



Sex differences in clinical and polysomnographic features of obstructive sleep apnea: The Turkish sleep apnea database (TURKAPNE) cohort

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ABSTRACT

Background: Previous reports from relatively small clinical cohorts have suggested that the clinical presentation of obstructive sleep apnea (OSA) differs between men and women.

Objective: We aimed to explore sex differences in clinical and polysomnographic features of OSA in a large nationwide registry.

Methods: Participants from the ongoing Turkish Sleep Apnea Database (TURKAPNE) Study from 34 centers were included in the current analysis. OSA was defined as an apnea-hypopnea index (AHI) ≥ 5 events/hour and was classified as mild, moderate, and severe according to AHI cut-offs 5, 15, and 30 events/hour, respectively.

Results: In all, 7130 patients (2259 women) were included. OSA was observed in 6323 (88.7 %), of whom 70.2 % were male and 29.8 % were female. In the OSA group, women were older (56.7 ± 11.9 vs. 49.5 ± 11.3 years; $p < 0.001$) and more obese (body mass index 34.3 ± 7.2 vs. 31.4 ± 5.6 kg/m²; $p < 0.001$) and had lower AHI (29.8 ± 24.1 vs. 36.8 ± 26.2 events/h; $p < 0.001$) than men. Loud snoring and witnessed apnea were more common in men than in women whereas women were more frequently presented with insomnia, headache, and mood changes. Women had significantly less total sleep time, less sleep efficiency, and longer sleep latency compared with men ($p < 0.001$ for each). Additionally, comorbid diseases such as diabetes mellitus, hypertension, asthma, psychiatric disorders, hypothyroidism as well as drug use were more common in women than in men independent of age and obesity ($p < 0.05$ for each).

Conclusions: Our results suggest significant sex differences in clinical and polysomnographic features in this nationwide Turkish adult population. Women with OSA have more symptom burden and comorbidities despite having a less severe AHI.

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1. Introduction

Obstructive sleep apnea (OSA) is a prevalent condition with intermittent complete or partial obstruction of the upper airway followed by recurrent hypoxia and sleep fragmentation during sleep [1,2]. Globally, OSA has been estimated to affect almost one billion individuals aged 30–69 years, based on the apnea-hypopnea index (AHI) threshold of 5 events/h [3]. To date, there is yet no data regarding the occurrence of OSA in Türkiye based on polysomnography (PSG) studies. According to a survey-based study, Turkish Adult Population Epidemiology of Sleep (TAPES), including a nationwide representative sample of 5021 participants, the estimated OSA prevalence based on the Berlin Questionnaire has been reported as 14 % [4].

Individuals with OSA present typical symptoms such as loud snoring, witnessed apneas and excessive daytime sleepiness. Notwithstanding, nocturia, nocturnal sweating, headache in the morning, and difficulties in concentration as well as depressive mood are also reported [5–12]. OSA may lead to impaired daytime function, metabolic dysfunction, increased risk of cardiovascular disease, traffic accidents, and mortality, and undiagnosed and untreated OSA is a significant burden on the healthcare system [13–15].

OSA generally has been considered as a male disease. Prevalence of OSA with a male-to-female ratio is 4:1–6:1 in clinic-based studies while community-based epidemiological studies have reported 2–4/1 as a male/female prevalence ratio [2,16–18]. The sex difference decreases following menopause [19]. It has been proposed that upper airways are more collapsible in men [20]. It has also been suggested that apnea episodes are shorter, and hypopneas are more common than apneas, and rapid eye movement (REM) predominant OSA is more frequent in women than in men [21]. It has been argued that female patients with OSA are underdiagnosed and treatment is frequently delayed [5,6], which has been attributed to the differences in the clinical presentation of OSA [5–13,22–24]. Two previous reports from Türkiye have addressed the sex differences in OSA between Turkish men and women [11,12]. The sample size was relatively small, and home sleep apnea test (HSAT) was used as diagnostic tool in one of them [12], and the other one was a retrospective cohort study including 2827 patients with OSA [11]. Given that sociocultural status and the geographical distribution of participants could influence clinical presentation and symptom perception of OSA, a more detailed information in this context is urging.

In the current prospective study, we aimed to investigate sex

differences in OSA severity, symptoms, comorbidities and polysomnographic features in a large nationwide registry.

