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Original Article

Positional Obstructive Sleep Apnea and Periodic Limb Movements During Sleep: A Large Multicenter Study

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Objectives. The relationships among positional obstructive sleep apnea (POSA), obstructive sleep apnea (OSA), and periodic limb movements during sleep (PLMS) remain unclear. We investigated these relationships with respect to the severity of OSA and explored the underlying mechanisms.

Methods. We retrospectively reviewed 6,140 eligible participants who underwent full-night diagnostic polysomnography at four clinical centers over a 5-year period, utilizing event-synchronized analysis. We evaluated the periodic limb movement index (PLMI) and the periodic limb movement with arousal index (PLMAI). The impacts of POSA on the PLMI, PLMAI, and PLMS were analyzed in relation to the severity of OSA.

Results. The mean PLMI, the mean PLMAI, and the prevalence of PLMS were significantly lower in participants with severe OSA compared to the mild and moderate OSA groups. The mean PLMI among those with mild OSA exceeded that of control participants. Furthermore, the mean PLMI (4.8±12.7 vs. 2.6±9.8 events/hr, $P<0.001$), the mean PLMAI (0.9±3.7 vs. 0.5±3.3 events/hr, $P<0.001$), and the prevalence of PLMS (11% vs. 5.3%, $P<0.001$) were higher in patients with POSA than in those with non-positional OSA. This PLMS finding was particularly pronounced among those with severe OSA (odds ratio [OR], 1.554; 95% confidence interval [CI], 1.065–2.267) and was less evident in the mild (OR, 0.559; 95% CI, 0.303–1.030) and moderate (OR, 1.822; 95% CI, 0.995–3.339) groups.

Conclusion. Patients with POSA, especially those with severe OSA, exhibit a comparatively high prevalence of PLMS. In cases involving prominent PLMS, the diagnosis and treatment of POSA and OSA should be considered.

Keywords. *Obstructive Sleep Apnea; Sleep Apnea Syndromes; Periodic Limb Movement Disorder; Excessive Sleep-Related Periodic Leg Movements; Supine Position*

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INTRODUCTION

Periodic limb movements during sleep (PLMS) refer to periodic episodes of repetitive, highly stereotyped involuntary movements of the lower extremities [1]. These movements may be associated with arousal, and although PLMS is not typically linked to insomnia, it can lead to fragmented sleep and excessive daytime sleepiness [1,2]. PLMS is observed in patients with various sleep-related disorders, including restless leg syndrome (RLS), rapid eye movement sleep behavior disorder (RBD), and obstructive sleep apnea (OSA) [3]. For instance, PLMS has been found in 80% of patients with RLS, 70% of those with RBD, and 19.7% of those with OSA [4-8].

The third edition of the International Classification of Sleep Disorders stipulates that a diagnosis of periodic limb movement disorder (PLMD) is appropriate when PLMS occurs at a frequency exceeding 15 times per hour and is accompanied by sleep disturbances or functional impairment, in the absence of other sleep disorders [9,10]. The prevalence of PLMD in the general population ranges from 3.9% to 11% [8,11,12]. PLMD may be indicative of autonomic system dysregulation and/or inflammation and has been associated with an increased risk of cardiovascular and cerebrovascular diseases [13]. Additionally, medical conditions such as diabetes and migraine have been linked to PLMD [14].

OSA is characterized by upper airway obstruction that leads to recurrent episodes of cessation or reduction of airflow during sleep [15]. A diagnosis of OSA is established when the apnea–hypopnea index (AHI) exceeds 5 events per hour [15]. While the hypoxic effect, arousal intensity, and other metrics can also be used to diagnose OSA, the AHI has been shown to correlate more strongly with cardiovascular outcomes [16,17]. Although OSA and PLMS exhibit a known association, the specifics of their relationship have yet to be fully elucidated [6]. However, a low arousal threshold is a common feature of both OSA and PLMS, which may suggest a connecting factor between the two conditions [18]. PLMS occurs more frequently in individuals with mild OSA compared to those without OSA, yet it is much less common in those with severe OSA than in individuals without the disorder [19,20].

