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RESEARCH ARTICLE
KLİNİK ÇALIŞMA

Is it important to know the predominant respiratory event in AHI for the management of patients with OSA?

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ABSTRACT

Is it important to know the predominant respiratory event in AHI for the management of patients with OSA?

Introduction: *Obstructive sleep apnea (OSA) is a heterogeneous disorder. The apnea-hypopnea index (AHI) cannot fully reflect this heterogeneity on its own. In this study, the OSA patients were analyzed by grouping them based on the predominant type of respiratory event, and the distinctive findings of each group were evaluated.*

Materials and Methods: *The records of 213 patients with OSA were evaluated retrospectively and the patients were divided into three groups as Group 1 (apnea-predominant OSA; apnea index (AI)≥ 2x hypopnea index (HI) and HI≤ 15/hour), Group 2 (hypopnea-predominant OSA; HI≥ 2xAI and AI≤ 15/hour), and Group 3 [No Respiratory Event-Predominant OSA (NREP OSA)].*

Results: *There were 65 patients in Group 1, 58 patients in Group 2, and 90 patients in Group 3. There was no difference between the groups in terms of sex, age, body-mass index, the distribution of symptoms, and concomitant diseases (p> 0.05). Only witnessed apnea was more frequently described by Group 1 patients (p= 0.042). Except for the higher N2 percentage and arousal index (p= 0.009, p= 0.011, respectively) in those with apnea-predominant OSA compared to those with hypopnea-predominant OSA, there was no difference in sleep architecture. In the apnea-predominant group, while the AHI, apnea durations (p= 0.000, 0.000, 0.000, respectively), total oxygen desaturation index (tODI), NREM ODI and REM ODI were higher (p= 0.000, 0.000, 0.047, respectively), nocturnal minimum oxygen saturation (SpO_2) was lower (p= 0.001).*

Conclusion: *This study concluded that apnea-predominant OSA patients had more severe OSA in terms of AHI, respiratory event durations, and problems in oxygenation. These differences may guide the management of OSA.*

Key words: *Apnea hypopnea index (AHI); apnea-predominant OSA; hypopnea-predominant OSA; no respiratory event-predominant (NREP) OSA; oxygen desaturation index (ODI)*

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ÖZ

OSA'lı hastaların yönetiminde AHİ'deki baskın solunumsal olayın bilinmesi önemli midir?

Giriş: *Obstrüktif uyku apne (OSA) heterojen bir hastalıktır. Apne-hipopne indeksi (AHİ) tek başına, bu heterojeniteyi tam olarak yansıtamamaktadır. Çalışmamızda; OSA'lı hastalar polisomnografide baskın olan solunumsal olayın tipine göre gruplandırılarak analiz edildi ve her bir grubun karakteristik bulguları değerlendirildi.*

Materyal ve Metod: *OSA tanısı (total AHI≥ 15/sa) konulmuş 213 hastanın dosyası retrospektif olarak klinik ve polisomnografik verileri açısından incelendi. OSA'lı hastalar, Grup 1 (apne ağırlıklı OSA; apne indeksi (Aİ)≥ 2x hipopne indeksi (Hİ) ve Hİ≤ 15/sa), Grup 2 (hipopne ağırlıklı OSA; Hİ≥ 2x Aİ ve Aİ≤ 15/sa) ve Grup 3 (solunumsal olay dominansı olmayan -SODO- OSA; diğer solunumsal kriterleri karşılamayan) olmak üzere üç grupta değerlendirildi.*

Bulgular: *Grup 1'de 65, Grup 2'de 58, Grup 3'te 90 hasta vardı. Gruplar arasında cinsiyet, yaş dağılımı (p> 0,05), vücut kitle indeksi açısından fark yoktu (p> 0,05). Apne ağırlıklı OSA'lıların daha sık tarif ettiği tanıklı apne (p= 0,042) semptomu dışında gruplar arasında uykuda solunum bozukluğu ile ilişkili semptomların dağılımı ile eşlik eden hastalıkların sıklığı açısından fark yoktu (p> 0,05). Apne ağırlıklılarda, hipopne ağırlıklılara kıyasla N2 yüzdesi ve arousal indeksi daha yüksek olması (sırasıyla; p= 0,009, p= 0,011) dışında gruplar arasında uyku mimarisi açısında fark yoktu. Hem AHİ hem de apne süreleri, apne ağırlıklılarda diğer iki gruptakilerine kıyasla anlamlı olarak yüksekti (sırasıyla; p= 0,000, 0,000, 0,000), total oksijen satürasyon indeksi (ODİ) ile NREM ODİ ve REM ODİ daha yüksek (sırasıyla; p= 0,000, 0,000, 0,047) ve gece boyu saptanan minimum oksijen satürasyonu (SpO_2) daha düşüktü (sırasıyla; p= 0,001).*

