

Clinicals And Upper Airway Characteristics in Obese Children with Obstructive Sleep Apnea

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ABSTRACT

Introduction: Obesity is a factor that is strongly related to the occurrence of obstructive sleep apnea (OSA) in adults, although this association remains controversial for children. **Objective:** The aim of this study was to compare the clinical and upper airway characteristics, obtained by questionnaires, physical examination and laboratory tests, among obese children with and without OSA. **Method:** This was a prospective cohort study. 44 obese children (body mass index above the 95th percentile) were included in the study. Questionnaires, physical examination of the upper airway, nasofibrolaryngoscopy, polysomnography, and laboratory allergic tests were performed. **Results:** There were 22 male patients (50%), and the mean age was 7.6 ± 2.5 years. OSA was present in 19 (43%) patients. There were no statistically significant differences between the groups with and without OSA, in relation to clinical or laboratory allergic parameters. For the upper airway assessments, hypertrophy of the pharyngeal ($p=0.001$) and palatine ($p=0.049$) tonsils were the only parameters associated with OSA, and a modified Mallampati index of class III/IV also demonstrated a tendency towards being statistically associated with OSA ($p=0.081$). Moreover, these findings were confirmed to be factors associated with OSA in this group of children according to a logistic regression analysis. **Conclusions:** The occurrence rate of OSA in this obese pediatric population was high. Adenotonsillar hypertrophy and a modified Mallampati index of class III/IV were the factors associated with OSA.

Keywords: Obstructive sleep apnea; Obesity; Physical examination; Palatine tonsil; Pharynx.

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Received: September 14, 2016;
Accepted: January 27, 2017.

DOI: 10.5935/1984-0063.20170001

INTRODUCTION

In children, enlarged lymphoid tissues (hyperplasia of the pharyngeal and palatine tonsils) are the main factor involved in obstructive sleep apnea (OSA), and the adenotonsillectomy can provide relief from this disease in most cases¹⁻⁷. Obesity is acknowledged as a factor that is strongly related to the occurrence of OSA in adults⁸, although this association remains controversial for children⁹⁻¹⁸. Some authors have shown that the obesity is one of the most important factor for OSA persistence after adenotonsillectomy^{4-6,14,15}.

This association between OSA and obesity in children remains a subject of debate because many studies performed on children have not included a systematic assessment of the upper airway (UA) or laboratory tests to investigate allergic rhinopathy. However, these assessments may elucidate whether obesity, or perhaps a distinct anatomical factor, is in fact associated with the occurrence of OSA in obese children.

Therefore, this study sought to compare the clinical and polysomnographic findings, as well the UA characteristics obtained by physical examination, in obese children with and without OSA.

METHODS

A total of 46 obese children, who were above the 95th percentile for body mass index (BMI), were consecutively selected at the pediatric-endocrine clinic of the University between March 2008 and March 2009. Of these patients, 2 did not return for the polysomnography evaluation, so there were a total of 44 children who completed the study.

This study protocol was approved by the Research Ethics Committee of University (925/08), and all the patients' parents signed the informed consent.

The assessment protocol included the following components: questionnaires, anthropometric, UA, and craniofacial evaluations, nasofibrolaryngoscopy, polysomnography, serum immunoglobulin E (IgE), and the radioallergosorbent test (RAST). The systematic upper airway and craniofacial assessments were performed at the clinic of the otorhinolaryngology division of the University, and the polysomnography were performed at the sleep laboratory.

The inclusion criteria consisted of children of both sexes who were younger than 14 years of age and who had a BMI above the 95th percentile for their age and sex. The exclusion criteria consisted of children with genetic or neuromuscular diseases, craniofacial malformations, chronic pulmonary disease, use of sedative or stimulating medications, children who had previously been subjected to diagnosis and treatment for OSA, and non-cooperative patients.

Questionnaires

The children's caretakers answered questions related to the presence of sleep respiratory disorders, including the incidence of the following complaints: habitual snoring and witnessed breathing pauses in the sleep.

