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Obstructive sleep apnoea syndrome and obesity in children

阻礙性睡眠呼吸窒息與兒童肥胖

Objective. To review data on children who have both obesity and obstructive sleep apnoea syndrome.
Data source. Pubmed and MEDLINE (Ovid) literature search using the following key words: obstructive sleep apnea syndrome, obesity, and children.
Study selection. Literature and data on obesity-associated obstructive sleep apnoea syndrome in children.
Data extraction. Review of relevant information and data.
Data synthesis. Different definitions of obesity and obstructive sleep apnoea syndrome in children were used in different studies, which made it difficult to compare results from different studies conducted in different countries. Nonetheless, obstructive sleep apnoea syndrome was found to be moderately prevalent among obese children—namely, 13% to 36%. The severity of obstructive sleep apnoea syndrome was positively related to the degree of obesity. Blood pressure was found to be elevated in obese children with obstructive sleep apnoea syndrome. Weight reduction is an effective treatment.
Conclusion. Children with obesity and obstructive sleep apnoea syndrome face a double challenge. A holistic approach to management requires a clear understanding of how both problems interact.

目的：回顧患有阻礙性睡眠呼吸窒息綜合症的肥胖兒童的有關數據。
資料來源：Pubmed及MEDLINE（Ovid） 文獻檢索。文獻檢索的關鍵詞包括「阻礙性睡眠呼吸窒息綜合症」、「肥胖」、及「兒童」。
研究選取：與肥胖有關的兒童阻礙性睡眠呼吸窒息綜合症的相關文獻及數據。
資料選取：回顧有關的資料及數據。
資料綜合：各項研究對兒童肥胖及阻礙性睡眠呼吸窒息綜合症的定義並不相同，因此難以比較在不同國家進行的各項研究結果。然而，阻礙性睡眠呼吸窒息綜合症在肥胖兒童身上頗為普遍，百分比由13%至36%不等。阻礙性睡眠呼吸窒息綜合症的嚴重性，與肥胖的程度成正比。患有阻礙性睡眠呼吸窒息綜合症的肥胖兒童，其血壓亦較高。減肥是有效的療法。
結論：同時患有肥胖及阻礙性睡眠呼吸窒息綜合症問題的兒童面臨雙重挑戰。要達至全面的處理，必須了解兩個問題如何互相作用。

Key words:
Child;
Obesity;
Sleep apnea, obstructive

關鍵詞：
兒童；
癡肥；
睡眠呼吸窒息，阻礙性

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Introduction

Obstructive sleep apnoea syndrome (OSAS) occurs in 0.7% of 4- to 5-year-olds,[1] and OSAS and obesity among children can occur together. In 1981, Guilleminault et al[2] found that five (10%) of 50 children with OSAS were obese, and other researchers showed that 13% to 36% of obese children had OSAS.[3-5] It has been estimated that obesity increases the risk of OSAS by 4.5 times among children.[6] Given the increasing prevalence of obesity in our society[7] and worldwide,[8] the prevalence of paediatric OSAS is expected to rise. This review examines the current state of understanding of obese children with OSAS.

Definition of obesity

Obesity is often defined as a body weight greater than 120% times the median weight-for-height (MWH).[9,10] This definition is not ideal, because it may not reflect the composition of body fat. Nevertheless, the MWH is a convenient

Table. Summary of studies of obstructive sleep apnoea syndrome and obesity in children

Study	No. of obese patients	Patient with OSAS* No. (%)	Definition of obesity	Definition of OSAS
Mallory et al, 1989[3]	41	10 (24)	Weight ≥150% ideal body weight	AHI† >5 episodes per hour
Marcus et al, 1996[4]	22	8 (36)	Weight >120% MWH‡ or skinfold thickness >85%	Two of the following criteria: (1) Obstructive apnoea index >1 episode per hour (2) Desaturation (SaO_2 <92%) (3) Hypercapnia (peak end tidal CO_2 >53 mm Hg or duration of hypoventilation [peak end tidal CO_2 >50 mm Hg] >8% of sleep time)
Chay et al, 2000[5]	60	8 (13)	Weight ≥180% MWH	AHI >5 episodes per hour
	86	18 (21)	Body weight >120%-180% MWH	AHI >5 episodes per hour

* OSAS obstructive sleep apnoea syndrome
† AHI apnoea hypopnoea index
‡ MWH median weight-for-height

measure that is easy to obtain, and it is used as a standard in Hong Kong, because growth status can be assessed easily from the sex-specific weight-for-height chart.[11,12]

The body mass index (BMI)—weight in kilograms divided by the square of the height in metres—is frequently used for adults and is related to health risk: the cut-off value for obesity is 30 kg/m^2 and that for overweight is 25 kg/m^2.[13,14] This index is less easy to apply to children because their normal range of BMI varies with age and sex. Instead of using a fixed value, a percentile value of BMI is more commonly used as a definition for obesity in children. In the US, the 85th and 95th centile of BMI are recommended as the cut-off points for overweight and obesity, respectively.[15] These values, however, are based on US data and cannot be used as an international reference. A survey that pooled growth data from six countries and cities (including Singapore and Hong Kong) tried to resolve this problem by linking BMI values to the adult cut-off points of 25 and 30 kg/m^2.[16] For Hong Kong, the cut-off values for obesity is the 97th centile for boys and 98th centile for girls, and the cut-off values for overweight is the 88th centile for boys and 90th centile for girls. For convenience, BMI cut-off values of 90th and 97th centiles are used as definitions of overweight and obesity, respectively, for Hong Kong children.

