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ORIGINAL ARTICLE

Obstructive sleep-related breathing disorders in overweight and obese adolescents

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Abstract

Introduction and Objectives: The causes behind obstructive sleep-related breathing disorders (OSRBD) are multifactorial, with obesity playing a significant role. Approximately 60% of obese children experience OSRBD. This study aims to characterize the severity of OSRBD in overweight or obese adolescents undergoing polysomnography (PSG) in a tertiary-level hospital. **Methods:** This retrospective descriptive study analyzed clinical records and PSG parameters of overweight or obese adolescents referred for PSG between 2016 and 2021. Adolescents with neuromuscular, genetic, or syndromic pathologies were excluded. **Results**: Sixty-seven overweight/obese adolescents were included, with 67% being males. Clinical manifestations of OSRBD included snoring in 94%, apneas in 70%, and daytime symptoms (excessive somnolence, headaches, and low school performance) in 76%. The median age at PSG was 14 years old. OSRBD was found in 75% of adolescents, with 16% experiencing moderate to severe obstructive sleep apnea syndrome. Notably, three of these adolescents were asymptomatic. Approximately 27% of the adolescents studied had an indication for non-invasive ventilation (NIV). Out of those who were followed up for at least twelve months after starting NIV (9/18), 56% exhibited good adherence. **Discussion:** In our study, the prevalence of OSRBD was higher than described in the literature, albeit in a selected sample. The presence of OSRBD in three asymptomatic adolescents underscores the necessity of PSG, even in asymptomatic patients. NIV is a frequently chosen treatment, with challenges regarding long-term adherence in these patients.

Keywords: Adolescent obesity. Non-invasive ventilation. Obstructive sleep apnea syndrome.

Distúrbios obstrutivos do sono relacionados com a respiração em adolescentes com sobrepeso e obesos

Resumo

Introdução e Objetivos: A Perturbação Respiratória Obstrutiva do Sono (PROS) tem causas multifatoriais, com a obesidade a desempenhar um papel crescente. Cerca de 60% das crianças obesas tem PROS. Pretende-se caracterizar a gravidade da PROS em adolescentes com excesso de peso ou obesos referenciados para polissonografia (PSG) num hospital terciário. **Métodos:** Este estudo retrospetivo descritivo analisou os processos clínicos e parâmetros das PSG de adolescentes com excesso de peso ou obesos referenciados para PSG, entre 2016 e 2021. Foram excluídos adolescentes com patologias neuromusculares, genéticas ou sindrómicas. **Resultados**: Foram incluídos 67 adolescentes com excesso de peso ou obesidade,

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sendo 67% do sexo masculino. As manifestações clínicas de PROS incluíram ressonar em 94%, apneias em 70% e sintomas diurnos (sonolência diurna excessiva, cefaleias, baixo rendimento escolar) em 76%. A média de idade na realização da PSG foi 14 anos. Identificou-se PROS em 75% dos adolescentes, sendo em 16% Síndrome de Apneia Obstrutiva do Sono moderada a grave. De referir que três dos adolescentes com PROS eram assintomáticos. Cerca de 27% dos adolescentes estudados iniciaram ventilação não invasiva (VNI). Naqueles com pelo menos doze meses de follow-up (9/18), verificou-se boa adesão em 56%. **Discussão:** No nosso estudo, a prevalência de PROS foi mais elevada do que o descrito na literatura, mas esta era uma população selecionada. Três adolescentes assintomáticos apresentaram PROS, reforçando a necessidade de PSG mesmo em pacientes assintomáticos. A VNI é muitas vezes o tratamento de escolha, com problemas de adesão a longo prazo nestes doentes.

Palavras-chave: Obesidade na adolescência. Ventilação não-invasiva. Síndrome de apneia obstrutiva do sono.

