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Factors affecting the severity of the apnea hypoapnea index: a retrospective study on 838 Egyptian patients diagnosed with obstructive sleep apnea

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Abstract

Background: Obstructive sleep apnea (OSA) is a common condition in the general population that is highly correlated to obesity, and it is associated with major cardiovascular morbidity and mortality. In Egypt, obesity rates are known to be high; however, OSA remains largely under-diagnosed, and data on its current magnitude is very scarce. Thus, the aims of the study were to identify the percentage of OSA in a large sample of patients referred for polysomnography and to determine the effect of different demographic data on the severity of the disease.

Results: This retrospective study included 1012 patients. Medical data were reviewed by sleep specialists. The correlation between age, body mass index (BMI), and neck circumference (NC) with apnea hypoapnea index (AHI) was explored. Also, gender differences were analyzed. A total of 838 patients (81% males, 19% females) were diagnosed with OSA. Patients with mild, moderate, and severe OSA were 204 (24%), 146 (17%), and 488 (58%), respectively. Females were older than males (58.87 ± 10.25 versus 54.39 ± 22.96, $p = 0.001$) and BMI was not significantly different between both sexes (34.18 ± 13.53 versus 36.73 ± 23.25, $p = 0.07$), but NC was higher in men (43.56 ± 5.3 versus 39.34 ± 4.41, $p = 0.001$). AHI was significantly increased in men compared to women (47.97 ± 31.22 versus 37.95 ± 31.72, $p = 0.001$) and severe OSA was commonly diagnosed in men than women ($p = 0.001$). A positive significant correlation was found between BMI, NC with AHI, arousal index, average SpO_2, and desaturation index.

Conclusion: OSA is highly prevalent among our patients. Additionally, BMI and NC independently affected the severity of their disease.

Keywords: OSA, Obesity, Neck circumference, Gender, AHI

Background

Obstructive sleep apnea (OSA) is a common and chronic condition characterized by episodes of complete or partial obstruction of the upper airway leading to intermittent hypoxia, frequent arousals, and daytime sleepiness [1]. Well-known risk factors that increase the risk of OSA include obesity, age, male gender, upper airway anatomical abnormalities, or hormonal influences [2].

The prevalence of OSA, even though still under-diagnosed, has been investigated in different Western population cohorts, varying around 34% for men and 17% for women [3]. This incidence of OSA is expected to rise even more with the explosion of the obesity epidemics around the world [4]. However, even with the high obesity rates known in the Egyptian population affecting 37.1% in men and 50.8% in women [5–7], data

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regarding the prevalence of OSA in Egypt is still very limited.

Also, OSA is a known risk factor for many comorbid disorders, causing resistance to conventional treatments and increasing the risk of mortality, which multiplies health care expenditures [8, 9], and even though the distribution of comorbidities differs between men and women, their effect progressively increases with OSA severity [10]. Furthermore, a Danish study concluded that male gender, age, and continuous positive airway pressure (CPAP) treatment were the predictor variables for quality of life and survival in patients with OSA [11].

In fact, studies have shown that age aggravates OSA in males and in postmenopausal females due to hormonal influences [2]. It was also observed that cardiovascular (CV) diseases were more pronounced after 60 years of age [12]. Evidence from epidemiological studies supports an association between OSA and CV diseases such as coronary heart disease, arrhythmia, heart failure, and stroke [13, 14].

In addition, strong associations have been reported between OSA and the prevalence of hypertension (HTN) independently of other CV risk factors [15]. Further, a recent cross-sectional study conducted on around 4000 Egyptian patients with HTN found that 63% of the cohort had uncontrolled blood pressure values despite treatment, and about half of those patients had an increased BMI [16].

To our knowledge, no previous studies evaluated the effect neither of obesity, gender, age, nor of the NC on the severity of OSA in a large number of Egyptian patients. Thus, considering the important health-related consequences notably the cardiovascular morbidity and mortality associated with OSA, we sought to evaluate the incidence of the disease and to determine the factors that might affect its severity among our patients. In this work, we also shed the light on the differences existing between males and females diagnosed with OSA.