OSA can be categorized into different subtypes based on sleeping position. The Cartwright classification defines positional obstructive sleep apnea (POSA) as occurring when the AHI in the supine position is at least twice as high as in the non-supine position [21]. POSA represents a large proportion of OSA cases. The position in which a patient sleeps can influence the effectiveness of treatments for POSA, such as continuous positive airway pressure (CPAP) therapy and surgical interventions [22,23]. While POSA may coexist with other sleep disorders, no direct link has been established between POSA and PLMS. Nevertheless, a Danish study examining sleep positions in relation to the degree of body movements—including those of the arms, thighs, and upper back—found that a preference for the lateral sleep position increased with age and body mass index (BMI). The study also noted that the extent of nocturnal body movements correlated with factors such as sex, age, BMI, and smoking status [24]. Given that age, sex, and BMI are recognized risk factors for OSA, the sleep positions of OSA patients might be associated with their patterns of nocturnal body movement. Furthermore, body weight unloading and positional changes can influence the threshold for spinal root muscle response. Consequently, associations have been observed between either PLMS or low spinal flexor reflex thresholds and increased spinal cord excitability in response to changes in position [25,26].

Although several studies have reported associations between OSA and PLMS [3,6,20], research comparing the prevalence and risk of PLMS with a control group that does not have OSA, based on OSA severity and POSA status, is lacking. Therefore, our main objectives were to compare the status of PLMS according to the severity of OSA and to evaluate the relationship between PLMS and POSA.

HIGHLIGHTS

- We investigated the associations among positional obstructive sleep apnea (POSA), obstructive sleep apnea (OSA), and periodic limb movements during sleep (PLMS) in relation to the severity of OSA.
- We retrospectively reviewed raw polysomnography data of 6,140 participants from a multicenter database, utilizing event-synchronized analysis.
- POSA may increase the prevalence of PLMS, especially in patients with severe OSA.
- If PLMS are suspected, it is crucial to assess the status of POSA and ascertain the severity of OSA.

MATERIALS AND METHODS

The study protocol was approved by the Institutional Review Committee of Seoul National University Hospital (Seoul, Republic of Korea; No. C-2007-179-1143), Seoul National University Bundang Hospital (Seongnam, Republic of Korea; No. B-2010/640-401), and Hallym University College of Medicine (Chuncheon, Republic of Korea; No. 2020-03-022). Written informed consent was waived because the data were collected in a de-identified manner.

Data collection

This retrospective study used data from 6,140 patients who complained of sleep apnea or snoring and were recruited at four clinical centers (Seoul National University Hospital, Hallym University Hospital, Seoul Sleep Center, and Lee & Hong Otorhinolar-

