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Polysomnographic Findings between Obese and Non-Obese Pediatrics with Obstructive Sleep Apnea

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Abstract

Background: The prevalence of childhood obesity, which is associated with the health risk of OSA, is increasing. This study aimed to assess the polysomnographic findings of obese and non-obese children and adolescents with OSA.

Methods: In this cohort retrospective study, all the obese and non-obese children and adolescents with OSA referring to Sleep Disorders Clinic, Qazvin Children Hospital, during 2014-2019 were included. The participants were 52 pediatrics within the age range of 1-16 years old and mean age of 6.47±3.59 years, 20 (38.5%) of whom were female and 32 (61.5%) were male. The number of samples was determined according to previous studies, and the patients' case information was applied in this research. Obese children and adolescents were determined according to their BMI. PSG was performed for all the participants and its variables including sleep onset, sleep efficiency, sleep stages (N1, N2, N3, rapid eye movement (REM)), arousal index (AI), apnea hypopnea index (AHI), mean arterial oxygen saturation (SaO2), and total sleep time were determined and compared between the two groups.

Results: Mann-Whitney test showed a statistically significant difference in the percentage of REM sleep stage between the obese and non-obese groups (P=0.017). There was no statistically significant difference in the other polysomnographic variables between the two groups. In the obese group, linear regression showed significant correlation between body mass index (BMI) and AHI as well as mean arterial SaO2.

Conclusion: the percentage of REM sleep stage in the obese group with OSA was lower than that in the non-obese group. There was a correlation (P≤0.05) between obesity and respiratory events in sleep. It is predicted that with increasing age, obese people are more likely to have severe sleep apnea.

Key Words: Adolescents, Children, Obesity, Obstructive Sleep Apnea (OSA), Polysomnography (PSG).

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1- INTRODUCTION

Childhood obesity is one of the most important and serious general health issues that is associated with increased susceptibility to most of the non-communicable diseases such as hypertension, asthma and other respiratory problems, diabetes, sleep disorders, and liver disease (1, 2). Scientific documents have reported the increasing trend of childhood obesity worldwide, particularly in developing countries, like Iran. Janabi et al. found that obesity among Iranian girls and boys aged 5-9 and 10-19 years old increased from 6% in 2000 to 13.1% in 2016 (3). A study has demonstrated that sleep disorders are on the rise among children in recent years (4). The prevalence of sleep disorders in children has been estimated to be up to 30% (5). As reported by parents, 10-75% of children have sleep disorders worldwide that can range from simple bedtime resistance, frequent awakenings, and parasomnia to serious and dangerous events such as a variety of respiratory disturbances, especially obstructive sleep apnea (OSA) (6). Andersen et al. reported that the prevalence of OSA in obese children and the normal-weight group was 44.6% and 9.1%, respectively. OSA is a chronic disorder that is associated with complete or partial upper airway obstruction during sleep and results in intermittent apnea and hypopnea, and also a substantial proportion of patients with OSA are not obese (7). The prevalence of OSA in children has been estimated to be 1.2-5.7% (8). Evidence has shown that OSA is a complex disorder in adults and is associated with a significant variety of pathophysiological risk factors and symptoms. This variation is very important, because patients with different phenotypes need different treatments and show different health outcomes (9). Although many studies have been conducted on the phenotype and classification of adults with OSA, there is very little information about children with OSA. Obesity and adenotonsillar hypertrophy (ATH) have been identified as risk factors for OSA in children (10). Numerous studies have shown that obese children and adolescents are at higher risk for OSA. Silvestri et al. reported that 59% of obese children referring for evaluating sleep-disordered breathing (SDB) had OSA (11, 12). Obesity and its complications increase the severity of OSA among children (13). In a longitudinal study, Bazzano et al. followed up 844 participants for 35 years and found that obesity in childhood was associated with the increased risk of OSA in the middle age (14). Due to the increasing prevalence of obesity in children and adolescents, increased risk of sleep disorders, and existence of clinical problems and their consequences in various aspects of life, it is essential to monitor the symptoms and identify sleep disorders, including OSA in susceptible children and adolescents (like other obese people). Polysomnography (PSG) is a means for recording multiple parameters of sleep-related physiologic changes. Although PSG is a non-invasive gold standard for measuring the quantitative and qualitative structures of sleep and diagnosing respiratory diseases in sleep, it is a time-consuming and expensive method and cannot be used in large populations. Numerous studies have been conducted on the prevalence and risk factors of OSA (15). However, due to lack of access to children's sleep laboratories until 2014 in Iran, its relationship with obesity has not yet been well-established in different populations such as children and adolescents, especially in the Iranian population. Thus, there are many inconsistencies in this regard. Hence, this study aimed at assessing the polysomnographic finding between obese and non-obese children and adolescents with obstructive sleep apnea from 2014 to 2019.