Obstructive sleep apnoea syndrome in children

Paediatric OSAS is defined as "a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction and/or intermittent complete obstruction (obstructive apnea) that disrupts normal ventilation during sleep and normal sleep pattern".[17] The mean (standard deviation [SD]) value of obstructive apnoea of any duration is 0.1 (0.5) episodes per hour.[18] The normal value of obstructive hypopnoea—defined as more than 50% but less than 80% drop in flow—is not available. Obstructive sleep apnoea syndrome is best quantified in terms of combined apnoea and hypopnoea episodes per hour—that is, the apnoea hypopnoea index (AHI). In adults, and more so in children, there is no consensus on the normal value of AHI: values of 5, 10, 15, 20, or 30 have been used as indicators of OSAS in different studies and clinical settings.[19] At the paediatrics department of the Kwong Wah Hospital, an AHI of more than 2 is currently accepted as indicative of the presence of OSAS. Such a score has been found to be associated with a significantly elevated blood pressure in children.[20]

Obstructive sleep apnoea syndrome in obese children

The Table summarises published studies on OSAS among obese children.[3-5] Mallory et al[3] studied 41 children and adolescents with a history of breathing difficulty during sleep, as well as morbid obesity (ie a body weight of ≥150% of the ideal weight). The mean (SD) patient age was 10.3 (4.4) years. Ten (24%) of the 41 individuals had an AHI of more than five episodes per hour according to an overnight polysomnography study.

Marcus et al[4] studied 22 obese children (ie with a body weight of >120% MWH or a triceps and subscapular skinfold thickness of >85th percentile) who did not present with sleep or respiratory complaints. Their mean (SD) age was 10 (5) years and mean (SD) body weight was 184% (36%) of the MWH. Evidence of sleep-disordered breathing was observed in eight (36%) of the 22 individuals studied. There was a positive correlation between the apnoea index and the degree of obesity.

In a study from Singapore, Chay et al[5] studied 60 morbidly obese children (ie with a body weight of ≥180% MWH), eight (13%) of whom had an AHI of more than five episodes per hour. They also selected a high-risk group—those scoring more than 3.5 according to a formula described by Brouilette et al[21] or those identified by attending clinicians to be likely or highly likely to have OSAS—from 3611 less-obese children (ie with a body weight of >120%-180% MWH). Eighty-six less-obese children were studied by polysomnography and 18 (21%) were found to have an AHI of more than five episodes per hour. The authors estimated that for the whole population of Singaporean obese children, 5.7% had an AHI of more than 5.

Finally, Redline et al[6] reported that obesity—defined as a BMI of more than 28 kg/m^2—increased the risk of OSAS by four to five times in a case-control study of 25 children with an AHI of more than 10 and 339 children with an AHI of less than 5; their mean age was 11 years. Each increase of 1 kg/m^2 above the mean BMI of 18.8 was associated with a 12% increased risk of OSAS. Furthermore, a study by Brooks et al[22] demonstrated that the percentage ideal body weight was an independent predictor of OSAS.

Hence, childhood obesity is definitely associated with a higher risk of the development of OSAS. The wide difference in the prevalence rates among different studies could well be due to a number of factors, including ethnic predisposition and different diagnostic criteria for OSAS and obesity. A prospective cohort study is needed to shed light on the association between obesity and OSAS—particularly the temporal relationship of the onset of obesity and OSAS.

Cardiovascular co-morbidities

Tal et al[23] showed that the right ventricular ejection fraction was reduced in 37% of children with OSAS, and 7% of children with OSAS had pulmonary hypertension. Corpulmonale was reversed by treating OSAS.[23] Systemic hypertension—well described in adults with OSAS—has also been reported in paediatric patients.[24-26] Systemic hypertension results from the sympathetic overdrive observed in OSAS. In the absence of OSAS, systolic and diastolic blood pressures are both correlated with the severity of obesity, as measured by the BMI.[24] Children with OSAS have a higher blood pressure than those without OSAS, independent of BMI.[25] With the triad of obesity, OSAS, and resulting hypertension, the cardiovascular risk would be much greater than the sum of the individual effects of each disease—that is, there is a synergy among these three phenomena.

