Obstructive Sleep Apnea (OSA): Differences Between Normal-weight, Overweight, Obese, and Morbidly Obese Children

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Introduction

Pediatric obstructive sleep apnea (OSA) is characterized by obstruction of the upper airway during sleep leading to inadequate ventilation (1). Children experience frequent hypopnea and apnea events during sleep leading to arousals, oxygen desaturation, and hypercapnia

The association between overweight/obesity and pediatric OSA remains unclear. Some authors report a linear correlation between BMI and OSA at all ages while others have found a connection only in older children (2,3)

The primary objective of this study was to compare OSA severity, as measured by polysomnography, in normal-weight, overweight, obese and morbidly obese children. The secondary objective was to identify demographic and clinical parameters that contribute to any identified differences in OSA severity

Methods

Electronic medical records of children who underwent polysomnography over a 3-month period at Children's Medical Center were examined.

Inclusion criteria were:

1) Age 2-18
2) Height, weight and polysomnography data available

Exclusion criteria were:

1) Significant comorbidities including genetic, neuromuscular or endocrine disorders
2) Previous tonsillectomy and adenoidectomy

Demographic and polysomnogram measurements were recorded. Children were grouped into four age and sex-adjusted BMI percentile categories: normal-weight (5-85), overweight (85-95), obese (95-99), and morbidly obese (>99). A multilevel mixed effects regression model was used for analysis. Significance was set at $p \leq 0.05$.

Child undergoing polysomnography

Glossary of Terms

Apnea Hypopnea Index (AHI) – the number of complete (apnea) or partial (hypopnea) reductions in airflow per minute.
Central Apnea Index (CAI) – the number of apneas with no muscular respiratory effort.
REM Sleep (REM) – the percentage of total sleep time spent in the rapid eye movement stage.
Sleep Efficiency – the ratio between the total time spent asleep over the total study recording time.
Arousal Index – the number of arousals from sleep per minute.
Oxygen Desaturation (Sa02 nadir) – the lowest hemoglobin oxygen saturation recorded.
Peak CO2 – the highest C02 pressure in mmHg recorded.
Hypercapnia (TST >50mmHg CO2) – the percentage of total sleep time spent at greater than 50 mmHG C02

Results

	Normal-Wt	Overweight	Obese	Morbidly Obese	P-value
Age (mean)	5.8	7.4	9.1	8.0	<0.001
Wt lbs (mean)	42.6	52.4	64.1	67.7	<0.001
Gender					=0.425
Male	63 (53%)	20 (41%)	29 (48%)	35 (56%)	
Ethnicity					=0.381
Non- Black	87 (74%)	42 (86%)	50 (83%)	48 (76%)	
Black	31 (26%)	7 (14%)	10 (17%)	15 (24%)	

Table 1 – Demographics of Study Population

290 patients were included in this study. Table 2 summarizes the key results from univariate regression analysis. Age was not linearly associated with AHI (p=0.413), the arousal index, or the CAI. Age was strongly associated with a decreased percentage of sleep spent in REM (p<0.001) as well as decreased sleep efficiency (p=0.002). Older children also showed improved measurements of hypercapnia.

BMI z score alone was not linearly associated with AHI (p=0.232) but was associated with decreased REM sleep (p<0.001). The BMI z score was not associated with any other polysomnogram measurements.

Gender was not associated with any significant differences in parameters, including AHI (p=0.451). Likewise, African American children did not show an increase in AHI compared to their non-black counterparts (p=0.776).

	Age Coefficient	P-Value	Z Score Coefficient	P-Value
AHI	0.22	0.413	0.01	0.232
CAI	-0.06	0.059	-0.00	0.943
Arousal Index	-0.04	0.815	0.01	0.169
REM	-0.46	<0.001	-0.05	<0.001
Sleep Efficiency	-0.55	0.002	-0.01	0.090
Low SaO2 (Nadir)	0.16	0.163	-0.01	0.279
Peak CO2	-0.53	<0.001	-0.02	0.084
TST > 50 mmHg CO2	-0.78	0.013	0.00	0.866

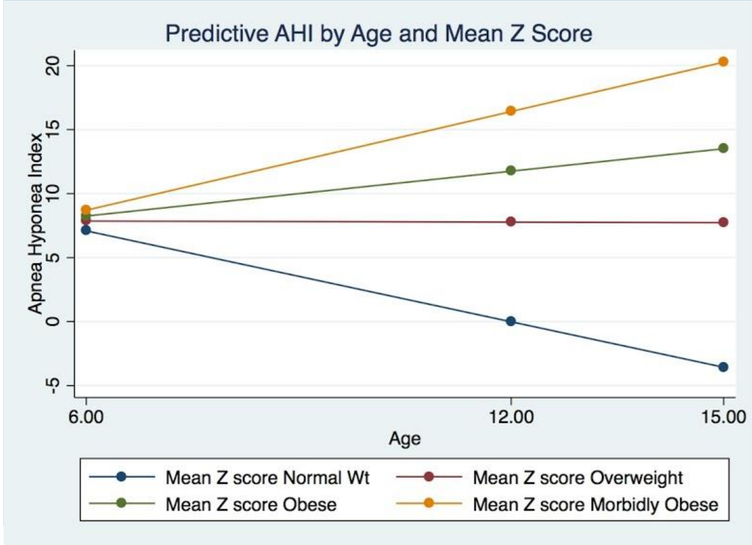
Table 2 - Univariate Regression of Age and Z Score vs. Polysomnogram Measurements

Table 3 demonstrates the results of multivariate analysis. We found that age and z score offered a strong positive correlation with AHI (p<0.001) and an r squared value of 0.06. Age and z score together also correlated positively with the arousal index (p<0.001). The multivariate model demonstrated a negative correlation with SaO2 nadir (p=0.019), and a positive correlation with peak CO2 (p=0.045).

	Age + Z Score Coefficient	P-Value
AHI	0.86	<0.001
CAI	0.01	0.659
Arousal Index	0.55	<0.001
REM	-0.12	0.105
Sleep Efficiency	-0.19	0.202
Low SaO2 (Nadir)	-0.23	0.019
Peak CO2	0.16	0.045
TST > 50 mmHg CO2	-0.11	0.696

Table 3 – Multivariate Regression of Age with Z Score vs. Polysomnogram Measurements

Results



Discussion

Present evidence-based guidelines recommend routine PSG prior to T&A for OSA in obese children. This is in contrast to normal-weight children who are more likely to have mild OSA and undergo T&A without the need for preoperative PSG. Previous studies have shown that OSA severity correlates with obesity and perioperative complications thus making preoperative PSG important in surgical planning. Equally, older children are more likely to have severe OSA and benefit from preoperative PSG.

This study shows that neither obesity nor age alone correlates with OSA severity in children. Gender and race were not associated, alone or in combination, with OSA severity in children. It is only the combination of obesity and age that correlates with OSA severity. Thus, it is older obese children who have a higher AHI, arousal index, oxygen desaturation, and elevated carbon dioxide levels during sleep.

This study reports an important finding; routine PSG may only be needed in older obese children. This may result in significant healthcare savings while maintaining patient safety. However, more studies are needed to define the cut-off age for when PSG is routinely needed in obese children and the best way to measure OSA severity in these children.

Conclusions

There are important differences in children with OSA in different weight categories. OSA severity is correlated with a combination of increasing age and weight but not with either variable independently. This study suggests that obese and morbidly obese older children are most likely to have severe OSA and should undergo routine PSG

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