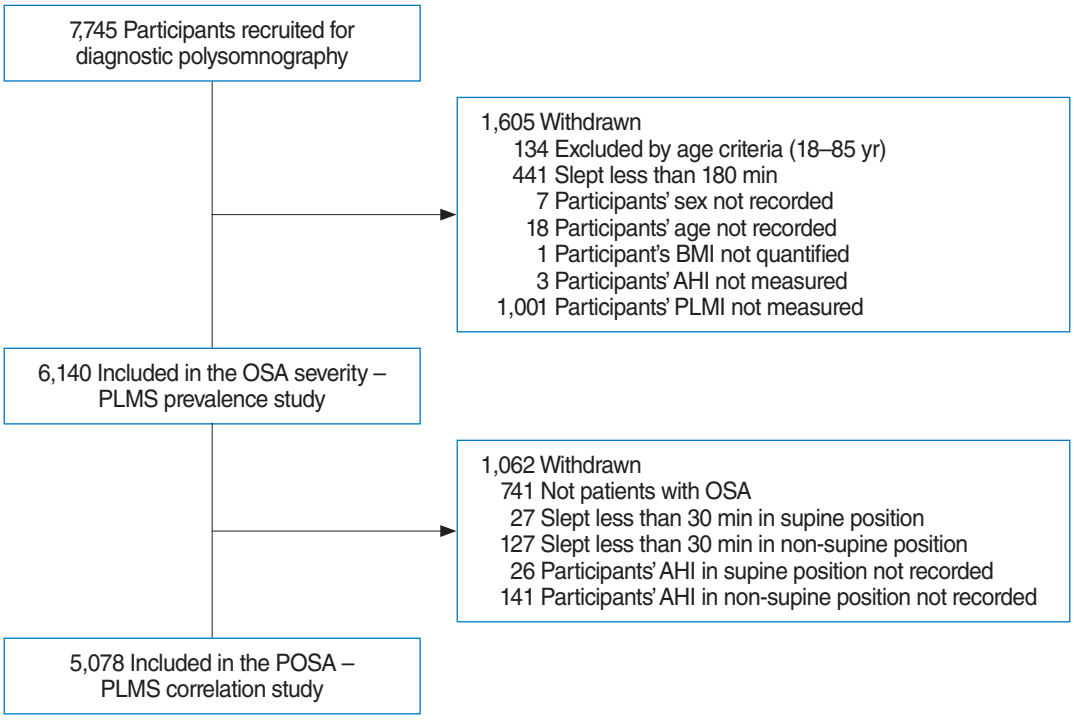

Fig. 1. Study flowchart. BMI, body mass index; AHI, apnea–hypopnea index; PLMI, periodic limb movement index; OSA, obstructive sleep apnea; PLMS, periodic limb movements during sleep; POSA, positional obstructive sleep apnea.

yngology Clinic) from January 2013 to December 2020. Full-night standard polysomnography (PSG) and demographic data were collected. For the analysis of OSA severity and PLMS prevalence, participants who were younger than 19 years old, older than 86 years old, had a total sleep time of less than 180 minutes, missed demographic and polysomnographic data (sex, age, BMI, AHI, and periodic limb movement index [PLMI]) were excluded. In addition, participants not diagnosed with OSA, slept less than 30 minutes in each position, and those without AHI data in each position were excluded for the analysis of correlation between POSA and PLMS (Fig. 1).

PSG data collection

A maximum of 21 data streams including electroencephalography, electrooculography, electrocardiography, nasal flow, breathing effort, pulse oximetry, and electromyography of the right and left tibialis anterior muscles were recorded during PSG. Raw data were interpreted by sleep technicians or sleep specialists and annotated in the PSG reports. All sleep, respiratory, and motor events were scored using the American Academy of Sleep Medicine Manual version 2.4 or 2.6 for the Scoring of Sleep and Associated Events during PSG [27].

PLMS and POSA

Limb movements were identified on the electromyograms of both tibialis anterior muscles. Limb movement was defined as an increase of more than 8 μV in the resting voltage that was sustained for 0.5–10 seconds [28,29]. A PLMS series was defined as four consecutive limb movements with 5–90 seconds between movements. If the interval between two limb movements was <5 seconds, these were considered as a single movement. Respiratory event-related limb movements were not considered as periodic limb movements; such movements occurred between 0.5 seconds before the start of a respiratory event to 0.5 seconds after the end of the event. A PLMI of at least 15 per hour was considered to indicate PLMS [27,30].

Apnea events were defined by drops in the oronasal thermal sensor exceeding 90% of the pre-event baseline levels, and hypopnea events were defined by drops in signal excursion exceeding 30% that persisted for >10 seconds [30]. The AHI was calculated by dividing the total number of apnea and hypopnea events by the total sleep time [30]. We used the Cartwright definition of POSA [31]; thus, the condition was present when difference of 50% or more in AHI between supine and non-supine positions.

Statistical analysis

All statistical analyses were performed using SPSS version 26.0 for Windows (IBM Corp.). One-way analysis of variance, independent *t*-tests, and chi-square tests were performed as appropriate to analyze participant distributions and compare means and standard deviations of PLMI, PLMAI, and PLMS. Logistic regression was performed to calculate odds ratios (ORs) for PLMS according to OSA phenotype and severity. Among parametric

Table 1. Baseline patient characteristics

Characteristics	Total	Control (AHI<5)	Mild OSA (5≤AHI<15)	Moderate OSA (15≤AHI<30)	Severe OSA (30≤AHI)	*P*-value
Number of cases	6,140	784	941	1,280	3,135	<0.001
Age (yr)	45.09±14.21	35.65±13.37	42.51±14.26	46.45±13.97	47.66±13.37	<0.001[a]
BMI (kg/m^2)	25.56±4.04	22.57±3.11	24.06±3.43	25.03±3.41	26.97±4.04	<0.001[a]
Male (%)	78.5	49.7	68.2	78.1	88.9	<0.001[b]
TST (min)	302.53±62.84	322.72±61.11	319.40±60.63	313.22±62.23	288.05±60.63	<0.001[a]
AHI (events/hr)	35.57±27.03	1.96±1.46	9.76±2.97	22.20±4.31	57.18±19.93	<0.001[a]
Exhibiting POSA (%)	70.2	-	85.9	84.3	59.8	<0.001[b]