2- MATERIALS and METHODS

2-1. Study design and population

In this cohort retrospective study, all the patients referring to the sleep disorders clinic of Qazvin children hospital, due to sleep disorders during 2014-2019 who underwent PSG were included. The information of all patients was retrieved from the records in their files. In this study, no direct intervention was performed on the patients and only the patient's information recorded in the file was used without mentioning his/her name. all patients were examined based on case information. The sampling method is census. Finally, the number of obese children with OSA was 26, which were compared to 26 non-obese children with OSA (52 children and adolescents) were selected.

2-2. methods

All subjects diagnosed with OSA were divided into two groups with and without obesity. Obesity was defined as a body mass index standard deviation (*z*-) score (BMIsds) greater than 2, adjusted for age and gender. "Overweight" was defined as a BMI between the 85th and 95th percentiles for children of the same age and sex; "obese" was defined as a BMI over the 95th percentile for children of the same age and sex. The participants' heights were measured using a wall-mounted stadiometer with the accuracy of 2 mm in the standing position without shoes while their feet were close to each other. Their weight was measured using a Sega scale (made in Germany) with the accuracy of 0.1 kg while wearing minimal clothing. BMI was calculated by dividing weight in kilogram by height in squared meter (Normal BMI was defined as <25 kg/m^2, overweight as between 25–29.9 kg/m^2, and obese as ≥ 30 kg/m^2, non-obese subjects had a BMI < 30 kg/m^2). Considering the standard weight charts based on age for girls and boys, those who had a BMI greater than 95% of the standard value were considered obese (2, 16).

2-3. Measuring tools: Laboratory measurements

To perform PSG, children and adolescents were present in the hospital-affiliated sleep clinic after having a light dinner and 4 hours before the test. PSG was performed for all the participants under the supervision of an experienced nurse while their parents were accompanying them. The bedroom used for the PSG had proper temperature and lighting, adequate ventilation, minimal noise, and a comfortable bed. The gold electrodes were attached to the patient by the nurse based on the latest guidelines of American Academy of Sleep Medicine (AASM). Patients went to bed at the same time as they slept at home. After turning off the light, the test started, lasted for an average of 300 mins per participant, and ended in the morning when the light was turned on. In PSG, electroencephalography (EEG), electrooculography (EOG), chin and legs muscles electromyography (EMG), respiratory effort (chest and abdomen), nasopharyngeal airflow, pulse oximetry, body position, and snoring sounds were recorded (16). Parameters such as sleep onset, sleep efficiency, sleep stages (N1, N2, N3, Rapid Eye Movement (REM)), Arousal Index (AI), AHI, mean arterial Oxygen Saturation (SaO2), and total sleep time and waking after sleep onset were determined. All data collected on the computer were scored manually by the sleep fellowship according to the AASM standards (2).

2-4. Intervention

The results expressed in the form of BMI reference charts and age-related prevalence for boys and girls. Children with BMIs above 85% and 95% were considered overweight and obese, respectively. PSG was conducted for all children under the observation of a trained nurse. One of the parents accompanied their child through the night. The bedroom had a proper temperature and lighting, adequate ventilation, minimal sources of noise and a comfortable bed. A 6-channel computerized PSG was developed with leads for an oronasal flow cannula, a thoracoabdominal strain gauge and electromyogram, pulse oximeter, body-position sensor, electroencephalogram and static charge– sensitive bed. After calibration of the device, along with turning off the lights, the computers began data recording.