Methods

This was a retrospective study on 1012 patients referred for evaluation of sleep-related breathing disorders at the Cairo Center for Sleep Disorders, an outpatient private center in Cairo, Egypt, between January 2012 and December 2014. This study was conducted in accordance with the International Committee of Harmonization Guidelines for Good Clinical Practice with applicable local regulations and ethical principles laid down in the Declaration of Helsinki. All medical files were reviewed by sleep specialists. Data collected included full medical history, demographics, measurements of weight and height, body mass index in kilograms per square meter, neck circumference (NC), Epworth Sleepiness Scale (ESS) scores, and the diagnosis that was concluded after a polysomnography study. Laboratory full night diagnostic polysomnography that was attended by a sleep technician and performed using the Alice 5 or Alice 6 Diagnostic Sleep system (Philips Respironics Inc., Murrysville, PA, USA) involved the recording of electroencephalography with two frontal derivations, two central derivations, two occipital derivations, right and left eye derivations, nasal pressure, nasal-oral airflow (thermal device), snore sensor, respiratory effort (abdominal and thoracic effort), oxygen saturation with pulse oximetry, submental EMG, and right and left anterior tibialis EMG. Polysomnography results were scored and interpreted manually according to the American Academy of Sleep Medicine Manual for the scoring of sleep events defining apnea events as the cessation of airflow by ≥ 90% for at least 10 s and hypopnea events as a reduction in the airflow by ≥ 30% for at least 10 s and oxygen desaturation of ≥ 4% [17]. Patients included in the study

Table 1 Demographics and clinical characteristics of patients diagnosed with OSA

		Mean	± SD
Age (years)		55.25	21.20
Weight (kg)		111.83	43.68
Height (cm)		171.87	54.41
BMI (kg/m^2)		34.67	15.88
NC (cm)		42.78	5.40
		Number	**%**
Sex	Male	678	81
	Female	160	19
Hypertension	Yes	344	41.1
	No	494	58.9

BMI body mass index, *NC* neck circumference

Table 2 Description of the sleep data of the patients diagnosed with OSA

		Mean	± SD	IQR	
ESS		10.34	6.41	6.00	15.00
TST		301.52	91.14	246.00	365.50
AI		35.75	24.84	16.00	55.00
SpO$_2$		91.52	7.06	90.00	95.00
DI		55.94	43.24	18.70	84.50
AHI		46.05	31.54	15.50	73.50
		Number	**%**		
OSA	Mild	204	24.3		
	Moderate	146	17.4		
	Severe	488	58.2		

IQR interquartile range, *ESS* Epworth Sleepiness Scale, *TST* total sleep time, *AI* arousal index, *DI* desaturation index, *AHI* apnea hypoapnea index, *OSA* obstructive sleep apnea

Table 3 Comparison between patients with mild, moderate, and severe OSA

		OSA			*p*	Sig
		Mild, mean ± SD	**Moderate, mean ± SD**	**Severe, mean ± SD**		
Age (years)		53.75 ± 12.21	57.54 ± 12.59	55.19 ± 5.44	.256*	NS
Weight (kg)[a]		105.02 ± 22.66	102.57 ± 23	117.28 ± 20.37	.001*	HS
Height (cm)		169.9 ± 12.27	170.21 ± 9.75	173.14 ± 90.87	.722*	NS
BMI (kg/m^2)[a]		32.34 ± 8.7	31.76 ± 7.87	36.47 ± 14.35	.001*	HS
NC (cm)[a]		41.55 ± 5.23	40.5 ± 4.93	43.98 ± 5.12	.001*	HS
		N (%)	*N* (%)	*N* (%)		
Sex	Male	151 (22.27%)	110 (16.22%)	417 (61.5%)	.001**	HS
	Female	53 (33.13%)	36 (22.5%)	71 (44.38%)		

BMI body mass index, *NC* neck circumference
*ANOVA
**Chi-square test
[a]Mild vs. moderate (NS), mild vs. severe (HS), and moderate vs. severe (HS)

were those meeting the diagnostic criteria of OSA according to the Third Edition of the International Classification of Sleep Disorders and then categorized into mild (AHI 5–15), moderate (AHI 15–30), and severe (AHI > 30) [18]. Patients less than 18 years old and patients who underwent polysomnography for less than 4-h duration were excluded.

Study variables

The primary objective was to determine the percentage of OSA in a large clinical sample. Secondly, we wanted to investigate the effect of age, gender, BMI, and NC on the severity of the AHI. We also explored the correlation between each of the age, BMI, NC with ESS, AHI, and other sleep parameters [average oxygen saturation (SpO_2), desaturation index (DI), arousal index (AI), and total sleep time (TST)] and compared sleep-related differences between men and women.