Keypoints

What is known
- Obesity is associated with obstructive sleep-related breathing disorders, especially obstructive sleep apnea syndrome
- Non-invasive ventilation is key for treatment along with weight loss

What is added
- Obese or overweight adolescents should be evaluated with PSG even when asymptomatic

Introduction

Obstructive sleep-related breathing disorders (OSRBD) are more prevalent in the pediatric population, particularly among obese children and adolescents. Approximately 59 to 66% of obese children have OSRBD[1-4]. The etiology of OSRBD is multifactorial, involving factors such as adenotonsillar hypertrophy, craniofacial morphology, obesity, and genetic predisposition[1,5,6]. The significance of obesity as a risk factor for pediatric OSRBD is growing, mirroring the rising prevalence of obesity in this population[1-4]. The pathophysiology is characterized by the obstruction and collapse of the upper airway during sleep, along with decreased pulmonary compliance and impaired responses to hypoxemia and hypercapnia[1,5-8].

Characteristic symptoms of OSRBD, such as snoring, apnea, and daytime sleepiness, often go undervalued or underdiagnosed due to their normalization in the general population. However, it is essential to note that snoring is not synonymous of OSRBD, and OSRBD can manifest without snoring[1,6,7,9,10-12]. Polysomnography (PSG) is therefore considered the gold standard for diagnosis[6,11,13,14]. Nonetheless, there are significant limitations in performing PSG, as it is a demanding examination, requiring technical and human resources[6,13].

The identification of overweight or obese adolescents with OSRBD is crucial due to their consequences, particularly in elevating cardiovascular and metabolic risks. In OSRBD, hypoxemia, hypercapnia, and microarousals contribute to increased sympathetic activity, oxidative stress, inflammatory cytokines, as well as endothelial and platelet dysfunction[1,5,10,11].

The primary approach to treating OSRBD in overweight and obese patients is weight control. However, in some cases, non-invasive ventilation (NIV) may be necessary[15]. Long-term adherence in adolescents is often challenging and inconsistent[2,15].

The objective of this study is to characterize the severity of OSRBD in adolescents referred for PSG due to their obesity, with or without symptomatology.

Methods

Study sample

This study includes patients referred for PSG between 2016 and 2021, aged 10 years and older, with a body mass index (BMI) ≥ +2 z-score (obesity[1]) or with a BMI ≥ +1 z-score (overweight[1]) and symptoms of OSRBD.

In our hospital, obese or overweight adolescents with OSRBD symptoms, with a BMI > 35 kg/m^2 or a z-score ≥ 3, or with other cardiovascular or metabolic comorbidities, are typically referred for PSG. Patients with other independent risk pathologies for OSRBD (neuromuscular, genetic, or syndromic diseases) were excluded.

Study location

The adolescents included were evaluated beforehand in General Pediatric, Pediatric Obesity, or Pediatric Pneumology outpatient appointments at a tertiary-level hospital. PSG was performed in our hospital Sleep Laboratory.

Study design

The PSG tests conducted in the Sleep Laboratory were filtered according to the study criteria. Examination reports and patient electronic records were analyzed, and relevant data was collected.

All PSG tests were performed with the Alice 5 Respironics System®, under the supervision of trained sleep technicians. Various parameters were recorded, including an electroencephalogram (C3M2, C4M1, O1M2, O2M1, F3M2, F4M1), bilateral electrooculogram, submental electromyogram, right and left tibial electromyogram, electrocardiogram (DII), respiratory flow with nasal cannula and oronasal thermistor, thoracic and abdominal movements, peripheral oxygen saturation, transcutaneous carbon dioxide, respiratory noise, body position, and an audio-visual record. American Academy of Sleep Medicine rules were applied for sleep and respiratory scoring[16]. The following definitions were used: upper airway resistance syndrome (UARS) if respiratory effort-related arousals (RERA) were > 1/hour; obstructive sleep apnea syndrome (OSAS) according to the obstructive apnea-hypopnea index (AHI) (mild if AHI is 1 to 5, moderate if 5-10 and severe if ≥ 10); and obstructive sleep hypoventilation (OSH) if transcutaneous CO_2 ($TcCO_2$) > 50 mmHg in > 25% of the total sleep time (TST)[16,17].

Adherence to non-invasive ventilation was considered "good" if the percentage of nights on NIV was more than 80%, and the mean duration on NIV was at least six hours per night.

Dyslipidemia was considered if the total cholesterol was > 170 mg/dL, or triglycerides were > 150 mg/dL, or LDL cholesterol was > 130 mg/dL or HDL cholesterol was < 35 mg/dL, (blood tests collected with a minimum 12-hour fasting period)[18]. Insulin-resistance was considered to be positive if a fasting homeostasis model assessment of insulin resistance was > 2 in more than one evaluation with a minimum 12-hour fasting period[19]. Hypertension was taken into consideration if the adolescent's blood pressure (systolic or diastolic blood pressure) was over the 95th percentile for age, sex, and height, in multiple evaluations.

