Paediatric Respiratory Reviews 15 (2014) 211–218

Contents lists available at ScienceDirect

Paediatric Respiratory Reviews

Mini-Symposium: Obesity and the Respiratory system

Sleeping too Close Together: Obesity and Obstructive Sleep Apnea in Childhood and Adolescence

Joseph L. Mathew [1], Indra Narang [2,3,*]

[1] Pediatric Pulmonology Unit, Advanced Pediatrics Centre, Postgraduate Institute of Medical Education and Research, Chandigarh, India 160012
[2] Division of Respiratory Medicine, The Hospital for Sick Children, Toronto, Canada
[3] The University of Toronto, Toronto, Canada

EDUCATIONAL AIMS

- To highlight the importance of obstructive sleep apnea (OSA) as a significant contributor to co-morbid disease in obese children
- To describe the prevalence of OSA in overweight and obese children and adolescents
- To discuss the current evidence for cardiovascular, metabolic and neurocognitive dysfunction in children with obesity related OSA
- To illustrate the treatments strategies and their outcomes for OSA in obese children.

ARTICLE INFO

Keywords:
Obesity
Obstructive sleep apnea
Cardiometabolic disease

SUMMARY

To review the current available literature exploring the prevalence, severity, consequences and treatments for obesity related OSA in children and adolescents. The published literature was searched through EMBASE and Pubmed using a pre-defined search strategy. There is evidence showing that OSA occurs more frequently and may be more severe in children and adolescents who are overweight or obese compared with lean children. Obesity and OSA are independently associated with adverse cardiovascular, metabolic, and neuropsychological consequences. The magnitude of these abnormalities when obesity and OSA co-exist is not well established. Treatment options for obesity related OSA includes adenotonsillectomy, but it does not cure OSA in over 50% of obese children. Positive airway pressure (PAP) therapy delivered through continuous or bi-level modes is successful, but limited by generally poor compliance. There is increasing experience with bariatric surgical techniques which are effective for the treatment of obesity and its related complications. As obesity related OSA is highly prevalent, more research is needed to understand the interaction of these two conditions with regards to pathophysiology, adverse consequences and optimal management strategies.

INTRODUCTION

The prevalence of obesity across all age groups has nearly doubled since 1980 [1]. It has reportedly more than doubled in children in the age range 6–11 y from 7% to 18% and tripled in adolescents 12–19 y of age from 5% to 18% between 1980 and 2010 [1,2].

Overweight and obesity are strongly associated with multiple morbidities, among which sleep-disordered breathing (SDB), particularly obstructive sleep apnea (OSA), is gaining importance. The spectrum of SDB ranges from primary snoring effecting about 1.5–27.6% of children, to frank OSA effecting 0–5.7% of children [3,4].

Polysomnography (PSG) is the gold standard for the diagnosis of OSA. The severity grading for OSA is expressed as the number of

* Corresponding author. Division of Respiratory Medicine, The Hospital for Sick Children, 555 University Avenue, The University of Toronto, Toronto, ON M5G1X8, Canada. Tel.: +1 416 813 6346; fax: +1 416 813 6246.
E-mail address: indra.narang@sickkids.ca (I. Narang).

Abbreviations: AHI, Apnea Hypopnea Index; AT, Adenotonsillectomy; BMI, Body Mass Index; BP, Blood Pressure; CI, Confidence Interval; CPAP, Continuous Positive Airway Pressure; EDS, Excessive daytime sleepiness; HDL, High Density Lipoprotein; hs-CRP, High sensitivity C-reactive Protein; LSG, Laparoscopic Sleeve Gastrectomy; LTE E4, Leukotriene E4; MetS, Metabolic Syndrome; NS, Not Significant; OR, Odds ratio; OSA, Obstructive Sleep Apnea; PAP, Positive Airway Pressure; PSG, Polysomnography; QOL, Quality of Life; RCT, Randomized Controlled Trial; RR, Relative Risk; SaO_2, Oxygen saturations; SDB, Sleep disordered breathing; SE, Standard Error of the Mean; y, years.

1526-0542/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.prrv.2013.09.001

obstructive apneas and hypopneas per hour during sleep, the apnea-hypopnea index (AHI). Children with an AHI of 1–5 events per hour are categorized as having mild OSA, 5–10 per hour as moderate OSA and >10 per hour as severe OSA [5]. The most common etiologic risk factor for childhood OSA is adenotonsillar hypertrophy with a peak age of incidence between 2 and 8 years. Obese children with OSA tend to be older, have less lymphoid hyperplasia and are at increased risk for cardiovascular and metabolic dysfunction than their lean counterparts who have OSA [6,7].

In this review, we present data on (i) the epidemiological evidence for the prevalence and severity of obesity related OSA, (ii) the adverse consequences of obesity related OSA, and (iii) the management of obesity related OSA.