Statistical analysis

Kolmogorov–Smirnov's test was used to evaluate the normal distribution of continuous data. All results are presented as mean and SD values or as median and interquartile range according to the distribution of data. Categorical results are presented as numbers of cases and percentages. For univariate analysis, continuous variables were compared between 2 groups using the Student *t* test or Mann–Whitney *U* test depending on the distribution of data. ANOVA and Kruskal-Wallis tests were used to compare numerical variables between 3 groups according to data distribution with post hoc test for pair-wise comparisons. Categorical variables were compared using the chi-square test. Pearson's or Spearman correlation coefficients were used to assess the correlation between variables. Multivariate linear regression analysis was performed for finding the predictors of AHI. The *p* value was considered significant as the following: $p > 0.05$, not significant (NS); $p < 0.05$, significant

Table 4 Comparison between patients with mild, moderate and severe OSA

	OSA						*p*	Sig
	Mild		Moderate		Severe			
	Mean ± SD	**Med (IQR)**	**Mean ± SD**	**Med (IQR)**	**Mean ± SD**	**Med (IQR)**		
ESS[A]	8.15 ± 6	7 (4–12)	9.01 ± 5.44	8 (6–13)	11.64 ± 6.52	12 (7–16)	.001*	HS
TST	293.74 ± 96.1	290.7 (241–352)	294.42 ± 90.87	300.5 (245–362.5)	306.8 ± 88.86	314 (250–369.5)	.139**	NS
AI[A].	18.98 ± 14.99	16 (10.1–22.8)	21.8 ± 14.35	18.2 (11.1–29.3)	46.8 ± 24.61	45.65 (25.4–65.5)	.001**	HS
SpO_2[A]	94.13 ± 3.96	95 (93–96)	93.36 ± 5.12	94 (93–96)	89.86 ± 8.05	92 (88.5–94)	.001*	HS
DI[B]	24.16 ± 39.07	14.4 (7.3–25.3)	34.38 ± 29.47	26 (16.6–39.8)	75.7 ± 36.93	75.5 (56.6–93.5)	.001**	HS

IQR interquartile range, *ESS* Epworth Sleepiness Scale, *AI* arousal index, *DI* desaturation index
*ANOVA
**Kruskal-Wallis test
[A]Mild vs. moderate (NS), mild vs. severe (HS), and moderate vs. severe (HS), by post hoc test
[B]Mild vs. moderate (S), mild vs. severe (HS), and moderate vs. severe (HS), by post hoc test

Table 5 Correlation between each of age, BMI, and the NC with ESS, AHI, and sleep data

		AHI	ESS	TST	AI	SpO_2	DI
BMI (kg/m^2)[a]	*R*	.167	.211	− .147	.187	− .354	.472
	p	.0001	.0001	.0001	.0001	.0001	.0001
	Sig	HS	HS	HS	HS	HS	HS
NC (cm)[a]	*R*	.267	.133	− .045	.250	− .284	.338
	p	.0001	.001	.236	.0001	.0001	.0001
	Sig	HS	HS	NS	HS	HS	HS
Age (years)[a]	*R*	− .045	.000	− .130	− .143	− .017	− .089
	p	.194	.997	.0001	.0001	.626	.012
	Sig	NS	NS	HS	HS	NS	S

BMI body mass index, *NC* neck circumference, *AHI* apnea hypoapnea index, *ESS* Epworth Sleepiness Scale, *TST* total sleep time, *AI* arousal index, *DI* desaturation index
[a]Spearman correlation

(S); and $p < 0.01$, highly significant (HS). All statistical procedures were carried out using SPSS version 20 for Windows (SPSS Inc., Chicago, IL, USA).

Results

Patients

The diagnosis of OSA was established in 838 (83%) of the 1012 patients referred to our center for polysomnography evaluation. Among patients with OSA, 678 (81%) were males and 160 (19%) were females. Patients with mild OSA were 204 (24.3%), and those with moderate OSA were 146 (17.4%) while 488 (58.2%) of the patients had severe OSA. Their characteristics are summarized in Table 1, and their sleep data are described in Table 2.

Differences between mild, moderate, and severe OSA

We found a highly significant difference between patients with mild, moderate, and severe OSA as regards the BMI, NC, ESS, AI, SpO_2, and the DI ($p = 0.001$). These differences are shown in Table 3 and 4. The increase in BMI and NC was highly associated with severe AHI and reduced SpO_2 ($p = 0.0001$). No significant association was found between the age and the AHI ($p = 0.194$). The correlations that were found between each of the age, BMI, NC with AHI, ESS, TST, AI, SpO_2, and the DI are described in Table 5. The linear regression analysis of the factors affecting the severity of OSA revealed that the BMI and the NC were the two risk factors that independently aggravated the severity of the AHI in our cohort (Table 6).