Values are presented as mean±standard deviation unless otherwise indicated.
AHI, apnea–hypopnea index; OSA, obstructive sleep apnea; BMI, body mass index; TST, total sleep time; POSA, positional obstructive sleep apnea.
[a]Analysis of variance. [b]Chi-square test.

Table 2. Relationship between periodic limb movements during sleep and the severity of OSA

Parameter	Total (n=6,140)	Control (n=784)	OSA			*P*-value
			Mild (n=941)	Moderate (n=1,280)	Severe (n=3,135)	
PLMI (events/hr)	4.22±12.02	4.29±11.35	6.10±16.05	5.26±14.27	3.21±9.38	<0.001[a]
PLMAI (events/hr)	0.84±3.67	1.38±4.69	1.26±3.92	1.06±4.46	0.50±2.82	<0.001[a]
PLMS (%)	9.3	8.7	13.1	11.4	7.4	<0.001[b]

Values are presented as mean±standard deviation unless otherwise indicated.
OSA, obstructive sleep apnea; PLMI, periodic limb movement index; PLMAI, periodic limb movement with arousal index; PLMS, periodic limb movements during sleep.
P-values obtained through [a]analysis of variance and [b]chi-square test were used to compare the mild, moderate, and severe OSA groups.

tests, Bonferroni post-hoc test was performed considering equal variance and unequal sample size [32]. Significance was determined at $P<0.05$.

RESULTS

A total of 7,745 participants who underwent diagnostic PSG were initially evaluated. After excluding those lacking data on age, sex, BMI, or PLMI, 6,140 participants remained for inclusion. For the analysis examining the correlation between PLMS and POSA, 5,078 patients with OSA were included after further exclusions (Fig. 1). Baseline characteristics of the participants, including mean age, sex, BMI, mean total sleep time, and mean AHI, are presented in Table 1. The proportion of POSA varied significantly among subgroups categorized by OSA severity.

Relationship between PLMS and the severity of OSA

PLMI, PLMAI, and PLMS values are summarized by OSA severity in Table 2. The mean (±standard deviation) PLMI and PLMAI were 4.22 (±12.02) and 0.84 (±3.67), respectively. The prevalence of PLMS was 9.3%. The mean PLMI values for the control group and the mild, moderate, and severe OSA groups were 4.29 (±11.35), 6.10 (±16.05), 5.26 (±14.27), and 3.21 (±9.38), respectively. Notably, the mean PLMI was significantly lower among patients with severe OSA than among both the mild and moderate OSA groups, while it did not differ significantly from the control group ($P=0.146$). The mean PLMI for patients with mild OSA was significantly higher than that of the control group ($P=0.010$). However, no significant differences in PLMI were observed between the control group and those with moderate to severe OSA. The mean PLMAI was significantly lower among patients with severe OSA than in the other OSA groups; however, no significant difference was observed between the control group and those with mild or moderate OSA. The prevalence of PLMS decreased significantly with increasing OSA severity: 13.1% in the mild OSA group (OR, 0.952; 95% confidence interval [CI], 0.677–1.340; $P=0.779$), 11.4% in the moderate group (OR, 0.600; 95% CI, 0.427–0.842; $P=0.003$), and 7.4% in the severe group (OR, 0.327; 95% CI, 0.233–0.459; $P<0.001$), as shown in Table 3.

Table 3. Risk of periodic limb movements during sleep according to the severity of OSA

OSA severity	Total	PLMS (No. %)	OR (95% CI)[a]	*P*-value
Control	784	68 (8.7)	-	-
Mild	941	123 (13.1)	0.952 (0.677–1.340)	0.779
Moderate	1,280	146 (11.4)	0.600 (0.427–0.842)	0.003
Severe	3,135	233 (7.4)	0.327 (0.233–0.459)	<0.001

OSA, obstructive sleep apnea; PLMS, periodic limb movements during sleep; OR, odds ratio; CI, confidence interval.
[a]Odds ratios were adjusted for sex, age, and body mass index.