Data collection methods

Demographic and clinical information was collected, including gender, age, previous ear, nose, and throat (ENT) surgery, allergic rhinitis, co-morbidities with increased cardiovascular and metabolic risk, and parents' obesity and NIV use. In terms of symptomatology, we evaluated snoring, apnea, and daytime symptoms such as excessive daytime somnolence, headaches, or low school performance. Anthropometric data at the PGS was recorded and the BMI z-score was calculated.

The PSG results analyzed were efficiency, obstructive AHI, RERAs, minimum blood oxygen level, time spent with $TcCO_2$ above 50 mmHg, and PSG conclusion. For those adolescents who started NIV, adherence was evaluated at the 12-month follow-up.

Data analysis methods

Descriptive and univariate analyses were performed using independent t-tests for continuous variables and a Chi-square test for categorical ones. The non-parametric Mann-Whitney test was used for variables with a non-normal distribution. Results were expressed as mean ± standard deviation for normally distributed variables and as median [minimum – maximum values] for non-normally distributed variables. The significance level was set at $p < 0.05$. The statistical analysis was made using the Statistical Package for Social Sciences (SPSS®) for Windows®, version 29.0.

Ethics

The study complies with national legislation and the Helsinki Declaration.

Results

Sixty-seven adolescents were included, with 67% being males. PSG for these patients accounted for 8% of the total PSG tests performed in the Sleep Laboratory during the study period. Patients' demographic and clinical data are summarized in table 1. Most of the patients were referred from outpatient consultations in our hospital, and 24% were referred from level II hospitals in the Central Region of Portugal. The median age at referral for PSG was 14 (10-18) years old. Snoring was the most frequent symptom (94%), nocturnal apneas were identified in 70% of the patients, and 76% exhibited diurnal symptoms (excessive daytime somnolence, headaches, or low school performance). Four adolescents were referred without any symptoms, and they had a mean BMI z-score of +4.2 ± 0.59. About 24% had undergone previous ENT surgery for OSAS (adenotonsillectomy), and 45% were undergoing medical treatment for allergic rhinitis. The mean BMI z-score at the PSG was +3.2 ± 0.88 kg/m^2. The prevalence of other cardiovascular or metabolic risk factors was as follows: insulin-resistance in 44%, dyslipidemia in 18%, and hypertension in 11%. At least one parent was

Table 1. Demographic and clinical information

Variables	n = 67
Gender (male)	45 (67%)
Adolescent's age at PSG (years old)	14 (10-18)
Symptomatology	
Snoring	63 (94%)
Apneas	47 (70%)
Diurnal symptoms	51 (76%)
ENT surgery	15 (24%)
Allergic rhinitis	30 (45%)
BMI z-score at PSG	+3.2 ± 0.9
Cardiovascular or metabolic co-morbidities	
Insulin resistance	22 (44%)
Dyslipidemia	9 (18%)
Hypertension	6 (11%)
Parents	
Obesity	23 (42%)
NIV use	7 (13%)

BMI: body mass index; ENT surgery: ear, nose, and throat surgery; NIV: non-invasive ventilation.

Table 2. PSG data

Variables	n = 67
PSG data	
Median efficiency, n (%)	77 (27-92)
Obstructive AHI (per hour)	0 (0-22)
RERA index (per hour)	11 (0-52)
Minimum blood oxygen level, n (%)	93 (83-98)
% of total sleep time with $TcCO_2$ > 50 mmHg, n (%)	0 (0-100)
PSG conclusion	
No respiratory compromise	17 (25%)
UARS	22 (33%)
Mild OSAS	14 (21%)
Moderate OSAS	6 (9%)
Severe OSAS	5 (8%)
OSH	3 (4%)

AHI: apnea hypopnea index; OSAS: obstructive sleep apnea syndrome; OSH: obstructive sleep hypoventilation; RERA: respiratory effort-related arousals; TcCO2: transcutaneous CO2; UARS: upper airway resistance.

obese in 42% adolescents, and 13% of parents had OSAS treated with NIV.