Snoring was assessed using a subjective scale to grade its frequency, and children who were reported to snore every day or almost every day were considered to exhibit habitual snoring. Witnessed breathing pauses were considered present when they were reported as occurring every day or almost every day.

Nasal complaints were also investigated, and the presence of nasal obstructions or symptoms suggestive of rhinopathy, such as nasal itching, runny nose and/or sneezing, were considered frequent when they had occurred every day or almost every day during the previous month.

Physical examination

The physical examination was made by only one trained doctor. The neck circumference (cm) and BMI (weight in kg/height² in meters) were evaluated. The BMI z scores were calculated according to age and gender using open-access online software (Epi Info, Centers for Disease Control and Prevention; <http://www.cdc.gov/epiinfo/>), where greater values indicated greater degrees of obesity.

As described by Zonato et al.¹⁹, children were considered to have craniofacial abnormalities when two or more of the following features were present: retrognathia, a narrow or ogival hard palate, and/or Angle's dental occlusion of class II. For the UA examination, pharyngeal abnormalities were present when 3 or more of the following features were present: webbed, posterior, or a thick soft palate; tonsillar pillars in the medial position; and/or a thick and long uvula^{19,20}.

The palatine tonsils were assessed and classified according to the methods described by Brodsky²¹. Grade III or IV tonsils, i.e., those occupying more than 50% of the oropharynx, were considered hypertrophic. The modified Mallampati index (MMI) was used, as suggested by Friedmann et al.²², and classes III and IV were considered to represent a bad relationship between the base of the tongue, the soft palate, and the oropharynx. All patients were subjected to anterior rhinoscopy and nasofibrolaryngoscopy (Pentax flexible fiberoptic) to assess the nasal septum, nasal turbinates, and the pharyngeal tonsil, which were considered hypertrophic when they occupied at least 75% of the choana.

Nasal abnormalities were defined by the presence of the following conditions: 1) septal deviations of grade II (touching the inferior nasal concha) or III (compressing the inferior nasal concha and touching the lateral wall of the nose), 2) Grade I septal deviation (not touching the inferior nasal concha) associated with complaints of frequent nasal obstruction or lower turbinate hypertrophy, and 3) lower turbinate hypertrophy associated with complaints of nasal obstruction or frequent rhinopathy complaints. Patients were considered to have frequent nasal obstruction and rhinopathy when these symptoms were reported as having occurred every day or almost every day during the previous month.

Polysomnography

The sleep studies were recorded using a computerized system (Alice, Respironics, Marieta, GA). The recordings were

performed over the course of one night and consisted of the following components: an electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG) (submental and masseter), and electrocardiogram; an airflow assessment using a pressure transducer through a nasal cannula, and an oronasal thermistor; an assessment of respiratory movements by means of abdominal and chest piezo bands; measurements of percutaneous oxygen saturation (SpO_2), using pulse oximetry, and exhaled CO_2 ; recordings of snoring with a microphone; and the application of a body positioning sensor.

Sleep staging was performed according to the criteria proposed by Rechtschaffen and Kales²³, and arousals were assessed according to the criteria of the American Sleep Disorders Association (ASDA, 1992)²⁴. The assessment of respiratory events was performed according to the criteria proposed by the American Thoracic Society¹.

For the obstructive apnea index (OAI), the reference criterion of normality represented 1 or fewer respiratory events per hour; furthermore, a mild increase was defined as 1 to 5 events per hour, a moderate increase was represented as 5 to 10 events per hour, and a severe increase was represented as more than 10 events per hour³. In this study, OSA was defined for children with an OAI above 1 per hour.

Laboratory tests

Blood samples were collected to assess serum immunoglobulin E (IgE) levels, and radioallergosorbent test (RAST) for inhalants including allergens, such as dust and home dust mites (household dust, *Dermatophagoides pteronyssinus*, *Dermatophagoides farina*, and the cockroach) and fungi (*Penicilliumnotatum*, *Cladosporiumberbarum*, *Aspergillus fumigatus*, and *Alternaria alternata*).

The reference values for IgE levels in children between the ages of 0 and 3 years are 0 - 46 UI/mL, and those for children between the ages of 3 and 6 years are 0 - 280 UI/mL. All children exhibiting levels greater than the reference values were considered IgE-positive.