Sonuç: *Apne ağırlıklı OSA'lıların hem AHİ hem de solunumsal olayların süreleriyle oksijenizasyon problemleri açısından daha ciddi OSA'lı olduğunu gördük. Bu farklılıkların OSA tedavisinde de yönlendirici olabileceğini düşünüyoruz.*

Anahtar kelimeler: *Apne hipopne indeksi (AHİ); apne ağırlıklı OSA; hipopne ağırlıklı OSA; solunumsal olay dominansı olmayan -SODO- OSA; oksijen destürasyon indeksi (ODİ)*

INTRODUCTION

Obstructive sleep apnea (OSA) is a disorder characterized by recurrent partial and/or complete collapse of the pharynx during sleep and is also a heterogeneous disorder (1-8).

OSA is diagnosed with the apnea-hypopnea index (AHI), which indicates the number of obstructive respiratory events per sleep hour. However, this definition does not capture the importance of the relatively higher levels of apnea or hypopnea. Although there are studies that identify different OSA phenotypic models, few studies were found to include only respiratory event-based assessment (6-10).

In this study, the OSA patients were analyzed by grouping them based on the predominant-respiratory event.

MATERIALS and METHODS

Out of 355 OSA patients who were retrospectively diagnosed with OSA [Apnea-hypopnea index (AHI)≥ 5/hour] by conducting Type 1 polysomnography (PSG) between January 2016 and November 2018, the records of 213 patients, whose total sleep duration was ≥240 minutes and AHI was ≥15/hour, were retrospectively reviewed and their clinical and polysomnographic data were examined (Figure 1).

This retrospective study was approved by the Local Academic Board and Ethical Committee [number: 2021/430 (2021000430-2)] and was designed in accordance with the Helsinki Declaration.

According to the AHI results, 213 patients included in the study had moderate (AHI= 15-30/hour) and severe OSA (AHI≥ 30/hour).

Apart from the symptoms, body mass index [weight (kilogram)/height^2 (m^2)], diseases such as diagnosed diabetes mellitus (DM), systemic arterial hypertension (HT), coronary artery disease, chronic obstructive pulmonary disease, and gastroesophageal reflux were also registered in patients' files.

All patients were administered supervised overnight Type 1 polysomnography with Comet Plus (Grass Technology, An Astro-Med, Inc. Subsidiary, West Warwick USA). During the PSG recording montage, C3-M2, C4-M1, O1-M2, and O2-M1 derivations were used for the electroencephalography (EEG), and E1-M2, E2-M1 derivations and jaw electromyogram (EMG) were used for the left and right electrooculogram (EOG), oronasal thermistor, thoracic and abdominal respiratory effort (inductive plethysmography), and pulse oximetry.

PSG was scored manually according to standard criteria, including sleep stages and respiratory events, by a single operator certified in sleep disorders (11).

PSG findings included total sleep time (TST) (minutes), sleep efficiency (TST/total time spend in bed X 100) (%), sleep latency (duration from the moment