The data from the PSG tests is summarized in table 2. OSRBD were identified in 75% of the obese adolescents (50/67 patients): 33% had UARS, 21% had mild OSAS, 9% had moderate OSAS, 8% had severe OSAS, and 4% had OSH. Adolescents with an abnormal PSG were older and had a higher BMI z-score at the time of referral for PSG than those with a normal PSG, though with no statistical significance. Three obese adolescents with OSRBD (one with moderate OSAS and two with mild OSAS) were asymptomatic

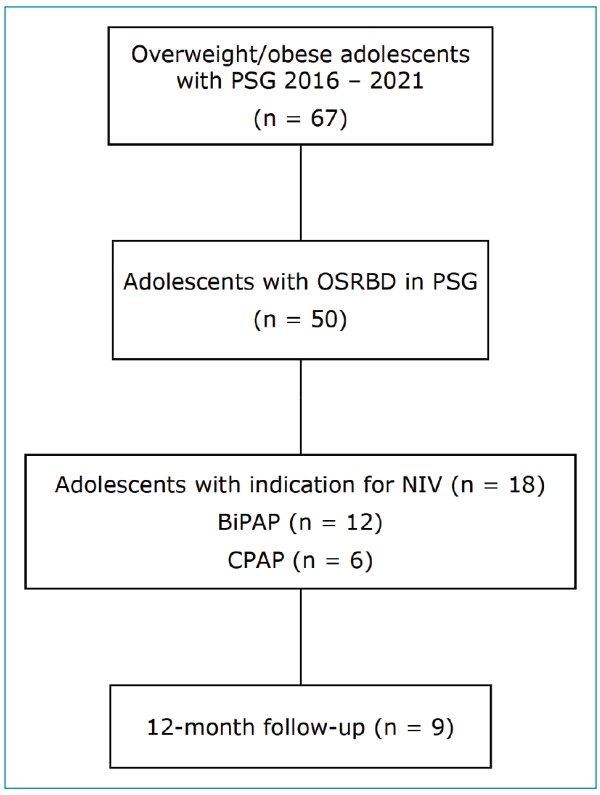

Figure 1. Sample description.

and were referred for PSG due to a high BMI (median BMI 39 kg/m^2 and a median BMI z-score of +4.3). When analyzing adolescents with OSAS, nocturnal apnea was more frequent in mild and moderate cases than in severe ones, without statistical significance (79% vs. 67% vs. 40%, p = 0.283).

Approximately 36% of those with any OSRBD in the PSG (18/50) had an indication for NIV, corresponding to 27% of the total sample (Fig. 1). All adolescents with an indication for NIV had higher BMI z-scores than others with OSRBD but without this indication, without statistical significance (+3.6 ± 1.1 vs. +3.1 ± 0.9, p = 0.055). All patients with severe OSAS and OSH initiated NIV. Among those with moderate OSAS (five), four initiated NIV, and one showed significant weight control after one year, leading to an improvement in OSRBD. Five patients with mild OSAS or UARS initiated NIV due to significant diurnal symptoms. BiPAP was the ventilation mode used in all patients with severe OSAS, OSH, and in most patients (three out of five) with moderate OSAS. In the other cases, CPAP or auto-CPAP was used.

One of the asymptomatic patients with OSRBD started NIV. He was referred for PSG due to a BMI of 39 kg/m^2 (BMI z-score of +4.9), and his PGS showed moderate OSAS.

Out of all the patients on NIV (18/67), nine were followed up for at least twelve months. Overall adherence to NIV was good in five, corresponding to 56% of this group.

Discussion

Pediatric obesity has become an increasingly prevalent health issue in recent decades, leading to a rise in pathologies where obesity serves as a risk factor. Consequently, pediatric OSRBD are on the rise, especially among overweight and obese children and adolescents[1-4].

Our hospital, the only one in the Central Region of Portugal with a Pediatric Sleep Laboratory, faces limited availability for PSG, requiring careful consideration and structuring indications. Throughout the study period, approximately 8% of all the PSG tests conducted were for obese adolescents, either with or without significant OSRBD symptoms, or overweight adolescents with concerning OSRBD symptoms. The mean BMI at the time of referral for PSG was 33.5 ± 6.6 kg/m^2 (BMI z-score of +3.2 ± 1.0), indicating a selection of more severe cases for this evaluation. Most patients were referred from our hospital's outpatient consultations, possibly indicating a lack of awareness about the incidence of OSRBD and the need for PSG in obese patients among pediatricians in other centers.