Differences between males and females

Comparison between the two sexes revealed that females were older than males (58.87 ± 10.25 versus 54.39 ± 22.96, $p = 0.001$) and that the BMI was almost equal between both sexes (34.18 ± 13.53 versus 36.73 ± 23.25, $p = 0.07$), but the NC was significantly higher in men (43.56 ± 5.3 versus 39.34 ± 4.41, $p = 0.001$). Hypertension coexisted in 41% ($n = 344$) patients; 80% ($n = 277$) of these patients were men and 20% ($n = 67$) were women.

Sleep parameters in men and women

Sleep parameters were similar between males and females such as the TST (302.46 ± 90.5 versus 297.59 ± 93.97, $p = 0.270$), the SpO_2 (91.85 ± 6.47 versus 90.11 ± 9.01, $p = 0.416$), and the DI (54.36 ± 39.48 versus 62.79 ± 56.47, $p = 0.423$). The AI was markedly high in men (37.92 ± 24.81 versus 26.5 ± 22.85, $p = 0.001$). AHI was significantly increased in men compared to women (47.97 ± 31.22 versus 37.95 ± 31.72, $p = 0.001$), and severe OSA was commonly diagnosed in men than in women ($p = 0.001$) as seen in Fig. 1. The above sex differences are illustrated in Table 7.

Discussion

Obstructive sleep apnea is a common disorder leading to excessive daytime sleepiness and reduction in health-related quality of life that is usually associated with major cardiovascular complications [19]. It is generally accepted that the disorder is more common in men than in women [20], and many studies have outlined the sex-related differences as well as the clinical and sleep characteristics of patients diagnosed with OSA in different populations [21–23].

The present study describes some of the demographics and clinical and sleep characteristics that were found in a large cohort of Egyptian patients diagnosed with OSA. Our objective was to identify the percentage of OSA among a large sample of Egyptian men and women referred to a sleep center for symptoms related to OSA; to evaluate the influence of age, gender, obesity, and NC on

Table 6 Linear regression analysis to determine the factors affecting the severity of OSA

	Regression coefficients	*p*	Sig.	95% CI for regression coefficients	
Age (years)	**− .015**	**.767**	**NS**	**− .115**	**.085**
Gender	− 4.920	.134	NS	− 11.367	1.526
BMI (kg/m^2)	.213	.002	HS	.077	.349
NC (cm)	1.506	.0001	HS	1.023	1.989