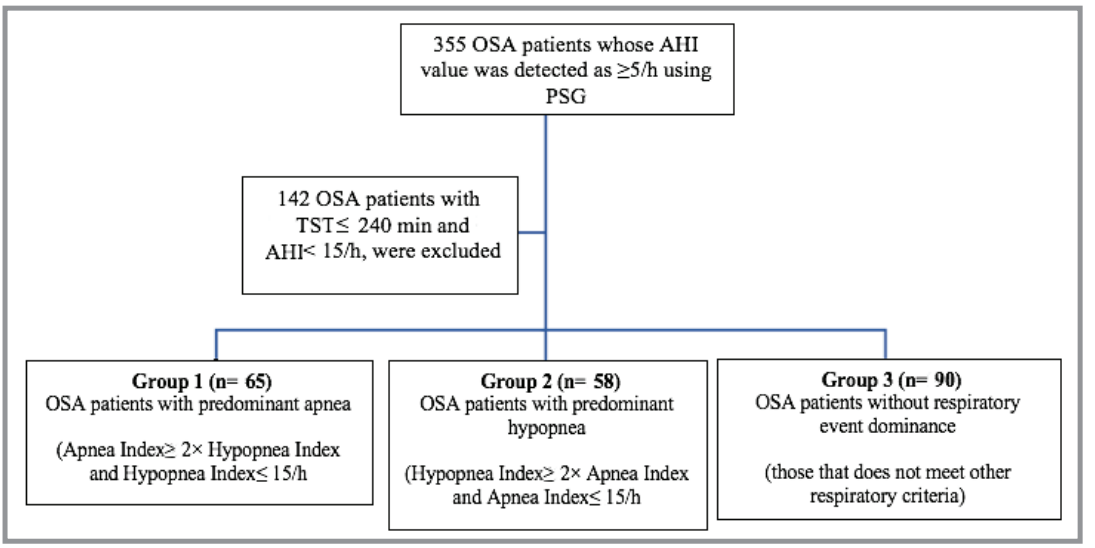

Figure 1. The groups of OSA patients.

sleep recording starts to the epoch in which the first sleep stage is seen, minutes), the percentage of sleep stages to the TST, arousal index (total number of arousal X60/TST), overnight mean oxygen saturation (mean SpO_2), overnight minimum SpO_2, nocturnal oxygen desaturation (spending more than 30% of the night as SpO_2< 90%). The number of episodes of a 3% decrease in the SpO_2 per sleep hour was evaluated as the oxygen desaturation index (ODI) (11).

For respiratory events, apnea was defined as at least a 10-second-long complete interruption in oronasal respiratory flow, hypopnea was defined as a 30% decrease for at least 10 seconds, and arousal in EEG or a 3% or greater decrease in oxygen saturation. Apnea events were categorized as obstructive, mixed, or central based on whether there is a thoracoabdominal movement accompanying the loss of the respiratory event. Apnea index (AI) was defined as the total number of apnea per sleep hour [(obstructive apnea + central apnea + mixed apnea) X 60/TST]; hypopnea index (HI) was defined as the number of hypopnea per sleep hour (hypopnea X 60/TST), and AHI was defined as the total number of apnea and hypopnea per sleep hour [(apnea + hypopnea) X 60/TST] (12).

Patients who had a TST lower than 240 minutes in the PSG, OSA patients with AHI< 15/hour, patients who were pregnant, had active cancer and/or received treatment for this condition, used sedative medications, had an alcohol addiction, used positive airway pressure (PAP) treatment, or were operated due to OSA diagnosis were excluded from the study.

The OSA patients (AHI≥ 15/hour) were evaluated in three groups based on the predominant respiratory event in the AHI: Group 1 (apnea-predominant OSA; AI≥ 2 x HI and HI≤ 15/hour), Group 2 (hypopnea-predominant OSA; HI≥ 2 x AI and AI≤ 15/hour), and Group 3 [No Respiratory Event-Predominant (NREP) OSA; do not meet other specified respiratory criteria)] (Figure 1).

Statistical Analysis

The distribution of the parameters was evaluated with the Shapiro-Wilk test and parameters with normal distribution were given as mean ± SD and intergroup comparison was conducted with a t test or one-way ANOVA test while non-normal parameters were given as median (IQR) and intergroup comparison was conducted with Kruskal-Wallis test. Ordinal parameters were evaluated using the Chi-squared test. A p-value less than 0.05 was deemed significant.

Statistical analyses were performed using SPSS 22.0 (IBM Corp. Armonk, NY, USA). Power analysis was conducted with G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007).

RESULTS

There were 65 patients in Group 1 (16 F/49 M), 58 patients in Group 2 (16 F/42 M), and 90 patients in Group 3 (23 F/67 M). There was no difference between the groups in terms of sex, age, and body-mass index (p= 0.929, 0.689, 0.573, respectively) (Table 1).

