: body mass index; NC: neck circumference; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; WHHR: (waist/hip)-to-height ratio; ABSI: a body shape index; BAI: body adiposity index; AVI: abdominal volume index; CI: conicity index; AHI: apnea hypopnea index; Desaturation (%): Sleep time of SpO2<90%, O2 sat: oxygen saturation, ODI: oxygen desaturation index

Table 4. Anthropometric measurements of patients with and without cardiometabolic disease

	Cardiovascular disease			Hypertension			Diabetes mellitus		
	Yes	No	p	Yes	No	p	Yes	No	p
BMI (kg/m^2)	31.8±5.71	31.49±5.53	0.688	33.58±6.44	30.68±4.91	<0.001	34.48±6.46	30.86±5.11	<0.001
NC (cm)	41.13±3.37	40.42±3.96	0.183	40.93±4.2	40.36±3.73	0.175	41.99±3.7	40.19±3.84	<0.001
WC (cm)	112.89±13.62	108.95±13.13	0.031	115.12±13.92	107.21±12.27	<0.001	116.67±13.73	107.92±12.62	<0.001
HC (cm)	111.42±13.7	110.32±11.31	0.496	114.68±14.41	108.73±9.85	<0.001	115.32±14.63	109.39±10.63	0.001
WHR	1.02±0.07	0.99±0.08	0.008	1.01±0.07	0.99±0.08	0.013	1.02±0.07	0.99±0.08	0.004
WHtR	0.67±0.09	0.66±0.09	0.148	0.7±0.09	0.64±0.08	<0.001	0.71±0.09	0.65±0.08	<0.001
WHHR	0.6±0.05	0.59±0.05	0.120	0.61±0.04	0.59±0.05	<0.001	0.62±0.04	0.59±0.05	<0.001
ABSI	0.09±0	0.09±0.01	0.004	0.09±0.01	0.08±0.01	<0.001	0.09±0	0.09±0.01	0.066
BAI	33.38±8.46	33.58±7.23	0.842	36.72±8.24	32.22±6.63	<0.001	36.87±8.66	32.8±6.91	<0.001
AVI	25.9±6.52	24.13±5.76	0.029	26.94±6.65	23.34±5.23	<0.001	27.65±6.56	23.66±5.5	<0.001
CI	1.42±0.09	1.38±0.09	0.004	1.42±0.08	1.37±0.09	<0.001	1.42±0.08	1.38±0.09	<0.001

Significant values are given in bold; BMI: body mass index; NC: neck circumference; WC: waist circumference; HC: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio; WHHR: (waist/hip)-to-height ratio; ABSI: a body shape index; BAI: body adiposity index; AVI: abdominal volume index; CI: conicity index

Table 5. Cutoff values of the anthropometric measurements for predicting severe OSAS and ROC analysis results

	Cutoff	AUC	Sensitivity	Selectivity	PPV	NPV	p
ABSI	>0.08	0.583	0.597	0.517	0.414	0.693	0.005
BAI	>28.29	0.567	0.846	0.310	0.414	0.779	0.024
AVI	>25.54	0.735	0.611	0.751	0.583	0.772	<0.001
CI	>1.37	0.666	0.718	0.536	0.469	0.770	<0.001

Significant values are given in bold; OSAS: obstructive sleep apnea syndrome; ROC: receiver operating characteristic; AUC: area under the curve; PPV: positive predictive value; NPV: negative predictive value; ABSI: a body shape index; BAI: body adiposity index; AVI: abdominal volume index; CI: conicity index

Table 6. Logistic regression analysis results that determine OSAS presence

	p	Odds ratio	Confidence interval 95%	
Sex	0.001	0.082	0.018	0.368
Age	0.000	1.102	1.051	1.155
BMI	0.538	1.087	0.834	1.417
BAI	0.782	0.976	0.823	1.158
AVI	0.041	1.223	1.008	1.483

Significant values are given in bold; BMI: body mass index; BAI: body adiposity index; AVI: abdominal volume index

current study, although WC and WHtR were determined to have a positive correlation with AHI, ODI, and the percentage of oxygen desaturation and a negative correlation with the average and minimum oxygen saturation. Furthermore, both parameters demonstrate a meaningful difference among the 4 groups, and the value of WC and WHtR increased as OSAS severity increased. Thus, the hypothesis is that these parameters reflect the severity of OSAS and the deterioration of oxygen saturation at night, which is a mortality-related measure in OSAS. When the relationship among WC, WHtR, and comorbidities was examined in patients with OSAS, WC was established to be significantly higher in patients with CVD, DM, and HT, whereas WHtR was remarkably higher in patients with DM and HT.