OSA obstructive sleep apnea, *BMI* body mass index, *NC* neck circumference

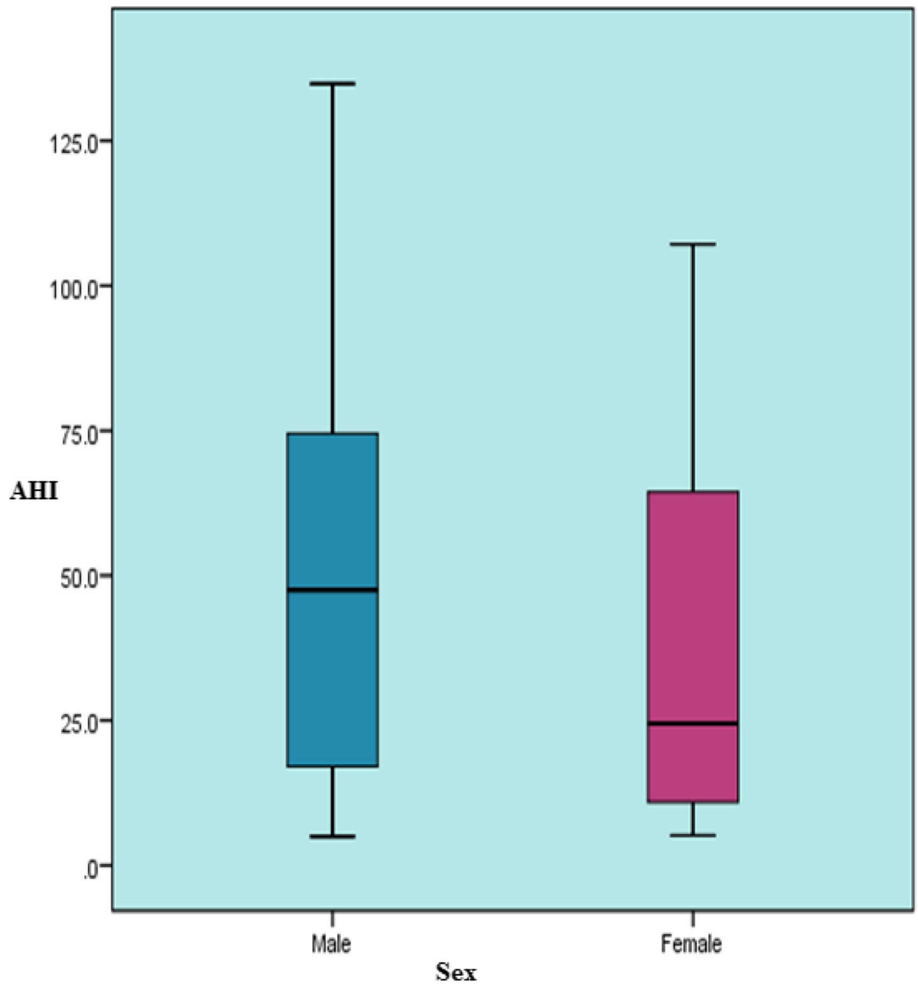

Fig. 1 Comparison of AHI severity between Egyptian men and women

the severity of their disease; and to recognize eventual differences between them.

In this work, 83% of the patients referred to our center were diagnosed with OSA, which is consistent with what was previously reported in different parts of Egypt. In the delta region, a study which included 50 patients found that 80% of them had OSA [24]. Also, in another work in the same region, an equal figure was found in a sample of 400 patients [25]. Authors from Alexandria evaluated 32 patients with tachyarrythmias by a level III sleep study and diagnosed 84% with OSA [26]. A slightly higher rate was found in an earlier study conducted in Cairo on 230 patients showing that approximately 87% of the patients had OSA [27].

Our results differed from what was shown in a recent work that evaluated 170 patients in the south of Egypt in whom 59% were diagnosed with OSA agreeing to a recent work that evaluated 120 patients [28, 29]. Also, in a sample of 80 patients, OSA was diagnosed in 65% of them almost equal to another work that examined 145 patients referred for polysomnography [30, 31].

On a parallel note, obesity has long been considered to be a major risk factor for OSA, and the prevalence of OSA among obese individuals is approximately 40%. Indeed, almost all men with class III obesity also have OSA [32, 33]. Practically, NC, waist circumference, BMI, and the size of the retroglossal space are regarded to have a major impact on the severity of OSA [34].

Not surprisingly, our results showed a positive significant correlation between BMI, NC with AHI, and other parameters of disease severity in agreement with a Turkish study that evaluated about 240 patients and found that severe AHI was associated with increased BMI [35]. In fact, the regression analysis of our results showed that BMI and NC were the only factors that independently affected the severity of OSA in our patients.

In the same clinical setting, age did not affect the severity of the disease in our studied patients. However,

Table 7 Comparison between men and women diagnosed with OSA

	Male		Female		*p*	Sig
	Mean ± SD	**Med (IQR)**	**Mean ± SD**	**Med (IQR)**		
Age (years)	54.39 ± 22.96	54 (44–63)	58.87 ± 10.25	60 (52–65.5)	.001[a]	HS
Weight (kg)	113.69 ± 46.99	110 (95–126)	103.97 ± 24	101 (86–119)	.012[a]	S
Height (cm)	175.18 ± 59.71	174 (168–178)	157.94 ± 13.44	160 (155–163)	.001[a]	HS
BMI (kg/m^2)	34.18 ± 13.53	32 (28.3–37.7)	36.73 ± 23.25	34.0 (29.08–40.6)	.07[a]	NS
NC (cm)	43.56 ± 5.3	43 (41–46)	39.34 ± 4.41	39 (36–42)	.001[a]	HS
AHI	47.97 ± 31.22	47.5 (17.1–74.5)	37.95 ± 31.72	24.45 (10.9–64.4)	.001[b]	HS
ESS	10.23 ± 6.48	9 (5–15)	10.82 ± 6.11	10 (6–15)	.304[a]	NS
TST	302.46 ± 90.5	314 (246.5–368)	297.59 ± 93.97	294.75 (240–353.75)	.270[b]	NS
AI	37.92 ± 24.81	31.07 (17.5–58)	26.5 ± 22.85	19.9 (10.7–38.3)	.001[b]	HS
SpO_2	91.85 ± 6.47	94 (90–95)	90.11 ± 9.01	93 (90–95)	.416[b]	NS
DI	54.36 ± 39.48	52.3 (18.6–82.5)	62.79 ± 56.47	47.8 (19.4–88.3)	.423[b]	NS
	***N* (%)**		***N* (%)**			
OSA	Mild	151 (22.3%)	53 (33.1%)		.001[c]	HS
	Moderate	110 (16.2%)	36 (22.5%)			
	Severe	417 (61.5%)	71 (44.4%)			