PREVALENCE AND SEVERITY OF OSA AND RELATIONSHIP TO BODY WEIGHT

Prevalence of OSA among children/adolescents with obesity (Table 1)

Kheirandish-Gozal et al [8] included 518 consecutive children and adolescents (4–17y) with habitual snoring, of whom 142 were overweight or obese (BMI z-score >1.2). OSA (AHI >2/hr) in obese/overweight compared to non-obese subjects was more prevalent (78% and 61.7% respectively) and more severe (AHI 9.6/hr and 7.2/hr respectively). Reade et al [9] showed that in 90 children aged 4.2–18 years of age, AHI was >1/hr with O_2 < 90% in 30/56 (53%) obese (BMI >95th centile) subjects compared to 10/34 (29%) non-obese subjects. In studies without a control group, Li et al [10] performed PSGs in 94 referred obese (BMI >95th centile) Chinese children and adolescents (7–18y) with habitual snoring; 47% had mild OSA (AHI >1/hr) and 13% had moderate to severe OSA (AHI >10/hr). Similarly, in 91 children and adolescents (6–16y), of whom 27 were overweight and 64 obese (defined by International Obesity Task Force criteria, BMI z-score >2.7), only 49/91 (54%) had a normal PSG [11]. Among those who were obese, 11% had an AHI 2-5/hr and 8% had an AHI >5/hr. In 41 morbidly obese (weight >150% ideal weight) children and young adults (3–20 y), 24% had OSA using an AHI >5/hr. Moreover, SaO_2 was <90% for >3% of the total sleep time in 20% of these children [12]. In a separate cohort of children with severe obesity (BMI z-score >3.0), Dubern et al [13] reported severe OSA (AHI >10/hr) in 7/51 (14%) of cases. Some of the disparities between the studies are likely related to the different study designs, different participant characteristics and variable definitions for OSA and obesity.

Associations between BMI and OSA among children/adolescents (Table 2)

Barone et al [14] reported the BMI of 149 children (5–15y) with OSA and 139 children who did not have OSA. BMI >95th centile was observed in 7% controls compared to 37% of cases with OSA. Tauman et al [15] categorized 135 children (mean age 9 y) according to the AHI, <1/hr, 1-5/hr and AHI >5/hr. There was a significantly higher proportion of obese (BMI z-score >1.65) children in those with higher AHI values. Similarly, Shen et al [16] recruited 282 children (mean age 5 y) with habitual snoring and 94 healthy controls. OSA was defined as AHI ≥1/hr. The mean BMI z-scores for controls, AHI 1-5/hr, AHI 5-20/hr, and AHI ≥20/hr were 0.49, 0.36, 0.36 and 0.92, respectively (p = NS). The mean AHI in lean and overweight/obese children (BMI z-score >1.034) with OSA was 6.40/hr and 8.95/hr, respectively (p = NS). In a retrospective review [17], BMI was measured in 255 children (2–14 y) with PSG confirmed OSA (AHI >3/hr); there was no observed association between obesity and OSA. The differences in the ages and the definitions of OSA between these studies may have accounted for the disparate findings. In a smaller study, Canapari et al [18] compared BMI between children with obesity (BMI >95th centile) and OSA (n = 15) and obese without OSA (n = 16). The BMI was higher in those with OSA compared to those without OSA (43.9 ± 13.9 kg/m^2 versus 35.4 ± 5.8 kg/m^2, respectively) suggesting that the severity of BMI may be associated with the presence of OSA.

The etiological factors predisposing to obesity related OSA remains to be determined. Dayyat et al [6] compared tonsil size, adenoid sizes, and Mallampati score in 206 non-obese children with OSA (mean AHI 10/hr) and 206 obese children (matched for age, gender, ethnicity, and obstructive AHI). The mean adenotonsillar size was larger in non-obese children than obese children (3.85 ± 0.16 vs 3.01 ± 0.14 cm^3), suggesting that obese children have less lymphoid tissue for the same magnitude of OSA when compared to non-obese children. In one magnetic resonance [MR] based study of the head and neck, evaluating 34 obese children, subjects with OSA compared with no OSA had a significantly larger volume of adenoids (10.5 ± 4.4 vs 7.1 ± 3.6 cm^3), palatine tonsils (10.1 ± 3.9 vs 7.8 ± 2.5 cm^3), and retropharyngeal lymph nodes (4.7 ± 2.4 vs 3.1 ± 1.6 cm^3) respectively [19]. Further, lymphoid

Table 1
Prevalence of OSA among children and adolescents with obesity

Author	Study design	Age	Total cohort	No. with obesity	Definition of obesity	Definition of OSA	Main Findings
Kheirandish-Gozal [8]	Cohort with control group	4-17 y	518	142	BMI z-score >1.2	AHI >2/hr	• OSA in 78% of overweight/obese vs 62% non-obese, OR 2.22, 95% CI 1.42-3.48.
Reade [9]	Cohort with control group	4-19 y	90	56	BMI >95th centile	AHI >1/hr with O_2 <90%	• OSA in 54% obese vs 30% non-obese, RR 2.77, 95% CI 1.12-6.85. • The mean AHI/hr in obese vs non-obese, 8.9 ± 13.7 vs 5.1 ± 9.2 (p < 0.05)
Li [10]	Cohort	7-18 y	94	94	BMI >95th centile	AHI >1/hr	• 60/94 (64%) had OSA. Of these, 47/60 had AHI 1.0-10.0/hr and 13 had AHI >10/hr
Verhulst [11]	Cohort	6-16 y	91	64	IOTF criteria	Obstructive apnea index >1/hr or Obstructive AHI >2/hr.	• Among obese, 11% had mild OSA and 8% had moderate to severe OSA.
Mallory [12]	Cohort	3-20 y	41	41	Morbid obesity, >150% ideal weight	AHI >5/hr	• OSA in 24%, • SaO_2 <90% for >3% sleep time in 20%,
Dubern [13]	Cohort	Mean 12.3 ± 2.3y	51	51	Severe obesity, BMI z-score >3.0	AHI >10/hr	• OSA in 7/51 (14%).