2. Material-methods

2.1. The study population

The rationale and the design of the Turkish Sleep Apnea Database (TURKAPNE) study has previously been published [25]. In summary, the TURKAPNE study is an ongoing national, multicenter, observational, prospective cohort study, which was started in October 2017. Adults with suspected OSA who are referred to the sleep centers are invited to participate in the study. In all, 34 sleep centers have been participating (Fig. 1 – Türkiye map). Study with available demographics, anthropometric measurements (height, weight, body mass index [BMI], circumferences of the neck, waist, and hip), questionnaires, comorbidities and polysomnographic data from 34 centers were included in the current analysis. Patients with limited life expectancy due to advanced renal disease or uncontrolled malignancies, alcohol dependency and using mandibular advancement devices or positive airway pressure therapy were excluded.

2.2. Ethical considerations

The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the Ethics Committee of the Medical Faculty of the Marmara University, Istanbul (approval nr: 09.2016.311). All patients provided written informed consent. The study was registered with the Clinical Trials. gov (NCT02784977).

2.3. Data collection and data quality assurance

The TURKAPNE project uses a precisely designed web based data collection system constructed for transferring data to the central database www.turkapne.org at a server hosted by Hetzner Online GmbH localized in Jestetten, Germany [25]. Each center has a personal login to a clinical report format module containing predefined submodules for recording data. Each sleep center has complete access to data on its own patients. The registry of the participants is coded and the identity of the patients is kept at the reporting sleep center and secured with a written



Fig. 1. The map of Türkiye representing the cities with participating sleep centers.

participant identity log. Data quality is randomly checked by an independent data monitoring board with full access to the complete database.

2.4. Demographic and anthropometric data, comorbidities and concomitant medications

When logging into the system, information on age, gender, marital and educational status, driver's license, smoking and alcohol habits, height, weight, neck circumference, waist/hip circumference, heart rate and systemic blood pressure at the time of diagnosis, comorbidities, concomitant medications and information of menstrual/menopause status in women were recorded.

2.5. Excessive daytime sleepiness

Epworth Sleepiness Scale (ESS) consists of eight self-rated items and assesses the probability of dozing using a scale ranging from 0 (never) to 3 (high). The sum of each item score yielded a global score (range, 0–24). ESS assesses the risk of sleepiness in which patients with scores above 10 were considered as having significant daytime sleepiness and high risk for OSA [26]. Sleepiness was assessed by the Turkish version of the ESS [27].

2.6. Polysomnographic findings

All patients underwent PSG for at least 7 h, and the use of coffee, alcohol, sedatives was banned on the same day. Indicators such as electroencephalogram, electromyography, blood oxygen saturation, electrooculogram, electrocardiogram, snoring, mouth airflow, nasal airflow, chest breathing and body position were included in the monitoring. Polysomnography data contain total sleep time, sleep efficiency, sleep latency, REM latency, sleep stages, AHI, oxygen desaturation index (ODI), average and minimum oxygen saturation levels, time spent below 90 % oxygen saturation (T90 %), arousal index, periodic limb movement index, and heart rate. It was also detected sleep breathing disorders during supine/non-supine position and during the REM and non-REM sleep stages. Sleep staging and respiratory event scoring was in accordance with the latest guidelines [28,29]. Apneas were scored when there was a ≥ 90 % reduction in airflow amplitude for ≥ 10 s. Hypopneas were scored where there was a ≥ 30 % reduction in airflow amplitude for ≥ 10 s, accompanied by either an arousal or desaturation of ≥ 3 %. We defined OSA as an apnea–hypopnea index (AHI) ≥ 5 event/hour, and

moderate-to-severe OSA as an AHI ≥ 15 event/hour, and a severe OSA as an AHI ≥ 30 event/hour [30].

2.7. Statistics

Statistical analysis was performed with IBM SPSS 28.0 for Windows packaged software. Numerical variables were reported with mean $\pm$ standard deviation and categorical variables with frequency and percentage. The significance of differences among groups was assessed by Student-t test, and Chi-square test was applied for analysis of categorical variables. A value of $p < 0.05$ was considered significant. Multiple logistic regression analysis was used to determine the relationship between comorbidities and clinical symptoms with female sex, and odds ratio (OR) and 95 % confidence intervals (CI) were presented.