IQR interquartile range, *BMI* body mass index, *NC* neck circumference, *AHI* apnea hypoapnea index, *OSA* obstructive sleep apnea, *ESS* Epworth Sleepiness Scale, *TST* total sleep time, *AI* arousal index, *DI* desaturation index
[a]Student *t* test
[b]Mann-Whitney test
[c]Chi-square test

age has been described to be a risk factor for the occurrence of OSA in the general population [36]. Also, the AHI was significantly associated with age [37]. It reported as well that OSA is predominantly a disease of middle-aged men [2, 20] whereas age higher than 60 years was considered the only risk factor for OSA in females [38] probably due to hormonal influences [39].

Additionally, in our cohort, OSA was more common in men (Fig. 1) which is concordant to what was classically published in various studies [23, 27, 31, 40–43]. Our study also revealed that severe OSA is highly diagnosed in men which is similar to the reports from different populations [22, 23, 35, 43] despite the fact that in our cohort, BMI was almost similar between men and women in contrast to what was published elsewhere [22, 31, 40, 44].

This discrepancy in the gender-related incidence of OSA is not entirely clear since women and men were described to have common symptoms such as snoring, witnessed apneas, and daytime sleepiness [45]. This sex-related difference has been attributed however to factors such as body fat distribution because men tend to have an upper body fat deposition in contrast to women. Increased fat tissue deposition in the pharyngeal region and reduced operating lung volumes in obesity act together to reduce the upper airway caliber, modify airway configuration, and increase their repetitive collapsibility [46].

Noteworthy, strong evidence linked OSA with HTN [15, 47, 48], and interestingly, CPAP treatment demonstrated quite a large decrease in blood pressure values in patients with OSA [49]. Therefore, an important finding in our study is that 41% of the patients had associated HTN which is equivalent to European data [15]. Also, a work conducted in the south of Egypt observed that 45% of the patients diagnosed with OSA had associated HTN [28]. Recently, authors from Cairo also showed that HTN existed in almost 50% of their patients with OSA [29]. These findings still require further investigations as two other Egyptian studies noticed a higher prevalence of coexistent OSA and HTN affecting 68% and 77% of their patients, respectively [25, 50].

In conclusion, our study assessed the frequency and risk factors of OSA in a large clinical cohort of Egyptian patients. We also confirmed that OSA is the sleep disorder mostly encountered around sleep centers in Egypt. Additionally, BMI and NC were the two risk factors that independently aggravated the severity of the AHI in our cohort.

Nevertheless, the present findings should be interpreted taking into consideration some limitations of the study. First, females were under-represented probably due to their traditional social role within the family leading to neglected or under-reported symptoms. Another explanation is that physicians may hesitate in referring women for sleep studies describing their main sleep complaint to be due to insomnia or depression. Also, we did not assess the waist to hip ratio which is considered a better measure of fat distribution for males and females diagnosed with OSA [51, 52]. Further, our work is retrospective, our clinic population is not representative of the community, and the results cannot be extrapolated on the general population.

Finally, fellow colleagues in Egypt particularly cardiologists and primary care physicians should be aware of the serious effects and complications of OSA (e.g., resistant HTN). Physicians should also orient women for sleep studies when they are presented with symptoms related to OSA.

The use of sleep questionnaires such as the ESS might be helpful as an initial screening tool for OSA. Further multicenter studies including a large number of patients are needed to confirm the extent of OSA, CPAP effects, and the related cardiovascular consequences among Egyptian patients.

Abbreviations

AHI: Apnea hypoapnea index; AI: Arousal index; BMI: Body mass index; CPAP: Continuous positive airway pressure; CV: Cardiovascular; DI: Desaturation index; ESS: Epworth Sleepiness Scale; HTN: Hypertension; NC: Neck circumference; OSA: Obstructive sleep apnea; SpO_2: Peripheral capillary oxygen saturation; TST: Total sleep time

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Authors' contributions

AG: literature search, manuscript preparation, writing, review, and editing. SL: manuscript review. All authors have read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate

This study was conducted in accordance with the International Committee of Harmonization Guidelines for Good Clinical Practice with applicable local regulations and ethical principles laid down in the Declaration of Helsinki

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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