OSRBD prevalence was 75%, unsurprisingly higher than in other studies involving obese adolescents due to the selected sample in our study. Males were more frequently affected, in line with the literature, which reports a higher incidence of identifiable respiratory compromise in PSG among males[14,20-22].

Symptoms were as frequent as in other studies[1,13,22] and did not predict the presence of OSRBD in PSG. In our study, three obese asymptomatic adolescents had OSAS in PSG, with one of them requiring NIV. This underscores the importance of assessing OSRBD in all obese adolescents and conducting PSG if there are risk factors (BMI > 35 kg/m^2 or BMI z-score ≥ +2 or co-morbidities with cardiovascular and metabolic risks), even in the absence of symptoms[11,13].

Approximately 27% (18/67) of the obese adolescents studied met the criteria for NIV. BiPAP was the preferred ventilation mode when OSAS was moderate to severe or in OSH situations. This choice was linked to the severity of the upper airway collapse and the need for higher pressures to reduce AHI. It is also associated with the impact of restriction and decreased pulmonary compliance due to obesity. NIV was initiated for all adolescents during an inpatient period, with the collaboration of nurses and pediatricians experienced in NIV adaptation. Regular outpatient consultations (first month and every six months) were conducted. Among patients completing twelve months of follow-up, only 56% exhibit good NIV adherence. This difficulty in the adolescent population is well-described in literature (related to defiance of authority and difficulties in therapeutic compliance, common in this age and present in other chronic pathologies). This is verified even when adherence is defined with less ambitious criteria (at least four hours per night in 50-70% of nights)[23,24].

The main limitations in this study include the small sample size and the fact that it involved a selected population. Consequently, the prevalence of OSRBD and its various subtypes cannot be generalized.

However, our study points out that the importance of conducting at least one PSG test during the follow-up of even apparently asymptomatic obese adolescents. OSRBD may be present and could be severe enough to start non-invasive ventilation. This brings attention to the reality of limited PSG availability, primarily due to inadequate human and technical resources. There is a need to readapt and establish protocols for diagnosing and managing obese adolescents, given the increasing prevalence of this health problem. Furthermore, it is crucial to enhance treatment approaches, focusing not only on NIV, but especially on strategies with a genuine impact on weight control.

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Author contributions

M. Lopes Costa: Conception and design of the study, report, review or other type of work or paper; Acquisition of data either from patients, research studies, or literature; Analysis or interpretation of data either from patients, research studies, or literature; Drafting the article; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work. S. Ferreira, R. Soares: Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work.

N. Madureira: Conception and design of the study; Analysis or interpretation of data either from patients, research

studies, or literature; Critical review of the article for important intellectual content; Final approval of the version to be published; Agreement to be accountable for the accuracy or integrity of the work.

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Conflicts of interest

None.

Ethical considerations

Protection of humans and animals. The authors declare that no experiments involving humans or animals were conducted for this research.

Confidentiality, informed consent, and ethical approval. The study does not involve patient personal data nor requires ethical approval. The SAGER guidelines do not apply.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