Table 1. OSA patients' sex, body mass index, ESS results, and symptom distribution

Parameters	Group 1 (Apnea-predominant OSA) n= 65	Group 2 (Hypopnea-predominant OSA) n= 58	Group 3 (OSA with no respiratory event predominancy) n= 90	p
Age (year)	55.0 ± 11.5 (28-85)	53.3 ± 11.5 (28-77)	54.7 ± 12.9 (19-84)	0.689*
Sex Male n (%)	49 (75.4)	42 (72.4)	131 (74.4%)	0.929**
BMI (kg/m^2)	33.1 ± 6.9 (21.4-56.3)	31.6 ± 5.2 (21.3-41.5)	33.2 ± 6.5 (20.4-50.2)	0.573***
ESS	13.6 ± 4.3 (5-20)	15.3 ± 4.5 (10-20)	15.6 ± 3.5 (10-19)	0.607*
Snoring n (%)	57 (87.7)	44 (75.9)	62 (68.9)	0.240*
Witnessed apnea n (%)	58 (89.3)	43 (74.1)	60 (66.7)	0.042*
Excessive daytime sleepiness n (%)	46 (70.8)	37 (63.8)	58 (64.4)	0.690*
Morning headache n (%)	2 (3.1)	5 (8.6)	1 (1.1)	0.056**
Nocturia n (%)	2 (3.1)	3 (5.2)	1 (1.1)	0.351**

Results were given as mean ± SD (minimum-maximum).
* Results of ANOVA.
** Results of Chi-square test.
*** Results of Kruskal-Wallis test.
ESS: Epworth sleepiness score, BMI: Body mass index.

There was no difference between the patients in terms of normally distributed ESS (p= 0.607) (Table 1). There was no difference between the groups in terms of the distribution of symptoms, except for the witnessed apnea symptom that was often described by apnea-predominant OSA patients (p= 0.042). Although the number of patients with nocturia and morning headache complaints was higher in the hypopnea-predominant group, these numbers were not sufficient for statistical comparison between the groups (Table 1). Furthermore, although there is no statistical difference in terms of the prevalence of diagnosed accompanying diseases (Table 2), the rate of DM, HT, coronary artery disease, and cardiac failure was lower in hypopnea-predominant OSA patients.

Table 2. Distribution of comorbidities in OSA groups

Parameters	Group 1 (Apnea-predominant OSA) n= 65	Group 2 (Hypopnea-predominant OSA) n= 58	Group 3 (OSA with no respiratory event predominancy) n= 90	p*
Diabetes Mellitus	20 (30.8)	17 (29.3)	19 (21.1)	0.540
Hypertension	27 (41.6)	19 (32.8)	30 (33.3)	0.857
CAD	16 (24.6)	8 (12.1%)	12 (13.3)	0.100
Cardiac failure	3 (4.6)	2 (3.4)	3 (3.3)	0.971
COPD	8 (12.3)	5 (8.6)	12 (13.3)	0.605
GERD	7 (10.8)	4 (6.9)	11 (12.2)	0.505

All figures were given as number (percent), *Results of Chi-square test.
CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease, GERD: Gastroesophageal reflux disease.

Table 3. OSA groups' polysomnographic findings

Parameters	Group 1 (Apnea-predominant OSA) n= 65	Group 2 (Hypopnea-predominant OSA) n= 58	Group 3 (OSA with no respiratory event predominancy) n= 90	p*
TST (minutes)	340.4 ± 53.6 (241.5-490.0)	336.8 ± 44.6 (263.5-424.5)	344.8 ± 58.6 (242.0-486.9)	0.667
SE (%)	81.1 ± 13.9 (77.7-84.6)	79.8 ± 14.9 (75.8-83.7)	80.3 ± 11.8 (77.9-82.8)	0.593
SO (minutes)	8.9 ± 11.6 (6.1-11.9)	10.5 ± 12.6 (7.2-13.8)	10.1 ± 12.3 (7.5-12.7)	0.791
N1 (TST %)	4.5 ± 6.1 2.9-5.9	9.1 ± 3.7 1.8-16.5	5.1 ± 7.2 3.6-6.6	0.529
N2 (TST %)	61.5 ± 12.9 (33.9-87.8)	55.0 ± 12.9 (2.4-85.4)	58.5 ± 28.2 (16.5-64.4)	**0.019**
N3 (TST %)	13.4 ± 25.4 (7.1-19.8)	13.9 ± 11.4 (10.9-16.9)	13.1 ± 9.3 (0.0-15.0)	0.105
REM (TST %)	7.5 ± 6.1 (5.9-8.9)	8.7 ± 6.5 (7.0-10.4)	7.1 ± 4.9 (6.0-8.1)	0.261
WASO (minutes)	61.5 ± 44.3 (50.6-725)	71.6 ± 49.7 (58.5-84.6)	96.4 ± 15.3 (65.5-127.2)	0,169
ArI (per hour)	21.9 ± 18.2 (2.4-26.5)	13.6 ± 12.5 (2.5-16.9)	14.3 ± 11.7 (11.9-16.8)	**0.016**