In 2012, Krakauer et al. [5] had suggested a new anthropometric measure (ABSI), which can estimate both visceral abdominal and general overall adiposities. It was emphasized that ABSI predicted the risk of mortality when compared with the analysis findings adjusted for WC and BMI. Thomson et al. [23] appraised the correlation between adiposity indices such as weight, BMI, ABSI, BAI, WC, HC, WHR, and mortality in postmenopausal women in a study for a women's health initiative. At the end of the study, ABSI was deemed the best of the anthropometric measurements evaluated for prediction of mortality risk. In another study, Bouchi et al. [24] researched the correlation between ABI and arterial stiffness in patients with type 2 DM. They emphasized that ABSI reflects abdominal obesity independently of BMI and is an important indicator of arterial stiffness in patients with type 2 DM. Since its development, ABSI has been investigated in different patient populations such as those with HT, DM, metabolic syndrome, cardiovascular events, heart rate variability, and mortality in patients undergoing hemodialysis [25-32]. To the best of our knowledge, this is the first study that has compared the association of ABSI and the severity of OSAS and the entity of CMD in patients with OSAS. In this study; ABSI showed a significant difference between OSAS and non-OSAS groups, and there was a significant positive correlation between ABSI and AHI, ODI, and percentage of oxygen desaturation and a negative correlation between ABSI and average and minimum oxygen saturation. ABSI was

higher in patients with hypertension, CVD, and DM than in those without these diseases. These results demonstrate that ABSI reflects OSAS severity and oxygen desaturation in OSAS and is associated with CMD and can therefore be considered important in the prognosis of OSAS.

In a study conducted to investigate the 10-year cardiovascular risk in 3,199 patients, the discriminative performances of 5 different obesity indices (WC, WHR, WHtR, AVI, and CI) were evaluated. It was found that the highest discriminative indices were CI and WHR [8]. There has been no previous study in the literature investigating the importance of AVI and CI in OSAS cases. In this study, AVI and CI were found to be higher in patients with OSAS, CVD, hypertension, and DM. Both indices showed a significant correlation with all PSG parameters. The cutoff values for severe OSAS for AVI and CI were found to be >25.54 and >1.37, respectively. As the degree of OSAS severity increased, AVI also increased. One of the most important results of this study was the determination of AVI as an independent risk factor of OSAS using logistic regression analysis.

A study by Milman [33] demonstrated that although BMI was similar in both sexes, OSAS was less in women than in men. It was stated that this difference was due to the fat distribution in men. Resta et al. [34] have shown that AHI, OSAS prevalence, neck circumference (NC), and WHR were lower in women. In this study when anthropometric parameters were compared between sexes, NC and WHR were higher in men, whereas HC, WHtR, BAI, and CI were higher in women. Rivera et al. [35] investigated the efficacy of measurements showing abdominal obesity in the diagnosis of OSAS. When patients with AHI >10 and those with simple snoring were compared, their WC, NC, and WHR were found to be significantly different. In our study, WHR was found to be higher in patients with OSAS and was associated with PSG parameters. WHHR, another parameter investigated in this study, increased as the severity of OSAS increased. WHHR was associated with AHI and other PSG parameters. BAI, a parameter assessed for the first time in this study in patients with OSAS, was found to be associated with OSAS severity, oxygen desaturation, hypertension, and DM.

The evidence from this study emphasized the importance of anthropometric evaluations in the prediction of CMD in patients with OSAS in a comparatively larger cohort. However, it had some limitations, including the fact that the patients were not followed up prospectively, and the effects of continuous positive airway pressure treatment on anthropometric measurements were not investigated. In addition, mortality analysis was not performed in this study.

In conclusion, abdominal obesity is significantly associated with the presence and severity of OSAS and CMD in patients with OSAS. The anthropometric evaluation and measurements showing abdominal obesity can be used as a biomarker to predict CMD in patients with OSAS. Patients with abdominal obesity, even if asymptomatic, should be investigated for the presence of OSAS. The treatment approach should not only achieve weight loss in patients but also contribute to health with exercise programs and lifestyle changes targeting correction of abdominal obesity. This study can be considered a guide for planning further studies to evaluate the relationship between anthropometric measurements and mortality in patients with OSAS.

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