Table 4. Effects of POSA on periodic limb movements during sleep

Parameter	Total			Mild OSA (5≤ AHI <15)			Moderate OSA (15≤ AHI <30)			Severe OSA (30≤ AHI)		
	POSA (n=3,565)	Non-POSA (n=1,513)	*P*-value	POSA (n=759)	Non-POSA (n=124)	*P*-value	POSA (n=1,018)	Non-POSA (n=191)	*P*-value	POSA (n=1,788)	Non-POSA (n=1,198)	*P*-value
PLMI (events/hr)	4.8±12.7	2.6±9.8	<0.001[a]	5.4±14.4	7.8±20.7	0.012[a]	5.6±14.8	3.6±12.9	0.012[a]	4.1±10.5	1.9±6.9	<0.001[a]
PLMAI (events/hr)	0.9±3.7	0.5±3.3	<0.001[a]	1.1±3.6	2.2±6.1	<0.001[a]	1.1±4.0	1.2±6.9	0.151[a]	0.7±3.5	0.2±1.4	<0.001[a]
PLMS (%)	11.0	5.3	<0.001[b]	12.1	14.5	0.454[b]	12.2	7.9	0.085[b]	9.8	3.9	<0.001[b]

Values are presented as mean±standard deviation unless otherwise indicated.
POSA, positional obstructive sleep apnea; OSA, obstructive sleep apnea; AHI, apnea–hypopnea index; PLMI, periodic limb movement index; PLMAI, periodic limb movement with arousal index; PLMS, periodic limb movements during sleep.
[a]Independent-samples *t*-test. [b]Chi-square test.

Table 5. Risk of periodic limb movements during sleep according to positional obstructive sleep apnea status

OSA severity	POSA		Non-POSA		OR (95% CI)[a]	*P*-value
	Total	PLMS	Total	PLMS		
Total	3,565	392 (11.0)	1,513	80 (5.3)	1.389 (1.049–1.839)	0.022
Mild	759	92 (12.1)	124	18 (14.5)	0.559 (0.303–1.030)	0.062
Moderate	1,018	124 (12.2)	191	15 (7.9)	1.822 (0.995–3.339)	0.052
Severe	1,788	176 (9.8)	1,198	47 (3.9)	1.554 (1.065–2.267)	0.022

Values are presented as number (%) unless otherwise indicated.
OSA, obstructive sleep apnea; POSA, positional obstructive sleep apnea; PLMS, periodic limb movements during sleep; OR, odds ratio; CI, confidence interval.
[a]Odds ratios were adjusted for sex, age, body mass index, and apnea–hypopnea index.

Association between POSA and PLMS

Table 4 presents PLMI, PLMAI, and PLMS values according to the type of OSA. In the POSA group, the mean PLMI, mean PLMAI, and PLMS prevalence were 4.8 (±12.7), 0.9 (±3.7), and 11%, respectively. In contrast, the non-positional OSA (non-POSA) group displayed significantly lower values of 2.6 (±9.8) for PLMI, 0.5 (±3.3) for PLMAI, and 5.3% for PLMS prevalence (all $P<0.001$). The mean PLMI was significantly lower among patients with moderate ($P=0.012$) and severe ($P<0.001$) non-POSA compared to the analogous POSA severity groups. However, the mild non-POSA group displayed a significantly greater mean PLMI than the POSA group ($P=0.012$). The mean PLMAI also differed significantly between the non-POSA and POSA groups for both mild and severe OSA ($P<0.001$), but no significant difference was found for moderate disease ($P=0.151$). Accordingly, regarding patients with POSA, a significantly greater prevalence of PLMS was observed only in the severe disease group ($P<0.001$).

The prevalence of PLMS increased with age, while it was lower in obese patients and male participants (Supplementary Table 1). A minimal correlation was observed between total sleep time and the prevalence of PLMS. Conversely, the prevalence of POSA was lower in obese people and male participants, but it increased with longer total sleep time (Supplementary Table 2).