The AHI refers to the number of apneas and hypopneas occurring per hour of sleep, which was used to assess the sleep apnea severity. Apnea, defined as the cessation of nasal or oral airflow and hypopnea, is characterized by a reduction in the airflow equal or greater than 30% accompanied by arousal or a drop in SaO2 equal to or greater than 3%. OSA was recorded as the presence of apnea despite continued thoracic and abdominal respiratory effort. Central sleep apnea (CSA) refers to the lack of airflow and effort to breathe; mixed apnea (MA) is characterized by the CSA in one part of the event and OSA in the other part. The number of apneas/hypopneas occurring per hour of sleep was used to assess the OSA severity, so that it was classified as mild (1-4 events/h), moderate (5-10 events/h), and severe (more than 10 events/h) (16).

2.5- Ethical consideration

The informed consent form was signed by the patients' parents. This study was approved by the Ethics Committee, Qazvin University of Medical Sciences (IR.QUMS.REC.1399.075).

2-6. Inclusion and exclusion criteria

All obese children and adolescents with OSA who referred to sleep Lab were included in the study. Also for comparison, the same number of non-obese children and adolescents with OSA who were referred to Sleep Lab were included. All the individuals with a history of respiratory diseases such as asthma and allergic rhinitis, underlying genetic diseases such as Down syndrome, and neuromuscular diseases were excluded from the study.

2-7. Data Analyses

Data were analyzed using SPSS (version 24.0) (SPSS Inc, Chicago, USA). For probability distribution determination was used. Measure of central tendency for central value of probability distribution was calculated. Descriptive variables were expressed for frequencies and percentages distribution. Independent t-test and Chi-square test were applied for numerical and categorical data comparison between groups and determining the association between qualitative variables. Mann-Whitney nonparametric test and logistic regression were performed for randomly selected values between the two groups and for the two-way dependent variables, respectively. The p-value of less than 0.05 was calculated using linear-by-linear association and considered to be statistically significant.

3- RESULTS

In the present study, 52 children and adolescents within the age range of 1-16 years old and mean age of 6.47±3.59 years old were included, 20 (38.5%) of whom were female and 32 (61.5%) were male. Patients were divided into two obese and non-obese groups (n = 26 each). The mean BMIs of obese and non-obese individuals was 25.30±6.87 and 15.5±2.05 kg/m^2, respectively, which were significantly different ($P \leq 0.001$). In total, 40 patients (74.4%) had severe sleep apnea. However, the two groups were not statistically different in this regard (severe sleep apnea). There was no significant difference in the prevalence of AHI greater than 10 between the obese and non-obese groups (84.6% and 80.8%, respectively). Other demographic parameters of the participants are compared in **Table 1.**

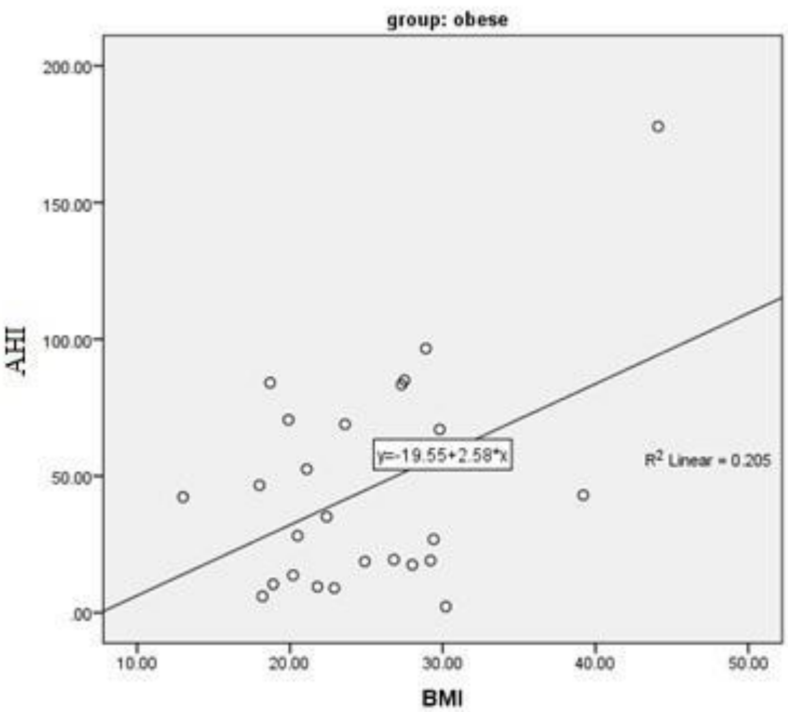
Based on the PSG findings, the mean total sleep time was reported as 6.1±1.5 h in all patients. There was no significant difference in the percentage of N_1, N_2, and N_3 sleep stages between the two groups. Sleep duration in the REM phase in the obese group was less than that in the non-obese group, which was statistically significant (P = 0.017). AHI was higher in the obese group than in the non-obese group (72.08±76.07 and 64.26±66.51, respectively). Other statistical analyses showed no significant correlation between PSG parameters and obesity. Comparison of the PSG results of the two groups is shown in **Tables 2**. It should be noted that there were no significant differences in AHI severity and all PGS indices between the females and males. The linear regression showed a significant correlation between BMI (r = 0.453, P = 0.02), and mean SaO2 (r = - 0.582, P = 0.002) in the obese group, while it was not significant in the non-obese group (**Fig. 1 and 2**). Logistic regression analysis showed that obesity was not independently associated with any of the PGS indices (**Table 3**). It also indicated that, with increasing age, the risk of obesity in people with AHI greater than 10 increased by 1.32 times (P=0.007, OR=1.32; 1.08-1.62).