All results were given as mean ± SD (minimum-maximum), * Results of Kruskall-Wallis test.
TST: Total sleep time, SE: Sleep efficiency, SO: Sleep on-set latency, Sleep stages N1, N2, N3, REM (% of TST), WASO: Wake after sleep onset, ArI: Arousal index.
Significant results are written in bold.

There was no difference between NREP-OSA patients, and both apnea-predominant and hypopnea-predominant OSA patients in terms of sleep macro-architecture. However, apnea-predominant patients had a higher stage N2 percentage and arousal index compared to hypopnea-predominant patients (p= 0.009, p= 0.011, respectively) (Table 3).

AHI was significantly higher in apnea-predominant patients compared to the patients in the other two groups (p= 0.000, 0.000, respectively). Similarly, AHI was higher in those with NREP-OSA compared to those with hypopnea-predominant OSA (p= 0.000). It was determined that 83.1% of the apnea-predominant patients (54/65), 27.6% of the hypopnea-predominant patients (16/58), and 55.6% of the NREP-OSA patients (50/90) had severe OSA (AHI≥ 30/hour) (Table 4).

The mean NREM and REM apnea duration was higher in the apnea-predominant group compared to OSA patients in the other two groups (p= 0.000, 0.000, 0.000, 0.000, respectively) (Table 4).

The mean REM hypopnea duration was higher in hypopnea-predominant patients and NREP-OSA patients compared to the apnea-predominant patients (p= 0.001, 0.000) (Table 4).

Total ODI, NREM ODI, and REM ODI were higher (p= 0.000, 0.000, 0.000, 0.001, respectively) and nocturnal minimum SpO_2 was lower (p= 0.001, 0.003, respectively) in apnea-predominant patients compared to hypopnea-predominant patients and NREP-OSA patients. While there was no difference between Group 1 and Group 2 in terms of mean SpO_2 (p= 0.355), NOD percentage was higher in Group 1 patients compared to patients in Group 2 and Group 3 (p= 0.022, p= 0.000, respectively). Additionally, there was no significant difference between Group 2 and Group 3 in terms of oxygen records (Table 4).

Table 4. OSA groups' respiratory findings in the polysomnography

Parameters	Group 1 (Apnea-predominant OSA) n= 65	Group 2 (Hypopnea-predominant OSA) n= 58	Group 3 (OSA with no respiratory event predominancy) n= 90	p*
AHI (per hour)	56.5 ± 25.1 (19.0-106.4)	23.2 ± 8.5 (15.2-55.5)	32.4 ± 18.1 (15-89.5)	**≤0.001***
Severity of OSA				
Moderate (n)	11	42	40	**≤0.001***
Severe (n)	54	16	50	
Mean NREM apnea duration (sec)	22.6 ± 7.8 (13.3-49.0)	16.6 ± 15.3 (11.6-21.5)	15.1 ± 3.3 (10.3-23.2)	**≤0.001***
Mean REM apnea duration (sec)	20.2 ± 10.9 (10.0-54.5)	10.4 ± 10.2 (10.0-44.3)	11.5 ± 8.7 (10.0-30.2)	**≤0.001***
Mean NREM hypopnea duration (sec)	21.1 ± 4.9 (10.0-21.8)	18.0 ± 4.4 (10.0-27.1)	17.9 ± 3.9 (11.9-33.5)	**0.044***
Mean REM hypopnea duration (sec)	17.1 ± 13.8 (1.0-64.8)	17.7 ± 10.6 (10.0-38.5)	24.5 ± 21.7 (10.0-31.2)	**0.002***
Mean nocturnal SpO_2 (%)	87.1 ± 15.7 (81.4-96.0)	91.2 ± 3.6 (80.3-94.7)	92.1 ± 2.9 (82.7-97.0)	**0.206***
Mean minimal SpO_2 (%)	70.5 ± 12.4 (50.0-86.0)	75.7 ± 14.5 (71.0-89.0)	77.2 ± 9.0 (51.0-89.0)	**0.001***
ODI NREM	39.9 ± 25.2 (30.7-49.2)	19.9 ± 14.0 (15.3-24.5)	23.3 ± 20.2 (17.2-29.4)	**≤0.001***
ODI REM	31.3 ± 24.3 (22.4-40.3)	18.4 ± 23.2 (10.9-25.9)	21.6 ± 22.6 (14.7-28.5)	**0.047***
Total ODI (per hour)	36.9 ± 23.8 (28.1-45.6)	19.7 ± 18.0 (13.9-25.6)	20.6 ± 16.3 (15.6-25.5)	**≤0.001***
NOD %	30.6 ± 28.5 (1.2-86.7)	22.7 ± 27.9 (0.1-97.1)	18.6 ± 26.2 (0.0-99.6)	**0.013***