References

1. Narang I, Mathew JL. Childhood obesity and obstructive sleep apnea. J Nutr Metab. 2012;2012:134202.
2. Katz SL, MacLean JE, Barrowman N, Hoey L, Horwood L, Bendiak GN, et al. Long-Term Impact of Sleep-Disordered Breathing on Quality of Life in Children With Obesity. J Clin Sleep Med. 2018;14(3):451-8.
3. Selvadurai S, Voutsas G, Kassner A, Massicotte C, Katz SL, Propst EJ, et al. Positional obstructive sleep apnea in an obese pediatric population. J Clin Sleep Med. 2020.
4. Kanney ML, Harford KL, Raol N, Leu RM. Obstructive sleep apnea in pediatric obesity and the effects of sleeve gastrectomy. Semin Pediatr Surg. 2020;29(1):150887.
5. Arens R, Muzumdar H. Childhood obesity and obstructive sleep apnea syndrome. J Appl Physiol (1985). 2010;108(2):436-44.
6. Parakh A, Dhingra D, Abel F. Sleep Studies in Children. Indian Pediatr. 2021;58(11):1085-90.
7. Andersen IG, Holm JC, Homoe P. Obstructive sleep apnea in children and adolescents with and without obesity. Eur Arch Otorhinolaryngol. 2019;276(3):871-8.
8. Van de Perck E, Van Hoorenbeeck K, Verhulst S, Saldien V, Vanderveken OM, Boudewyns A. Effect of body weight on upper airway findings and treatment outcome in children with obstructive sleep apnea. Sleep Med. 2021;79:19-28.
9. Ischander MM, Lloyd RD, Jr. Severe paediatric obesity and sleep: A mutual interactive relationship! J Sleep Res. 2021;30(3):e13162.
10. Bhatt SP, Guleria R, Kabra SK. Metabolic alterations and systemic inflammation in overweight/obese children with obstructive sleep apnea. PLoS One. 2021;16(6):e0252353.
11. Danielsen YS, Skjakodegard HF, Bjorvatn B, Juliusson PB, Pallesen S. Polysomnographic comparison of sleep in children with obesity and normal weight without suspected sleep-related breathing disorder. Clin Obes. 2022;12(1):e12493.
12. Torres-Lopez LV, Cadenas-Sanchez C, Migueles JH, Esteban-Cornejo I, Molina-Garcia P, C HH, et al. Does sleep-disordered breathing add to impairments in academic performance and brain structure usually observed in children with overweight/obesity? Eur J Pediatr. 2022;181(5):2055-65.
13. Martinez Cuevas E, Munoz Pelaez C, Ordax Carbajo E, Navazo Eguia AI, Martin Vine L, Prieto Jimeno A, et al. Sleep apnoea-hypopnoea syndrome in the obese and non-obese: Clinical, polysomnographical and clinical characteristics. An Pediatr (Engl Ed). 2021;95(3):147-58.
14. Bachrach K, Danis DO, 3rd, Cohen MB, Levi JR. The Relationship Between Obstructive Sleep Apnea and Pediatric Obesity: A Nationwide Analysis. Ann Otol Rhinol Laryngol. 2022;131(5):520-6.
15. Romero-Corral A, Caples SM, Lopez-Jimenez F, Somers VK. Interactions between obesity and obstructive sleep apnea: implications for treatment. Chest. 2010;137(3):711-9.
16. Medicine. AAoS. The AASM manual for scoring sleep and associated events. Version 2.3 2006.
17. SH S, Ferber R, Kryger M, Gozal D. Principles and Practice of Paediatric Sleep Medicine. Philadelphia: Saunders. 2014;2nd ed.
18. Kavey RE, Daniels SR, Lauer RM, Atkins DL, Hayman LL, Taubert K, et al. American Heart Association guidelines for primary prevention of atherosclerotic cardiovascular disease beginning in childhood. Circulation. 2003;107(11):1562-6.
19. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28(7):412-9.
20. Cielo CM, Keenan BT, Wiemken A, Tapia IE, Kelly A, Schwab RJ. Neck fat and obstructive sleep apnea in obese adolescents. Sleep. 2021;44(11).
21. Haim A, Daniel S, Hershkovitz E, Goldbart AD, Tarasiuk A. Obstructive sleep apnea and metabolic disorders in morbidly obese adolescents. Pediatr Pulmonol. 2021;56(12):3983-90.
22. Kang KT, Weng WC, Lee PL, Hsu WC. Age- and gender-related characteristics in pediatric obstructive sleep apnea. Pediatr Pulmonol. 2022;57(6):1520-6.
23. Shanmugam A, Binney ZO, Voyles CB, Bouldin E, Raol NP. Impact of OSA treatment success on changes in hypertension and obesity: A retrospective cohort study. Sleep Med. 2023;101:205-12.
24. Sawunyavisuth B, Ngamjarus C, Sawanyawisuth K. Adherence to Continuous Positive Airway Pressure Therapy in Pediatric Patients with Obstructive Sleep Apnea: A Meta-Analysis. Ther Clin Risk Manag. 2023;19:143-62.