Table-1: Comparison of demographic and respiratory findings in obese and non-obese pediatrics with OSA, n=52

Variables	Total	Obese, n=26	Non-obese, n=26	P-value
Age (years)	6.47±3.59	7.94±3.95	5±2.53	0.00
Gender (number / percentage) Female Male	 20 (38.5%) 32 (61.5%)	 11 (42.3%) 15 (57.7%)	 9 (34.6%) 17 (65.4%)	0.77
Weight (kilogram)	29.47±18.44	40.57±19.88	18.36±6.46	>0.00
Height (meter)	115.48±22.80	122.92±25.417	108.03±17.31	0.01
BMI	20.4±7.05	25.30±6.87	15.50±2.05	>0.00
Oxygen Desaturation Index (ODI) Normal Medium Intense	 2 (3.9%) 6 (17.6%) 40 (74.4%)	 2 (8%) 4 (16%) 19 (76%)	 0 (0%) 5 (19.2%) 21 (80.8%)	0.33
Respiratory Disturbance Index (RDI) < 10 > 10	 9 (17.3%) 43 (82.7%)	 4 (15.4%) 22 (84.6%)	 5 (19.2%) 21 (80.8%)	1

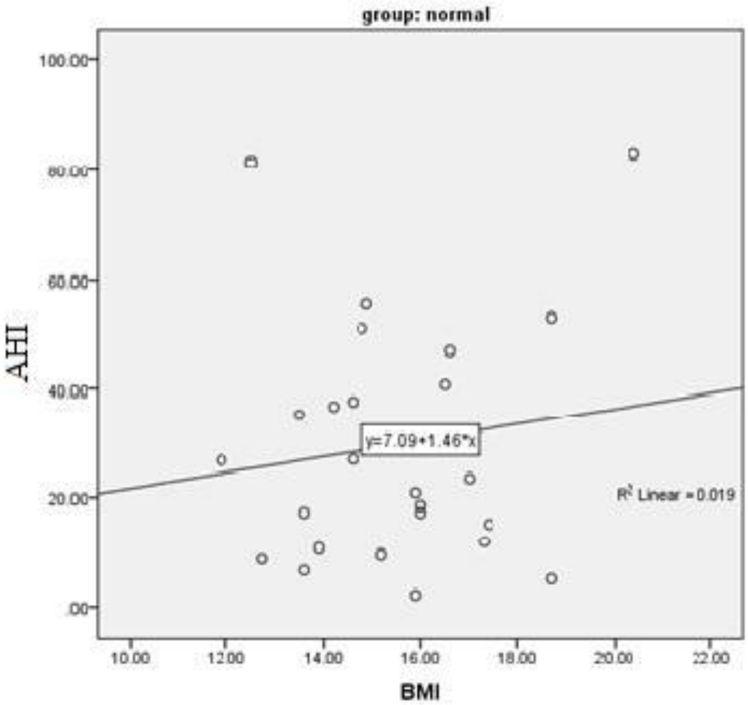
Table-2: Comparison of Polysomnography findings (Sleep Architecture and Respiratory Variables) in obese and non-obese pediatrics with OSA, n=52