3. Results

Out of 7130 patients who fulfilled the inclusion criteria, 2259 (31.7 %) were women. As presented in Fig. 2, OSA was observed in 6323 (88.7 %) participants, of whom 70.2 % were male and 29.8 % were female. The rate of OSA was significantly higher in men compared with women (91.1 % vs. 83.4 %, respectively, $p < 0.001$). Moreover, OSA was more severe in terms of AHI in a dose-response manner in men, whereas the rates of mild, moderate and severe OSA were similar in women (Fig. 2).

As shown in Table 1, women with OSA were older and more obese than men at the time of OSA diagnosis, and ESS scores were slightly higher in men compared with women (8.5 ± 5.8 vs. 7.7 ± 5.6 , respectively, $p < 0.001$). Proportion of married participants, education level, proportion of smokers and alcohol consumers were higher among men compared to women. Comorbid diseases such as diabetes mellitus, hypertension, asthma, arrhythmia, psychiatric disorders, hypothyroidism were more common in women than in men (Table 2). The use of drugs was much more common in women supporting the increased disease burden. In a logistic regression analysis, female sex was significantly associated with all aforementioned comorbidities independent of age and obesity (Table 3). Arrhythmia was age-dependent.

The distribution of symptoms that were reported as “often” or “very often” is illustrated in Fig. 3, and odds ratios for symptoms associated with female vs. male sex are shown in Table 4. Thus, the symptom presentations differed significantly in many items, i.e., loud snoring and witnessed apnea were more common in men than in women, whereas women were more frequently presented with insomnia, headache, and mood changes ($p < 0.001$ for each).

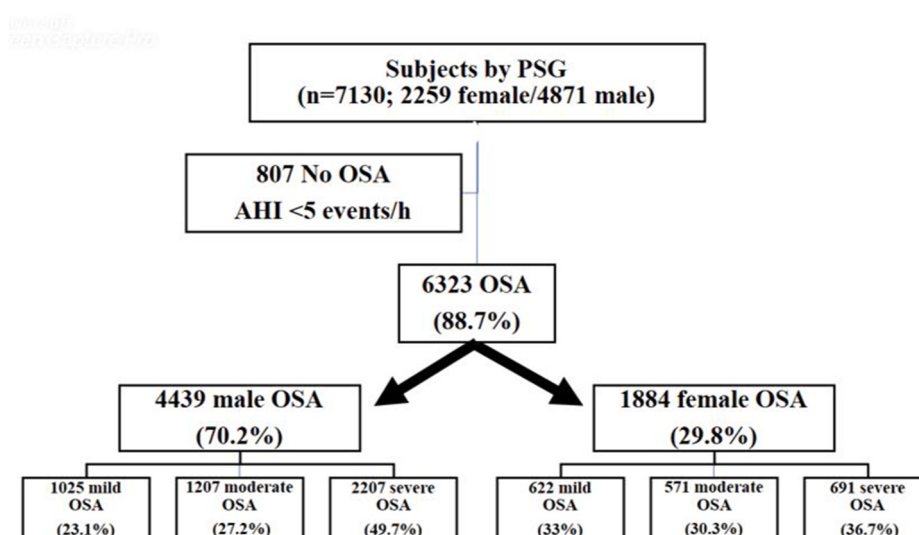


Fig. 2. Flow chart of the study cohort. Abbreviations: OSA, obstructive sleep apnea; PSG, polysomnography.

Table 1
Characteristics of the female and male participants with OSA (n = 6323).

	Female (n = 1884)	Male (n = 4439)	p Value
Age (years)	56.0 ± 11.3	49.5 ± 11.9	<0.001
	34.4 ± 7.2	31.4 ± 5.6	<0.001
BMI (kg/m ²)	7.7 ± 5.6	8.5 ± 5.8	<0.001
ESS score	1481 (78.6)	3878 (87.4)	<0.001
Civil status/married, n (%)			
Education Level			
No education, n (%)	336 (17.8)	324 (7.3)	<0.001
Primary School, n (%)	784 (41.6)	1110 (25)	
Secondary School, n (%)	151 (8)	542 (12.2)	
High School, n (%)	317 (16.8)	1165 (26.2)	
University, n (%)	296 (15.7)	1298 (29.2)	
Smoking			
Never smoker, n (%)	1134 (60.2)	1473 (33.2)	<0.001
Former smoker, n (%)	395 (21)	1369 (30.8)	
Current smoker, n (%)	355 (18.8)	1597 (36)	
Alcohol			
Never, n (%)	1795 (92.1)	3199 (72.1)	<0.001
Occasionally, n (%)	63 (3.3)	295 (6.6)	
Once a month, n (%)	50 (2.7)	418 (9.4)	
Once a week, n (%)	25 (1.3)	314 (7.1)	
Several times a week, n (%)	5 (0.3)	151 (3.4)	
Every day, n (%)	6 (0.3)	62 (1.4)	