The reference values for results of the RAST are grouped as follows: < 0.35 KU/L, undetectable; 0.35 - 0.7 KU/L, low level; 0.7 - 3.5 KU/L, moderate level; 3.5 - 17.5 KU/L, high level; and 17.5 - 50 KU/L, very high level. All children exhibiting detectable values were considered RAST-positive, independent of the severity.

Statistical analysis

Variables exhibiting a normal distribution are represented as the mean and standard deviation, whereas those with a non-normal distribution are represented by the corresponding nonparametric statistics. Comparisons between groups were performed using the Chi-squared test for categorical variables. Qualitative variables were compared using unpaired *t-test* if data present a normal distribution or the Mann-Whitney test if data not present normal distribution. The significance level was set at 0.05.

Logistic regression was performed for the following variables: age, BMI z-score, pharyngeal and palatine tonsil

hypertrophy, MMI, craniofacial alteration, nasal alteration, pharyngeal alteration, neck circumference, rhinopathy complaints, RAST results, and IgE levels. Because there were many explanatory variables for a limited number of patients, the backward Wald method was used for the logistic regression; the variables were included in different orders and stages, and only those exhibiting an association remained. The sample power was calculated using Minitab according to the OAI values.

The SPSS V16, Office Excel 2007, and Minitab 15 softwares were used for the analysis.

RESULTS

Of the 46 children initially included in the study, only 44 completed the assessment protocol. Of these final participants, there were 22 (50%) males and 22 (50%) females, and the average age was 7.6 ± 2.5 years. The mean BMI z-score of these patients was 2.5 ± 0.4 , and their mean neck circumference was 33.3 ± 3.3 cm.

The power of the sample size was calculated using Minitab according to the OAI. This sample population of 44 participants had a power of 78.2% (0.782).

According to the diagnostic criteria for OSA in children, 19 participants (43%) had OSA; of these, 11 were male and 8 were female ($p=0.128$). There were 6 children with mild OSA, 3 with moderate and 10 with severe OSA. Table 1 summarizes the sample according to age, BMI z-score and sleep characteristics.

The neck circumference, BMI, BMI z-score and age ranges were not significantly different when comparing the presence/absence of OSA.

From the clinical assessments, habitual snoring ($p=0.038$) and witnessed breathing pauses ($p = 0.017$) were more frequent in OSA group (Table 2).

For the comparison between the OSA and non-OSA groups, hypertrophy of both the pharyngeal (adenoid) ($p=0.049$) and palatine ($p<0.001$) tonsils was statistically more frequent in the OSA group, and a MMI of class III/IV also showed a tendency towards significance for the OSA group ($p=0.081$) (Table 3).

For the polysomnographic findings, as expected, for the comparison between the OSA and non-OSA groups, the significant findings included a high OAI ($p<0.001$), a greater frequency of arousals ($p = 0.005$), and a lower minimum oxygen saturation value ($p<0.001$) in the group with OSA. In addition, the percentage of REM sleep was higher ($p=0.003$) among patients with OSA (Table 1).

The comparison between the OSA and non-OSA groups for allergic complaints and the laboratory test results for allergic rhinitis did not show any significant differences (Table 4).

The following variables were included in the logistic regression model to identify factors associated with OSA: age, BMI z-score, neck circumference, palatine tonsils hypertrophy and pharyngeal tonsil hypertrophy, MMI, craniofacial alteration, nasal alteration, rhinopathy complaints, and positive RAST and positive IgE levels. The

Table 1. Characteristics of the sample. Age, BMI z-score and sleep parameters.