Variables	Total	Obese	Non-obese	P- value
Total sleep time (Hours)	6.1±1.5	6.1±2.45	6.1±39.61	0.66
Sleep Efficiency (%)	79.45±12.55	78.13±13.01	80.78±12.18	0.45
Sleep N1 non-REM (%)	8.93±6.34	10.62±7.53	7.24±4.39	0.17
Sleep N2 non-REM (%)	53.2±12.77	56.17±8.68	50.23±15.46	0.15
Sleep N3 non-REM (%)	7.42±22.45	7.90±21.77	7±23.12	0.58
Rapid Eye Movement Sleep (REM)	14.13±6.45	12.41±6.58	15.85±5.96	0.07
Arousal index (number of short awakenings / hour)	21.10±21.87	20.65±16.97	21.54±26.21	0.24
Average Arterial Oxygen Saturation	93.75±4.82	92.71±4.38	94.84±5.11	0.11
Minimum Arterial Oxygen Saturation	82.09±12.40	79.38±14.50	84.80±9.40	0.11
Oxygen Desaturation Index (ODI)	21.2± 27.53	29.12±35.6	13.28± 12.19	0.18
Total Central Apnea (number / hour)	21.52± 29.98	29.1 ±39.21	14.5±15.65	0.35
Total Mix Apnea (number / hour)	16.45± 40.73	24.01 ±57.97	10.33± 17.1	0.51
Number Of Obstructive Apnea (Number / hour)	95.90± 104.73	103.68± 125.79	88.42± 82.03	0.74
Total Number Of Hypopneas (Number / hour)	68.17± 70.86	72.08±76.07	64.26±66.51	0.68
Apnea Hypopnea Index / (Number / hour) (AHI)	37.72±32.41	45.75± 39.17	29.69 ± 28.8	0.13



BMI: Body Mass Index, AHI: Apnea Hypopnea Index

Fig. 1: Correlation between BMI and AHI in the obese group.



BMI: Body Mass Index, AHI: Apnea Hypopnea Index

Fig. 2: Correlation between BMI and AHI in the non-obese group

Table 3: Regression logistic analysis of PSG findings and BMI

PSG findings	Odds ratio	Confidence interval (CI)	P-value
Severe Obstructive Sleep Apnea (OSA)	1.31	0.309-5.551	0.71
Non- Rapid Eye Movement sleep (NREM)	1.09	0.995- 1.214	0.06
Rapid Eye Movement sleep (REM)	0.91	0.832 –1.006	0.06
Respiratory Disturbance Index (RDI)	1.01	0.997- 1.040	0.087