Data are expressed as mean ± SD unless otherwise stated.
Abbreviations: BMI, body mass index; ESS, Epworth Sleepiness Scale; OSA, obstructive sleep apnea.

Table 2
Comorbidities and drugs of the female and male participants with OSA (n = 6323).

	Female (n = 1884)	Male (n = 4439)	p Value
Comorbidities			
Diabetes mellitus, n (%)	474 (25.2)	671 (15.1)	<0.001
Hypertension, n (%)	801 (42.5)	1297 (29.2)	<0.001
Asthma, n (%)	295 (15.7)	305 (6.9)	<0.001
COPD, n (%)	44 (2.3)	180 (4.1)	0.001
Coronary artery disease, n (%)	79 (4.2)	209 (4.7)	0.392
Congestive heart failure, n (%)	71 (3.8)	124 (2.8)	0.046
Arrhythmia, n (%)	117 (6.2)	175 (3.9)	<0.001
Stroke, n (%)	15 (0.8)	33 (0.7)	0.874
Psychiatric disorders, n (%)	119 (6.3)	143 (3.2)	<0.001
Hypothyroidism, n (%)	138 (7.3)	62 (1.4)	<0.001
Medications			
Antihyperlipidemic drugs, n (%)	96 (5.1)	240 (5.4)	0.668
Inhaled medications, n (%)	122 (6.5)	199 (4.5)	0.001
Montelukast, n (%)	23 (1.2)	34 (0.8)	0.083
Antihistamine, n (%)	37 (2.0)	57 (1.3)	0.053
Insulin, n (%)	41 (2.2)	67 (1.5)	0.071
Oral antidiabetics, n (%)	278 (14.8)	448 (10.1)	<0.001
Thyroid medications, n (%)	189 (10.0)	87 (2.0)	<0.001
Beta-blockers, n (%)	262 (13.9)	439 (9.9)	<0.001
Calcium channel blockers, n (%)	141 (7.5)	228 (5.1)	<0.001
ACE inhibitors, n (%)	137 (7.3)	269 (6.1)	0.073
Angiotensin receptor blockers, n (%)	85 (4.5)	152 (3.4)	0.042
Diuretics, n (%)	71 (3.8)	107 (2.4)	0.004
Alpha blocker drugs, n (%)	26 (1.4)	67 (1.5)	0.733
NSAI drugs, n (%)	15 (0.8)	19 (0.4)	0.089
Proton pump inhibitors, n (%)	95 (5.0)	162 (3.6)	0.012
Aspirin, n (%)	137 (7.3)	309 (7.0)	0.668
Clopidogrel, n (%)	18 (1.0)	64 (1.4)	0.144
Warfarin, n (%)	10 (0.5)	15 (0.3)	0.276
Psychiatric drugs, n (%)	219 (11.6)	196 (4.4)	<0.001
Antiepileptic drugs, n (%)	16 (0.8)	35 (0.8)	0.878

Data are expressed as mean ± SD unless otherwise stated.
Abbreviations: ACE, Angiotensin converting enzyme; COPD, chronic obstructive pulmonary disease; NSAI, Nonsteroidal anti-inflammatory; OSA, obstructive sleep apnea.

Table 3
Odds ratios for comorbidities associated with female sex in a multivariate logistic regression analysis adjusted for age and obesity.