OSA severity and PLMS prevalence in those with and without PLMS

Based on logistic regression analysis, PLMS was significantly more common in those with POSA compared to the non-POSA group (OR, 1.389; 95% CI, 1.049–1.839), after adjusting for sex, age, BMI, and AHI. However, among the subgroups categorized by severity, this significant disparity was observed only for those with severe OSA (OR, 1.554; 95% CI, 1.065–2.267) (Table 5).

The relationship between PLMS and the severity of OSA was found to be significant ($P<0.001$) (Supplementary Table 3). Additionally, a significant association was observed between the prevalence of PLMS and the presence of POSA ($P<0.001$) (Supplementary Table 4).

DISCUSSION

We observed significant associations between the mean values of PLMI and PLMAI and the severity of OSA. Furthermore, the risk of PLMS was observed to decline as the severity of OSA increased. Specifically, the mean PLMI and PLMAI values decreased in conjunction with escalating OSA severity. The prevalence of PLMS also decreased as OSA severity increased. Notably, among all patients with OSA, the risk of PLMS was significantly elevated in the POSA group compared to the non-POSA group. However, in subgroup analysis, this difference was signifi-

cant only for the severe OSA subgroup. In other words, this significantly increased risk was not observed in the mild or moderate OSA subgroups.

The reported prevalence of PLMS varies according to age, ethnicity, and comorbid disease status. In a Wisconsin sleep cohort from the United States, the PLMS rate was found to be 25.3% in the general population [33]. In two German cohorts and one Swiss cohort, the prevalence rates of PLMS were 32.4%, 36.4%, and 28.6%, respectively [28,29], with most participants being middle-aged and White. Other studies of white participants have shown that PLMS prevalence can be as high as 61% in older adults, while being only 5.6% in children [34,35]. A community-based study reported a PLMS prevalence of 4.3% among African-Americans, compared to 9.3% in white individuals [36]. In South Korea, the prevalence was 29.3% among older individuals (mean age, 68.3±5.6 years) [37] and 9.3% in the general population. These findings suggest that both age and ethnicity may influence the prevalence of PLMS. The rates of PLMS in patients with OSA have varied in published studies, with 14.8% and 14.1% reported in studies from the United States and Korea, respectively [6,20]. In the present study, the PLMS rate among patients with OSA was 9.4%, which is lower than those reported in previous studies. This discrepancy may be attributed to the specific characteristics of our participant group. We observed a decrease in PLMS as the severity of OSA increased. Specifically, the prevalence of PLMS in subgroups with escalating OSA severity was 13.1%, 11.4%, and 7.4%, respectively. These figures are lower than those reported in a prior Korean study, which found prevalence rates of 17%, 15%, and 12% for increasing OSA severity [20]. The differences observed may reflect variations in the characteristics of participants across studies.

In the present study, among patients with OSA, 70.2% also presented with POSA, which is comparable to the 75% prevalence reported in the HypnoLaus Sleep Cohort [29]. The link between POSA and PLMS is not well understood; however, three hypotheses can be proposed. First, a low arousal threshold might be a shared characteristic of both OSA and PLMS, given that it is a recognized risk factor for each condition [18]. Huang et al. [38] found that individuals with POSA exhibited a lower arousal threshold compared to the non-POSA group. Since the proportion of patients with POSA decreases with increasing OSA severity, this theory could account for the lower prevalence of PLMS observed in patients with severe OSA.

Second, enhanced spinal root reflex responses may contribute to the onset of PLMS. A study in the United States found that PLMS was more prevalent among patients with RLS who exhibited diminished spinal flexor reflexes and heightened spinal cord excitability [25]. Another study indicated that spinal and supraspinal mechanisms play a more pivotal role in PLMS than the peripheral motor efferent and sensory afferent pathways [39]. Therefore, frequent activations of the spinal cord, due to lowered thresholds influenced by changes in body weight distribution and position, may provoke PLMS [26]. Compared to lying in the supine position, standing has been shown to increase the threshold and diminish the posterior root muscle response, which is a monosynaptic reflex elicited by single-pulse, transcutaneous spinal cord stimulation [26]. In an earlier study, the response to a second stimulus was lower and the response thresholds were higher in the prone position compared to the supine position [40]. Consequently, adopting a supine sleeping posture in patients with POSA could lower the threshold, amplify the response to spinal cord stimulation, and ultimately trigger more PLMS episodes.