	Non-OSA N=25	OSA N=19	Total N=44	p
Age (years)	7.6±2.4	7.6±2.6	7.6±2.5	0.95
BMI z-score	2.43±0.44	2.57±0.46	2.49±0.45	0.85
OAI (events/h)	0.1±0.2	12.2±13.9	5.5±11.0	p<0.001*
Arousals (events/h)	6.0±2.9	11.5±7.8	8.6±6.3	0.005*
REM sleep (%)	17.7±7.8	21.2±3.0	19.3±6.3	0.003*
Min SpO ₂ (%)	93.9±1.9	83.3±7.0	89.1±7.2	p<0.001*

OSA=group with obstructive sleep apnea; Non-OSA=group without obstructive sleep apnea; OAI=obstructive apnea index; min SpO₂=minimum oxygen saturation, *p=statistical value (p<0.05)

Table 2. Frequency of clinical complaints: a comparison between groups with and without OSA.

	Non-OSA N=25		OSA N=19		p
	N	%	N	%	
Habitual Snoring	20	80.0%	19	100%	0.038*
Witnesses Pauses	8	32.0%	13	68.4%	0.017*

OSA=group with obstructive sleep apnea; Non-OSA=group without obstructive sleep apnea; *p=statistical value (p<0.05); Chi-squared test (x²)

Table 3. Frequency of upper airway and craniofacial abnormalities: a comparison between groups with and without OSA.

	Non-OSA N=25		OSA N=19		p
	N	%	N	%	
Craniofacial abnormalities	20	80.0%	13	68.4%	0.380
Pharyngeal abnormalities	2	8.0%	0	0.0%	0.207
Nasal abnormalities	15	60.0%	10	52.6%	0.625
Hypertrophic palatine tonsils	6	24.0%	14	73.7%	0.001*
Hypertrophic pharyngeal tonsil	11	44.0%	14	73.7%	0.049*
MMI classes III / IV	15	60.0%	16	84.2%	0.081**

OSA=group with obstructive sleep apnea; Non-OSA=group without obstructive sleep apnea; MMI=modified Mallampati index, * p=statistical value (p<0.05), ** p=statistical value (0.10 < p≤0.05); Chi-squared test (x²)

Table 4. Frequency of allergic complaints and laboratory test results for allergic rhinitis: a comparison between groups with and without OSA.

	Non-OSA N=25		OSA N=19		p
	N	%	N	%	
Rhinopathy complaints	22	88.0%	12	63.2%	0.051
Positive IgE	16	64.0%	9	47.4%	0.270
Positive RAST	11	44.0%	8	42.1%	0.900

OSA=group with obstructive sleep apnea; Non-OSA=group without obstructive sleep apnea; IgE=serum immunoglobulin E, RAST=radioallergosorbent test *p=statistical value (p<0.05); Chi-squared test (x²)

factors that were significantly associated with the presence of OSA in this population of obese children included palatine tonsil hypertrophy (grades III and IV) (Odds Ratio: 14.1 (2.5 - 80.8); p=0.03) and a MMI of class III/IV (Odds Ratio: 8.9 (1.3 - 60.9); p=0.02) (Table 5).

Table 5. Logistic regression of the factors associated with OSA in obese children.

	Beta	Standart Error	Wald	p	RP (95% IC)
Hypertrophic palatine tonsils	2.65	0.86	8.81	0.03*	14.1 (2.5 – 80.8)
MMI classes III/IV	2.19	0.98	4.67	0.026*	8.9 (1.3 – 60.9)

MMI=modified Mallampati index, *p=statistical value (p<0.05)

DISCUSSION

The systematic assessment of the UA concluded that pharyngeal and palatine tonsil hypertrophy and a MMI of class III/IV were the main factors associated with the presence of OSA in a population of obese children. The remaining clinical markers (age, BMI, BMI z-score, and neck circumference) did not exhibit this association. It is important to note that the small sample size of this study may be a bias in this interpretation. The real role of obesity in the occurrence of OSA remains quite controversial.

The prevalence of overweight and obese children has increased during the last 10 years, and these conditions now affect approximately 10% of the childhood population. In the USA, 0.1% of children 2 to 18 years old are obese, and 5 to 18% are overweight^{25,26}. The prevalence of OSA among obese children is highly variable^{18,27,28}. In a review study, Verhulst et al.²⁹ found that the frequency of OSA among obese children varied between 13 and 59%. The differences in OSA prevalence between studies may be due to several factors, including different ethnicities and different diagnostic criteria for childhood obesity and OSA. The present study found an OSA prevalence of 43% in the investigated obese population, which is in agreement with these authors.