Symptoms	Odds Ratio	95 % Confidence Interval	p Value
Diabetes mellitus	1.4	1.18–1.57	<0.001
Hypertension	1.2	1.05–1.36	0.006
Asthma	2.3	1.93–2.77	<0.001
Arrhythmia	1.2	0.91–1.54	0.201
Psychiatric disorders	2.3	1.72–2.94	<0.001
Hypothyroidism	5.2	3.74–7.21	<0.001

As shown in Table 5, AHI as well as ODI was significantly elevated in men, whereas women had significantly less total sleep time, less sleep efficiency, and longer sleep latency than men ($p < 0.001$ for each).
When comparing the cohort stratified by the age of 50, as a cut-off for postmenopausal status in women, the occurrence of OSA was higher in the male patients younger than 50 years of age compared with premenopausal female patients (88.1 % vs. 69.1 %; $p < 0.001$). The occurrence was still higher among men above 50 years old than postmenopausal women but the difference was quite small though it was significant (95.2 % vs. 91.2 %; $p < 0.001$). Additionally, OSA severity in women before and after menopause was evaluated and it was found that postmenopausal women had significantly higher AHI (29.9 ± 24.4 vs. 16.9 ± 21.7 , $p < 0.001$) and ODI (33.4 ± 43.3 vs. 18.8 ± 34.4 , $p < 0.001$) than those before menopause.

4. Discussion

This article has reported several features concerning the clinical presentation and polysomnographic findings of OSA in Turkish male and female patients from the ongoing TURKAPNE Study.
To our best knowledge, this is the first, largest, prospective, nationwide cohort study regarding the sex differences in OSA severity, symptoms and comorbidities. We showed that loud snoring and witnessed apnea were more common, and the disorder was more severe in terms of AHI and ODI in men than in women, whereas women were older at the time of the OSA diagnosis and presented more comorbidities in terms of obesity, diabetes mellitus, hypertension, asthma, arrhythmia, psychiatric disorders and hypothyroidism. Thus, there were significant sex-differences and miss-match between the AHI severity and the symptom severity as well as comorbidities.
Previously, two single-center studies from Türkiye reported sex differences in OSA. In the study of Basoglu et al. [11], including 2827 OSA patients, women were also older and more obese, presenting atypical symptoms compared with the men. Comorbidities such as hypertension, diabetes mellitus, hypothyroidism and asthma were also more common in females. In another study, reported by Bostan et al. [12], OSA was prevalent among 589 adults based on home sleep apnea test recordings, and again, women were older and and more obese than men. Women presented more commonly with daytime fatigue, nocturia, headache in the morning, depressive mood and restless legs symptoms than did men. Thus, our current results confirm these previous findings and expand these results to be representative nationwide. One may argue that age and obesity may explain these sex differences. However, our results suggest that the majority of these comorbidities occur in women with OSA independent of age and obesity.
In literature, a few other studies addressed the sex differences in OSA in clinical cohorts. In a retrospective study in China, 580 patients with OSA were evaluated [7]. There were no significant difference in age at diagnosis but women complained more about insomnia, poor sleep quality and headache on awakening than men, while men more commonly reported snoring compared with women. Another retrospective study in Greece included 1010 patients with OSA and found no significant difference in BMI between men and women [22]. Thus, there might be ethnical, cultural and racial differences regarding sex differences in this research area.

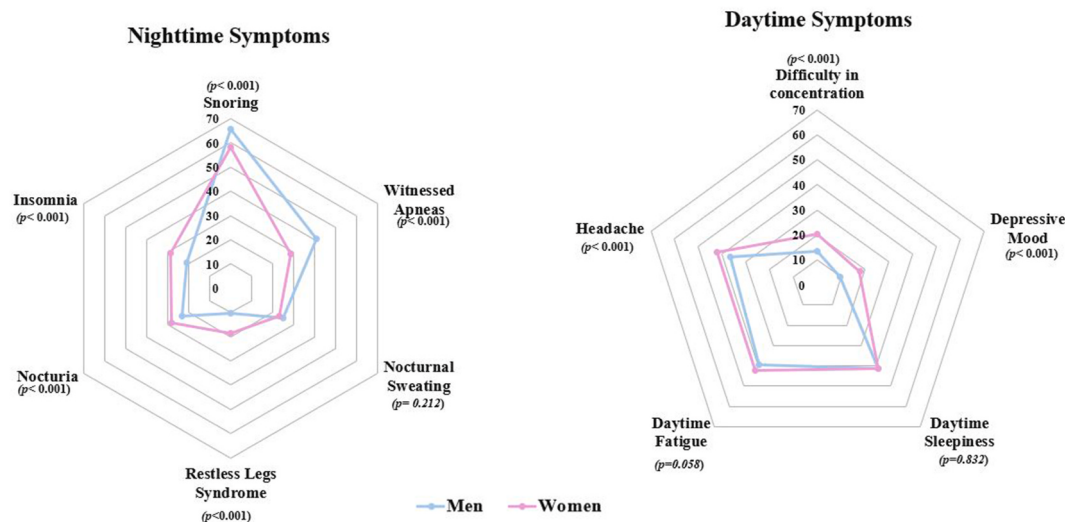


Fig. 3. Radar plot of the distribution of symptoms in female and male patients with OSA. Abbreviation: OSA, obstructive sleep apnea.