Finally, activation of the central pattern generator (CPG) may also play a role in PLMS. Patients with POSA tend to spend more time sleeping in the supine position [22], which can provoke involuntary movements of the lower extremities through the activation of the CPG [41,42]. Since PLMS can be triggered by CPG activation [43], an increase in supine sleep could be linked to a higher frequency of involuntary lower extremity movements resulting from this process. Consequently, POSA may exacerbate PLMS through a combined positional and CPG-related mechanism.

CPAP is considered the gold standard treatment for OSA [44,45]. A meta-analysis showed that CPAP use can reduce the AHI by up to 33.8 events per hour and lower systolic blood pressure by 2.4 mmHg [46]. This treatment has the potential to alleviate both airway obstruction and PLMS, contributing to several hypotheses. Retrospective studies investigating the impact of OSA treatment on PLMI have revealed that PLMI decreased following CPAP titration in patients with mild OSA, but increased in those with moderate to severe OSA [6,47,48]. Researchers have proposed that PLMI should be categorized into induced and spontaneous types [8,47]. Induced PLMI, which is related to residual respiratory events, may respond to CPAP treatment, while spontaneous PLMI, which occurs without an external stimulus, remains evident after CPAP titration [47,49]. This pattern was noted in both an earlier retrospective Korean study and the present research [50]. However, the Apnea Positive Pressure Long-term Efficacy Study found that CPAP titration did not significantly improve PLMI compared to sham CPAP [6]. That study differed from others in that it included a second CPAP titration 6 months after the initial one, while other investigations only compared data from the diagnostic PSG and CPAP titration status. Considering these disparate findings, future studies should incorporate long-term follow-up of patients with OSA to thoroughly assess the efficacy of CPAP treatment.

Our study had several limitations. First, the work was retrospective in nature; therefore, we cannot assert any causal relationship between PLMS and OSA. An event-synchronized analysis of a large cohort that considers all respiratory events and limb movements during sleep, along with sleep stages and positions, is warranted. Second, PSG was performed only once. While single-night studies are generally reliable for diagnosis, individual discrepancies between nights can be overlooked [51]. Third,

we adjusted for only the demographic factors of age, sex, and BMI when evaluating the impact of OSA on PLMS. Factors such as antidepressant use, physical inactivity, and current smoking are also associated with PLMS, but these were not accounted for in our analysis [28]. Fourth, our study displayed an imbalance in group size, with the number of patients with severe OSA being three times higher than the other groups. Since patients with severe OSA tend to exhibit a lower incidence of PLMI, this disparity may have compromised our interpretation of PLMS prevalence in the general population. Further studies employing propensity score matching to adjust for OSA severity may be necessary to mitigate substantial errors in resulting conclusions. Finally, given the definitions of PLM-related parameters, respiratory events should be distinctly identified through event-synchronized analysis. Our retrospective analysis excluded respiratory event-related limb movements from the PLMS count; hence, we relied on auto-scoring for this variable. Although we used validated software, the lack of clear validation criteria for PLMS may have introduced some bias. Considering the risk of PLMS during rapid eye movement sleep, additional research focusing on PLMS throughout this sleep stage is also needed.

POSA may lead to an increased frequency of PLMS, particularly in patients with severe OSA. When PLMS is suspected, evaluating the patient's POSA status and determining the severity of OSA are crucial steps. Such assessments can facilitate the selection of appropriate CPAP treatment.

CONFLICT OF INTEREST

Hyun-Woo Shin is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

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Conceptualization: HWS. Methodology: JHS, WHY, HWS. Software: JHS, WHY. Validation: YJK. Formal analysis: YJK, WHY. Resources: HWS. Data curation: JHS, WHY. Supervision: CSP, HWS. Project administration: CSP, HWS. Funding acquisition: HWS, YJK. Writing–original draft: JHS, YJK, CSP, HWS. Writing–review & editing: JHS, YJK, CSP, HWS.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found online at https://doi.org/10.21053/ceo.2024.00034.

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