Metabolic consequences

Obesity is well known to be associated with metabolic derangement, including dyslipidaemia, hyperinsulinism, impaired glucose tolerance, and hypertension.[27] The presence of these factors is termed the insulin-resistant syndrome, and they predispose obese patients to morbidities such as diabetes mellitus and coronary heart disease. Recent studies strongly support a link between sleep-disordered breathing and insulin resistance, independent of the degree of obesity in adult patients.[28,29] Respiratory dysfunction during sleep is thus also an independent risk factor of insulin-resistant syndrome. In children with OSAS, these metabolic consequences need to be investigated to ascertain whether a similar association also exists.

Postoperative respiratory complications

Tonsillar and adenoidal hypertrophy is the most common risk factor for OSAS in children. Adenotonsillectomy is the most common treatment for children with OSAS (ie those with sleep polysomnography values outside the normal range[30]), even in children with associated morbid obesity.[31] However, children with OSAS are at higher risk of postoperative respiratory compromise: they have a diminished ventilatory response to CO_2-rebreathing.[32] Researchers showed that the incidence of postoperative respiratory compromise was 25% in children with OSAS, compared with 1% in children undergoing adenotonsillectomy for other indications.[33,34] Pre-existing medical conditions, such as obesity, will increase the risk even further.

Weight disturbance

Children with OSAS have increased energy expenditure during sleep.[35] Treatment of OSAS by adenotonsillectomy is reported to increase weight secondary to decreased energy expenditure during sleep.[35] Soultan et al[36] studied weight change in 17 obese children with OSAS who weighed more than 120% of the MWH; some were morbidly obese (>150% MWH). After adenotonsillectomy, three of the seven obese children progressed to morbid obesity and four remained obese; of the 10 morbidly obese children, six increased their z-score for weight, one remained the same weight, and three decreased their z-score but remained morbidly obese. Of 25 children with normal weight before adenotonsillectomy for OSAS, seven became obese afterwards. Hence, dietary and exercise advice is an essential component in managing obese children with OSAS. Close follow-up after adenotonsillectomy is also essential to detect early and manage any further weight gain.

Psychosocial consequences

Paediatric OSAS can result in sleep fragmentation and abnormal behavior and learning difficulty,[37-39] which can result in poor school performance and emotional disturbance. For obese children, psychological impact such as stigmatisation, laziness, and sloppiness,[40] as well as social discrimination, may result in a negative self-image.[41,42] It is thus important to address these issues when treating obese children with OSAS.

Treatment of children with obesity and obstructive sleep apnoea syndrome

Adenotonsillectomy

Adenotonsillectomy should be considered in cases of moderate and severe OSAS, because chronic hypoxaemia is detrimental. However, Willi et al[43] reported resolution of sleep apnoea after weight loss in five morbidly obese children. Intensive weight reduction is an option for those who refuse or are not fit for adenotonsillectomy. An intensive weight reduction programme is an important first-line definitive treatment for obese children with mild OSAS, and supportive treatment is essential before and after the operation.[36]

Weight reduction

Weight reduction is not an easy task in children. It requires careful planning and multidisciplinary involvement, with active participation of both patients and their families. Long-term success has been documented by Epstein et al.[44,45] A weight-reduction strategy requires a carefully planned calorie-reduced diet and a regular exercise programme. A study in preadolescents found no weight loss if dietary recommendations were given without exercise.[46] There should be close monitoring by physicians to avoid complications. Input from psychologists in providing behavioural therapy to patients and parents is helpful in improving the outcome.[46-48]

Dietary intervention

For older children and adolescents, a weight-reducing diet usually provides 1000 to 1500 kcal daily (4.2-6.3 MJ). Diets of less than 1000 kcal are usually not advised.[50] The diet should provide at least 60% of the estimated average requirement for the child's age.[50] The weight loss is usually more marked in the first few weeks. A realistic and practical target should be set: 0.5 to 1.0 kg of weight loss per month is usually well tolerated.

Exercise

Moderate exercise is usually recommended for weight reduction. Different exercise levels are defined by their effects on the heart rate.[51] The intensity of exercise is commonly classified by metabolic equivalent (MET) to facilitate study in the field without a heart rate monitor. One MET refers to activity equivalent to eating or relaxed standing or supine rest. In the paediatrics department of the Kwong Wah Hospital, children and their parents are asked to note the exertion level associated with the exercise programme designed by the physiotherapist. They are asked to undertake similar moderate exercise level, as measured by subjective assessment of exertion level, with other personally preferred activities five times each week.

Conclusion

Children with obesity and OSAS face a vicious cycle in which obesity worsens OSAS, which then increases the body weight because of decreased activity. Together, these two phenomena have an exaggerated impact on different systems, especially the cardiovascular system. Family practitioners should be prepared to work with both the family and the paediatrician to break this vicious cycle.

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