Results were given as mean ± SD (minimum-maximum).
* Kruskal-Wallis test.
** Chi-square test.
Significant results are written in bold.
AHI: Apnea-hypopnea index, SpO_2: Oxygen saturation, ODI: Oxygen desaturation index, NOD: Nocturnal oxygen desaturation.

Power Analysis

A post hoc analysis was performed for ANOVA studies using the following variables: Study population of 213 cases, three groups, medium effect size (f= 0.25), alpha= 0.05, and observed power was calculated as 0.91.

DISCUSSION

The categorization, which was made based on the type of predominant respiratory event in OSA patients showed that those with apnea-predominant OSA were more severe cases in terms of PSG parameters, including high AHI and deep nocturnal deoxygenation. It was also found that these patients were associated with proportionately more frequent comorbidities. However, DM rates in the hypopnea-predominant group with lower mean AHI were similar to that of the other groups in the study, which is considered an important finding for the follow-up of these patients. We predicted that the evaluation of patients as a separate OSA phenotype according to the predominant respiratory event may be important in terms of long-term outcomes.

Today, AHI, which is identified as the total number of apnea and hypopnea per sleep hour measured in PSG, is actively used in the diagnosis and rating of OSA. However, the other PSG parameters are not used in the diagnosis and rating of OSA. Besides,

there is not enough data on this subject (5,12). On the other hand, we think that using not only the number of respiratory events, but also the predominant types, durations, and hypoxemia rating in the diagnosis of OSA and estimation of clinical results would be important in determining OSA phenotypes. In fact, while some of the patients with similar AHI results can predominantly have apnea, others can predominantly have hypopnea, in short, there can be different apnea/hypopnea rates.

Unlike the studies of Nakayama (5), Lacedonia (6), Zinchuk (7), and Jooosten (9) et al., our study did not use a cluster analysis based on PSG measurements other than AHI. We compared sleep architecture, respiratory event duration, oxygenation parameters, and accompanying diseases in OSA patients based on the predominant respiratory event apart from AHI, without a cluster analysis.

Lacedonia et al. (6) identified three groups using cluster analysis on 198 OSA patients. They found that HT was associated with nocturnal hypoxemia parameters rather than AHI in Group 1, which included patients who had morbid obesity, were younger, and had more severe OSA. Similarly, they showed that hypoxemia level associated with sleep was independently related to mortality in patients with moderate and severe OSA who were monitored prospectively (13).

Zinchuk et al. (7) identified seven patient clusters in their study. Traditionally, they have described different OSA phenotypes in the AHI-based severe OSA group (AHI≥ 30), including a cluster of patients with severe [apnea predominance (accompanied by desaturation and arousals)] OSA combined with hypopnea and hypoxia, arousal, and poor sleep. While the sleep architecture was partially preserved in the hypopnea and hypoxia group within these patient clusters, the number of arousals was high and the sleep architecture was significantly impaired in those with apnea predominance, as it was in our study. The literature showed that in cases of OSA diagnosis, important changes occur in the normal sleep macro-architecture, which includes sleep percentages and TST, due to frequent and repetitive sleep fragmentation and arousals (14,15). It was observed that these changes in the sleep architecture were often correlated with the severity of OSA (15). We also showed that there was a difference between hypopnea-predominant OSA patients and apnea-predominant OSA patients in terms of sleep macro-architecture. Both the stage N2 percentage and the arousal index, which suggests more frequent sleep fragmentations that are associated with higher AHI were higher in patients with apnea-predominant OSA. This result was consistent with the results of studies that compared severe OSA patients and mild OSA patients (15). Arousals are stimuli that terminate the respiratory event accompanied by hypoxemia and/or hypercapnia by increasing the ventilatory drive (5). When the ventilatory drive finally reaches the arousal threshold, respiratory effort-related arousal develops. Similar to the literature (16), we assumed that although there is a low threshold for arousal in hypopnea-predominant groups, apnea, which leads to an increase in ventilatory response with deeper hypoxemia and/or hypercapnia it causes, is responsible for more frequent arousal development.