Table 4
Odds ratios for symptoms associated with female sex in a multivariate logistic regression analysis adjusted for age and body-mass-index.

Symptoms	Odds Ratio	95 % Confidence Interval	p Value
Snoring	0.6	0.54–0.71	<0.001
Witnessed apnea	0.5	0.43–0.59	<0.001
Daytime sleepiness	0.9	0.80–1.05	0.2
Daytime fatigue	1.0	0.90–1.19	0.6
Headache	1.2	1.06–1.40	0.005
Insomnia	1.4	1.19–1.62	<0.001
Nocturia	0.9	0.75–1.02	0.1
Difficulty in concentration	1.7	1.43–2.05	<0.001
Depressive mood	1.9	1.57–2.33	<0.001
Restless leg syndrome	1.7	1.43–2.10	<0.001

Table 5
Polysomnographic parameters of the female and male participants with OSA (n = 6323).

	Female (n = 1884)	Male (n = 4439)	p Value
AHI, events/h	29.8 ± 24.1	36.8 ± 26.2	<0.001
ODI, events/h	32.9 ± 43	38.8 ± 51.3	<0.001
TST, min	370.4 ± 77.7	378.4 ± 74.4	<0.001
Sleep efficiency, %	81.2 ± 15.8	83.7 ± 17.7	<0.001
Sleep latency, min	30.4 ± 33.6	22.4 ± 26.7	<0.001
REM, % of TST	13.9 ± 7.7	14.2 ± 9.5	0.09
N3, % of TST	25.4 ± 16.4	22.5 ± 15.2	<0.001
Mean SpO ₂ , %	92.4 ± 5.5	92.6 ± 5.2	0.1
Minimum SpO ₂ , %	78.4 ± 11.0	78.4 ± 11.4	0.95
T90, %	7.7 ± 5.6	8.5 ± 5.8	0.2
Mean pulse, min	70.2 ± 14.9	68.2 ± 13.5	<0.001

Data are expressed as mean ± SD unless otherwise stated.
Abbreviations: AHI, apnea hypopnea index; ODI, oxygen desaturation index; OSA, obstructive sleep apnea; REM, rapid eye movement; SpO₂, saturation measured by oximeter; T90, percentage of sleep time with SpO₂ below 90 %; TST, total sleep time.

Previous studies have shown that menopause is a risk factor for OSA in women [18]. For this reason, we think that in many studies like ours, women diagnosed with OSA are older than men with OSA. Prevalence of OSA in women doubles after menopause independently of age and BMI [31]. Our results support these findings and additionally suggest that OSA is more severe after menopause in terms of AHI. Premenopausal women have been suggested to be protected from OSA with more stable respiratory effort in non-REM sleep in response to arousals and hypercapnia [32]. During the menopausal period, the soft tissue collapsibility increases, the respiratory drive as well as arousal threshold decreases, and this condition predisposes to upper airway obstruction [33]. It has also been suggested that postmenopausal women who do not use hormone therapy have higher apneic thresholds than premenopausal females and hormone therapy users resulting in unstable breathing [32]. Of note, the increase in the occurrence of OSA was similar in both men and women after the age 50 years in the current cohort, suggesting the effect of aging per se as a contributing role on the increased collapsibility of the upper airways.