BMI: Body Mass Index, PSG: Polysomnography

4- DISCUSSION

In this research we surveyed and assessed polysomnographic findings between obese and non-obese children and adolescents with obstructive sleep apnea. The increasing rate of obesity among children and adolescents worldwide, particularly in Iran, and conducting systematic reviews and meta-analyses in various countries highlight the importance of sleep monitoring as a behavioral factor along with the increased risk of obesity and overweight among age groups (17 and 18). Our results showed that the rate of REM sleep stage in the obese group was lower than that in the non-obese group (12.6% and 15.5%, respectively), which was statistically significant. Scientific documents have confirmed that the REM sleep stage plays a major role in consolidating and integrating memory and developing the central nervous system (19). In line with the results of our study, Jalilolghadr et al. conducted a case-control study to compare two groups of OSA obese children with and without metabolic syndrome. Results of Jalilolghadr et al. showed that REM sleep stage was shorter in the metabolic syndrome group (20). Liu et al. showed that REM sleep could be an important stage for metabolic and endocrine regulation, so that a decrease in this stage could lead to an increase in BMI. They reported that 1 hour less REM sleep could be associated with about 3-fold increased odds for being overweight (21). However, children with OSA experienced frequent upper airway collapse during REM sleep compared to NREM stage (22). It should be noted that REM sleep is important for brain development and cognitive status (23) and lower percent of REM sleep can affect the life quality of children with OSA (24). Given the importance of the ideal sleep cycle rhythm for normal growth and development in children and adolescents and its impact on their future life, it is necessary to identify and provide appropriate conditions to modify risk factors in obese children and adolescents who either have or are prone to develop OSA. The results of the present study showed that hypoxia was severe in 74.4% of participants. Consistent with this finding, Tavassoli et al. (19) also conducted a cross-sectional study on 30 obese and overweight children and adolescents and found no correlation between BMI and ODI and the OSA severity. There are also many other studies that have not reported any correlation between these factors (18). Some researchers have shown that children with OSA have normal or low weight during sleep (26). In the present study, a comparison was made between the two obese and non-obese groups with OSA. Linear regression showed a significant direct relationship between BMI and hypoxia in the obese group. Although the direct association between the OSA severity and obesity has already been confirmed in adults (27), such association in children has not been confirmed yet. The results indicated that the mean AHI in obese participants was much higher than that in the non-obese group. Dong et al. (18) also conducted a meta-analysis, in which they reviewed articles adopted from 7 databases until December 2017. They investigated the relationship between AHI and overweight and obesity and reported results similar to those of our study. Linear regression is the current research showed a significant negative relationship between SaO2 mean and BMI in the obese group. BMI was also associated with the increased risk of OSA, and an increase was observed in AHI in the obese group compared to the non-obese group. Evidence has suggested that OSA in obese groups is three times more prevalent than that in non-obese groups (28, 29).

The results of our study revealed that the mean and minimum arterial oxygen were lower in the obese group than in the non-obese group. However, this difference was not statistically significant between the two groups, which can be attributed to the small sample size. This finding was consistent with the results by Dayyat et al. (30) that compared the two groups of obese and normal-weight children aged over 7 years old. Previous studies have reported a decrease in arterial oxygen in children with OSA during sleep and its strong correlation with AHI (31). Our results showed that the mean AHI in the obese group was much higher than that in the non-obese group. Chuang et al. also conducted a study on 253 Taiwanese children and adolescents with OSA and found a positive correlation between BMI and AHI in school-aged children, emphasizing that BMI also affects the arousal index and minimum arterial oxygen (32). According to the results of the present study, children and adolescents with severe obesity are more likely to have OSA than those with less obesity. Also, the OSA severity will worsen with increasing obesity (34). Although the specific mechanism of this condition is not fully known, upper airway lymphoid hypertrophy (34), physiological effects of obesity on the respiratory system (35), and inflammatory processes (36) are among the potential contributing factors. It should be considered that abnormal respiratory and sleep patterns are more severe in obese children and adolescents with OSA, and are accompanied by repetitive cycles of hypoxia and interrupted sleep with vascular dysfunction and little physical activity. All these will increase the risk of complications such as cardiovascular diseases (37) as well as metabolic and cognitive dysfunction. Therefore, treating OSA and obesity is necessary for postponing their possible side effects. Using available and risk-free treatment and control methods such as lifestyle modification, increased physical activity, and exercise programs seems to be effective for adjusting AHI in obese children with OSA (38). Obstructive sleep apnea can occur in obese and non-obese individuals, so high demands of awareness, diagnosis, and management in such individuals are necessary (39). One of the main strengths of the present study was that the sleep status of pediatrics with OSA was measured using a standard objective instrument (polysomnography) in the first official academic and educational center related to Iranian children's sleep disorders. Another strength was the comparison of the two groups of children and adolescents with OSA. The most important limitations of the present study were the cross-sectional design and small sample size in each group. Some other limitations of this study include loss of patient, patient's non-assistance, lack of access to all patient information and financial budget.

5-CONCLUSION

In the present study, the rate of REM sleep in the obese group with OSA was less than that in the non-obese group. It is predicted that with increasing age, obese people are more likely to have severe sleep apnea. The results suggested that overweight, decreased arterial oxygen, and high AHI might be the causes or consequences of metabolic and cognitive impairment in children and adolescents with OSA. Therefore, due to the increasing rate of obesity among the Iranian pediatrics and the direct impact of obesity and overweight on the exacerbation of respiratory and non-respiratory symptoms and complications in obese children with OSA, further studies are recommended to be conducted with a larger population using subjective and objective tools to confirm this correlation.

5-1. Acknowledgement

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