Unlike the results of our study, Zinchuk et al. (7) showed in their study that hypoxia was more distinctive with hypopnea; however, desaturation was not predominant in the apnea-predominant group. In fact, in terms of these differences, whether the arousal physiologically develops before (if arousal develops before the airway is opened, hypoxia will be more distinctive) or after the opening of the airway is a very determinative factor.

Recurrent hypoxemia/reoxygenation (intermittent hypoxia) overnight, and sympathetic nervous system activation which are associated with respiratory events in OSA patients can cause cardiac complications such as hypertension and coronary artery disease and metabolic complications such as DM (6,7,10). Previous studies also showed that these complications are often associated with high AHI values and intermittent hypoxia, systemic inflammation, and endothelial dysfunction, which are caused by high AHI values (10,13,17). On the other hand, categorizing patients based only on their AHI values even though they have different physiological characteristics, can lead to erroneous decisions (7).

There are only a few studies in the literature that perform an evaluation based only on the type where the respiratory event is predominant, like in our study. Park et al. (10) evaluated 860 OSA patients in three groups based on apnea or hypopnea predominance, or both apnea and hypopnea predominance in their PSG, through an approximately 10-year retrospective assessment and investigated cardiovascular prevalence and risk factors in patients. As a result, they

determined that the hypopnea index was a more significant risk factor for coronary artery disease compared to the apnea index. Mathew et al. (18) showed that OSA patients with a BMI of higher than 45 had higher hypopnea-apnea rates. They explained this situation with the fact that flow limitation was related to dynamic obstruction in patients with extreme obesity and stated that hypopnea-predominant OSA patients with extreme obesity needed a high PAP. In 2020, Kim et al. (14) analyzed 4603 patients, who were admitted to the sleep center and were administered a PSG, to both categorize OSA phenotypes and to evaluate cardiovascular mortality differences in these phenotypes. They categorized patients into four groups based on their PSG variables. They determined that cardiovascular mortality was higher, especially in the groups with severe OSA and nocturnal hypoxemia. Similarly in our study, it was observed that cardiovascular diseases such as hypertension, and coronary artery disease were more common in apnea-predominant OSA patients and there were various cardio-metabolic complications in all groups. However, there was no statistical difference in terms of accompanying systemic disease diagnosed based on the type of predominant respiratory event. It was remarkable that the hypopnea-predominant group with similar sex and age distribution and BMI, but a lower number of severe OSA patients and lower nocturnal hypoxemia had a similar rate of DM, which is an important metabolic comorbidity, with the apnea-predominant group. It was suggested that the hypopnea-predominant group should be monitored as carefully as the apnea-predominant group, especially in terms of systemic results.

Nakayama et al. (5) determined in their study that if the apnea fraction (F_{apnea}) was high, the upper airway would more easily collapse, and these patients would often have a tendency to have severe OSA, similar to the literature (16). These results can be consistent with the high AHI values in the apnea-predominant patients in our study.

When the durations of respiratory events were compared between groups in this study, it was observed that mean apnea durations of apnea-predominant patients in all sleep stages were both longer than 20 seconds and mean apnea durations in other groups. Durations of respiratory events longer than average indicate an increased arousal threshold with desaturation (16).

ODI is an indicator of intermittent hypoxia. Similar to the literature (10), in our study, both total ODI and NREM and REM ODI's and NOD percentages were higher and nocturnal minimum SpO_2 was lower in the apnea-predominant group compared to the other two groups. Although hypopnea and hypoxia were found more prominently in the traditional severe OSA group in a previous study (7), nocturnal oxygenation parameters were significantly lower in the OSA group with predominant apnea in our study.