Another explanation for the higher age at OSA diagnosis in women could be that OSA is underrecognized due to atypical symptom presentations. Of note, the symptom burden of OSA was heavier in women though the OSA was less severe in terms of AHI. On the other hand, the categorization of the OSA severity based on the standard OSA metric, AHI, has been questioned during the last decade [28,30]. The new novel OSA metrics such as hypoxic burden, loop gain, arousal threshold, arousal intensity, delta heart rate might also be different in men and women, contributing to the different symptom manifestations. Indeed, endotypic analysis has shown that women have less upper airway collapsibility, better muscle compensation and lower respiratory arousal thresholds [34]. These features have been suggested to explain the relatively shorter durations of obstructive events in women, and more hypopnea events and fewer apnea events and less oxygen desaturation [35]. It has also been argued that women have later onset of OSA than men, but that they experience OSA at a time of quickly increasing cardiovascular risk factors [35].

One of the main explanations of the sex differences in the severity of OSA has been attributed to the increased predisposition to pharyngeal collapse in men. The fact that male airway is longer was proven by measurements from previous studies [20,36]. It has been suggested that men had increased pharyngeal airway length, increased soft palate area, and increased pharyngeal volume. However, no systematic differences were found in pharyngeal dilator muscle activation/responsiveness, or pharyngeal mechanics [20,36]. In a recent review, it has been suggested that sex-specific differences in the pathogenesis and presentation of OSA

reflect differences in responses to hypoxia and CO₂, as well as arousal threshold in addition to body fat distribution and upper airway anatomy [35].

Compared with men, women with OSA reportedly have more endothelial dysfunction and are more likely to develop hypertension and insulin resistance [37–40]. An increased incidence of left ventricular hypertrophy and heart failure were observed in aging women with moderate-to-severe OSA compared with women without OSA; disease incidence was partly explained by elevated plasma levels of high-sensitivity troponin (a marker of subclinical myocardial injury) [41]. Smoking, which causes endothelial dysfunction, seems to amplify the effect of OSA on the risk of incident cardiovascular disease, with the largest effects in women suggesting complex interactions between vascular disease risk factors, OSA and sex [42].

Regarding the polysomnography findings, our results confirm poor sleep quality in women in terms of less total sleep time, longer sleep latency and decreased deep sleep. Though not particularly addressed, these results are supportive for higher occurrence of comorbid insomnia in women than in men [43], which may have effect on adherence to PAP treatment.

The strengths of our study include the sample size of the study cohort, the structured questionnaires regarding symptoms, the gold standard polysomnographic investigations for the OSA diagnosis and the nationwide representatives of the study results.

We should also acknowledge certain limitations. Comorbidities were self-reported and a selection bias can therefore not be excluded. Snoring and witnessed apneas might be underreported among the patients without a bed-partner. The proportion of the participants from the cities and sleep centers were not equally distributed, so there might be some geographical differences between the regions. On the other hand, all sleep centers in the big cities such as Istanbul, Ankara, Izmir and Diyarbakır take care of patients from cities and rural areas and from different regions of the country, so we think that the distribution of the differences is representative nationwide. Similarly, the database does not include economic status of the participants and we can therefore not provide more detailed data between regions. Of note, there are other factors such as differences in health-related behaviors and access to care which may play role on the higher prevalence of comorbidities in women. These factors are not explored in the current manuscript. Finally, data regarding arousal index and periodic leg movements index were optional, and we had no complete data about those variables.

5. Conclusions

Our results suggest significant sex differences in sleep apnea severity, symptom presentations, and polysomnographic features in this large nationwide cohort. Women with OSA seem to have more symptom burden and comorbidities independent of age and obesity despite having a less severe OSA in terms of AHI compared to those findings in men. These aspects should be carefully considered in management of the individuals in order to avoid delay in diagnostic evaluation of OSA in women. Future studies would rely not only on AHI but also the novel parameters such as hypoxic burden, delta heart rate and arousal threshold, which hopefully might suggest how diagnosing OSA in women might benefit from a more holistic assessment.

CRedit authorship contribution statement

Aylin Pihtili: Writing – original draft, Investigation, Formal analysis, Data curation. **Esen Kiyan:** Writing – review & editing, Data curation. **Baran Balcan:** Writing – review & editing, Data curation. **Semih Arbatli:** Writing – review & editing, Data curation. **Aykut Cilli:** Writing – review & editing, Data curation. **Nejat Altintas:** Writing – review & editing, Data curation. **Aylin Özsancağ Ugurlu:** Writing – review & editing, Data curation. **Canan Gündüz Gürkan:** Writing – review & editing, Data curation. **Mehmet Sezai Tasbakan:** Writing –

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Declaration of competing interest

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