Approximately 12 to 16% of school-aged children exhibit habitual snoring^{30,31}, whereas only 2% exhibit OSA^{30,32}. A study performed in Italy investigated 2,209 children between the ages of 10 and 15 years using a questionnaire, and the frequency of snoring was 2.6 times higher among obese children³³. These findings were confirmed by the study from Urschitz et al.³⁴, which demonstrated a 4-fold increased incidence of snoring among obese children compared to their age-matched, non-obese peers. In our study, the age of the children varied between

3 and 13 years, and the frequency of habitual snoring was 88.6%. These results suggest an association between snoring and obesity.

Additionally, we found habitual snoring and witnessed breathing pauses during sleep, to be more frequent among individuals in the OSA group, as described previously². Tagaya et al.³⁵, comparing preschool and schoolchildren with OSA, found that OSA was more severe in preschool children, suggesting that OSA may resolve in some children during their growth.

None of the anthropometric parameters (neck circumference, BMI, BMI z-score) showed differences between the OSA and non-OSA groups. These results suggest that despite being predictors of OSA in adults^{36,37}, these parameters were not relevant for this population of obese children. The absent of association between neck circumference and OSA in obese children are similar to the findings of Xu et al.¹¹. In contrast, a study by Redline et al.⁹ found a significant association between neck circumference and OSA, although the criteria used to define obesity and OSA, as well as the age of the patient sample, differed from those used in our study.

Craniofacial and UA alterations are commonly described in adults with OSA^{19-22,38}, although no studies have performed systematic assessments in children. Most studies performed with obese children have been limited to the assessment of the pharyngeal and palatine tonsils^{10,11,13,29,39}. In the current study, thorough otorhinolaryngological assessments were performed that included an evaluation of the size of the palatine and pharyngeal tonsils as well as evaluations of the MMI and craniofacial, nasal, and pharyngeal alterations. As a result of this evaluation, pharyngeal and palatine tonsils hypertrophy exhibited a significant association with the presence of OSA, which is in agreement with other studies^{10,11,29}. In normal-weight children, Tagaya et al.³⁵ found that adenoid hypertrophy was a significant predictor of the apnea index but tonsil size had little influence on the apnea index. Dayyat et al.⁴⁰ found a modest association between adenotonsillar size and apnea index in nonobese children and no association in obese children.

A MMI of class III/IV is an acknowledged marker for both the presence and severity of OSA in adults^{19,20,38}, although few studies have been performed in obese children on this topic. Dayyat et al.⁴⁰, comparing obese and nonobese children found higher MMI in obese children. In our case series, a MMI of class III/IV was more frequent among patients in the OSA group. By contrast, the presence of craniofacial alterations or nasal alterations did not exhibit this association with the presence of OSA.

As expected, the polysomnographic assessment revealed that OAI was higher in the OSA group and was associated with lower levels of oxygen saturation and a greater number of arousals. The sleep architecture was preserved in both groups, as described previously³⁹, with the exception that the percentage of REM sleep was higher in the OSA group, although this finding does not seem clinically important.

Several studies have suggested that rhinitis may impair the quality of sleep and may contribute to sleep respiratory

disorders⁴¹. Treatment with intranasal corticoids for children who present with OSA or rhinitis can decrease the nasal resistance to airflow and the OAI⁴². The current study did not find correlations between rhinitis complaints, nasal alteration, IgE level, or positive RAST results and the presence/absence of OSA.

CONCLUSIONS

The prevalence of OSA in this population of obese children was high in comparison to the overall pediatric population, which confirms previous findings. However, the degree of obesity (BMI z-score) and the anthropometric predictors of OSA that are commonly used in adults (BMI and neck circumference) were not shown to be significantly associated with the presence of OSA. In contrast, evaluation of UA, using the size of the palatine tonsils and a MMI of class III/IV were found to be associated with the presence of OSA in obese children.

ACKNOWLEDGEMENTS

This study was supported by AFIP, FAPESP/CEPID and CNPq.

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