In this study, we determined that the most fundamental differences between the three groups, including AHI values and nocturnal oxygenation, were mainly determined by the predominant respiratory type, apnea or hypopnea. It was shown that both the AHI value and the rate of severe OSA patients were higher in NREP-OSA patients compared to the hypopnea-predominant group; however, nocturnal oxygenation parameters were closer to the hypopnea-predominant group. Also, the rates of accompanying systemic diseases were similar between these two groups.

It was shown that OSA prevalence increased with age (19). We found that the mean age of all three groups was over 50 years, which was consistent with the literature, and there was no difference between the groups. The rate of male patients was three times higher than the rate of female patients in all groups, which is also consistent with the literature (20,21). There are studies showing that hypopnea is dominant in female OSA patients (10,21); however, in this study, the rate of female-male distribution was similar between groups.

There are strong connections between obesity and OSA and many PSG parameters are correlated with OSA. However, there is no linear relationship between obesity and OSA and the severity of its symptoms (6). However, approximately 58% of the patients with AHI≥ 15 had obesity in the literature (22). Similarly, we also found that the mean BMI was above 30 in all three groups. Unlike the study showing that hypopnea was the predominant respiratory event, especially in those with high BMI (18), there was no difference in terms of BMI between groups in our study.

Cardinal symptoms of OSA patients are snoring, witnessed apnea, and excessive daytime sleepiness (23). Ye et al. (23) used the AHI≥ 15 criterion, as we did in our study, and identified the subtypes of OSA patients

by performing a cluster analysis based on symptoms on patients with similar age, BMI, and OSA severity, out of a cohort of 822 patients. They found that the group with minimal symptoms had higher cardiovascular comorbidity. Similar to the classic information, in this study, snoring, and excessive daytime sleepiness were observed frequently; however, witnessed apnea complaint was statistically higher in apnea-predominant OSA patients. Higher AHI and Arl values in this patient group may have had an effect in this situation. Moreover, there was not a group that had no symptoms among the patients who applied to get a PSG. In the literature, there are some studies showing that OSA patients with nocturnal hypoxia and more prominent sleep deprivation have more complaints of morning headache, regardless of the type of pathological respiratory event (24,25). In addition, it has been shown that laboratory parameters such as age, gender, comorbidities, AHI level, Arousal index, and nocturnal oxygen saturation may have an effect on the frequency of nocturia symptoms in OSA patients (26). In our study, the presence of symptoms such as morning headache and nocturia was not routinely questioned in patients who underwent PSG. It was based on the reporting of patients with these complaints. Although the number of patients with nocturia and headache complaints was higher in the hypopnea-predominant group, these numbers were not sufficient for statistical comparison between the groups. We think that the effects of pathological respiratory events on the distribution of symptoms can be discussed in new studies examining the symptoms of patients with OSA in more detail.

Being single-centered and retrospective are among the limitations of our study. Another limitation of this study is that it did not group the respiratory events according to patients' position and sleep stage, and it did not use periodical leg exercises, which can affect the sleep macro-architecture, within the PSG variables. The fact that this study mainly included moderate-severe OSA patients with treatment indications and mild OSA patients were not included was among the limitations. Additionally, patients' accompanying diseases were completely based on their statements, and no separate diagnostic procedure was carried out for this matter. Therefore, the frequency of accompanying diseases may be missing. Moreover, since this study did not include patients' treatment stage, PAP pressure or model needed in patient groups and differences in patients' compliance with treatment are not known.

In conclusion, we suggest that in addition to AHI, some parameters such as indicating the type of respiratory events in addition to AHI should be used for the optimal management of OSA.

Ethical Committee Approval: The approval for this study was obtained from Ankara University Faculty of Medicine Clinical Research Ethical Committee [Decision No: 2021/430 (2021000430-2) Date: 13.12.2021].

CONFLICT of INTEREST

The authors declare no conflicts of interest.

AUTHORSHIP CONTRIBUTIONS

Concept/Design: BG, TA

Analysis/Interpretation: BG, BB, SA, TA

Data acqusition: BG, BB, SA, TA

Writing: BG, BB, SA, TA

Clinical Revision: BG, TA

Final Approval: BG, TA

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