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Screening for obstructive sleep apnoea in overweight and obese children in Southern Sri Lanka

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ABSTRACT

Introduction: One of the main risk factors of obstructive sleep apnoea (OSA) is childhood obesity which account for about 60% incidence in obese children. Although polysomnography is the gold standard, it is costly and difficult to be used in children. The objective of this study was to use a prediction tool called a "Modified STOP bang tool" in the assessment of OSA in overweight and obese children in Southern Sri Lanka.

Methods: A descriptive cross-sectional study was conducted on ninety seven children (57 boys) aged 5 - 15 years with BMI $\geq 85^{th}$ percentile for age and gender based on CDC 2000 growth charts recruited from the nutrition clinic at the Teaching Hospital, Karapitiya, Sri Lanka. Modified STOP bang questionnaire which assessed snoring, tiredness, observed apnea, blood pressure 95^{th} percentile, BMI $>95^{th}$ percentile, academic problems, neck circumference $>95^{th}$ percentile for age, and male gender was considered on all study participants and a score was generated.

Results: Out of 97 children participated, 27.8% children had a higher risk of OSA and 49.5% had an intermediate risk of OSA. According to this study, significant risk factors for OSA in overweight and obese children included, being a male, BMI greater than 95^{th} percentile for age, obesity for age and sex, circumference greater than 95^{th} percentile for age, neck/ height ratio and waist/hip ratio.

Conclusion: In the community setting, modified STOP bang questionnaire is useful in the screening of overweight and obese children for OSA and for further follow-up.

Keywords: *Childhood obesity, modified STOP bang questionnaire, obstructive sleep apnoea, risk factors.*

Introduction

The prevalence of childhood obesity has increased alarmingly not only in developed countries but also in developing countries causing well documented adverse consequences including type 2 diabetes mellitus, dyslipidaemia, non-alcoholic fatty liver disease, hypertension and obstructive sleep apnoea in children (1). Obstructive sleep apnoea (OSA) is a common condition that corresponds to a series of pathophysiological alterations as a result of total or partial obstruction of the airway during sleep that can interfere with normal sleep structure and ventilation in children. It can result in neurocognitive, behavioural and cardiovascular complications, learning disorders and growth impairment in children and adolescents (2).

Unfortunately, children are infrequently screened in the primary care setting despite the potential benefits of early identification and treatment of OSA (3). Also, paediatric polysomnography is costly and not widely available in areas without specialized pediatric centers. The complications associated with under-diagnosis of OSA are further aggravated by the obesity epidemic and likely rising prevalence of OSA in children (4).

According to recently published guidelines, the incidence of OSA in the paediatric population is about 2% but is likely to be higher with obesity (5). Most children are around 2 - 8 years of age, due to the relative size of the lymphatic tissue of the upper airways and it is more common in males than in females (6). Although many studies have addressed the pathogenesis of OSA in adults, many aspects of this condition in children still remain unclear. However, there are many risk factors which can lead to a reduction or collapse of the upper airways which may contribute to the pathogenesis of OSA in children.

The objective of this study was to identify the prevalence and the independent risk factors associated with OSA in overweight and obese children in a clinical setting in Southern Sri Lanka with the intention of identifying a tool that would allow appropriate selection of obese children for OSA in resource limited settings.

Methods

Study population

A descriptive cross-sectional study was conducted on ninety-seven children (57 boys) aged 5 - 15 years who had a BMI ≥ 85^{th} percentile for age and gender based on the Centers for Disease Control and Prevention (CDC) 2000 growth charts from the Southern province of Sri Lanka. Exclusion criteria included a history of adenotonsillectomy, craniofacial abnormalities, neuromuscular disease and comorbidities such as Down syndrome, Crouzon syndrome, and Pierre Robin sequence. Parents of all study subjects provided written informed consent. The study protocol was approved by the Ethical Review Committee of the Faculty of Medicine, University of Ruhuna, Sri Lanka. Children were recruited at the nutrition clinic at the Teaching Hospital, Karapitiya, Galle, Sri Lanka and all study subjects underwent measurement of anthropometric parameters and body composition indices. An interviewer administered questionnaire was used to collect demographic data and suspected risk factors for sleep disorders.

Anthropometric assessment

Height was measured without shoes while the heel, buttocks, back of shoulder and occiput were kept in the vertical plane and head in horizontal Frankfurt plane using a wall-mounted stadiometer (Seca, Birmingham, UK) to the nearest 0.1 cm. The weight was measured using a calibrated electronic weighing scale (Nagata, BW-110H CAP, Taiwan) in minimal light indoor clothing, to the closest 0.1 kg. BMI was calculated as weight (Kg) divided by height (m) squared. Waist circumference was also measured at the umbilical level in the standing position to the nearest 0.1 cm. The method of Lohman, Roche and Martorel was used to measure the circumference of the neck. The participant sat upright with the head in the Frankfort Horizontal Plane and an inelastic tape was applied around the neck just below the laryngeal prominence. Then the neck circumference measurement was made perpendicular to the long axis of the neck. Neck circumference percentiles for age and gender were determined according to a reference data set of healthy weight children (7). Neck and height ratio (NHR) were calculated. Seated blood pressures were obtained in triplicate. The average of the measurements was used for data analysis. Blood pressure percentiles based on height, age, and gender were determined using CDC data (8). Body fat mass (FM), percentage fat mass (%FM), Android and gynoid fat mass were measured with a DXA Scanner (Hologic Discovery W, Hologic Inc., MA, USA) adhering to the manufacturer's recommendations.

Measurement were taken in light clothing without any metal items in their clothing or elsewhere while the study subjects were lying in a supine position. Scans were analysed by inbuilt software (for obese subjects) provided by the manufacturers. In vitro precision of the machine was checked on each scanning day with whole body phantom provided by the manufacturer. A single technician performed all DXA scans and analysed them using body composition analysis software provided by the manufacturer.

Modified STOP - Bang questionnaire

Modified teen STOP-Bang tool was used which included: Snoring (How often does your child snore loudly?), Tiredness (Is your child sleepy during the daytime?), Observed apnea (Does your child stop breathing during sleep?), systolic or diastolic blood pressure greater than or equal to 95th percentile for height and age, BMI greater than 95th percentile for age, Academic problems (Does your child have learning problems?), Neck circumference greater than 95th percentile for age, and male gender. The responses were collapsed into a positive or negative responses and the number of positive responses was calculated as the subject's teen STOP -bang score. Score between 0-2 was considered low risk, 3-4 as intermediate risk and 5-8 as high risk (8).

Statistical Analysis

Statistical analyses were conducted using *SPSS* software version 25 and *MINITAB* version 18. The Anderson-Darling test was used to determine the data normality. Normally distributed quantitative data were described by mean and standard deviation while non-parametric data were described using median and interquartile range (IQR).

Furthermore, qualitative data were presented as frequency and percentage. One way ANOVA and Kruskal-Wallis test were used to compare continuous variables in three groups and a chi-square test was conducted for categorical variables.

Univariate logistic regression analysis was performed to evaluate the relationship between STOP-Bang Score with risk factors for obstructive sleep apnoea in children. The odds ratios (OR) and 95% confidence intervals (CI) were calculated. Receiver operating characteristic (ROC) curve was generated based on obese children's STOP-Bang scores. $p < 0.05$ was set as the significance level in all tests.

Results

Of the 97 overweight and obese children (58% boys) recruited to the study, average age of children was 10.6 and average BMI of children was 25.5 Kg/m^2. Table 1 shows demographic and anthropometric data of children. A significant difference was not observed between the girls and the boys with regard to age, weight, height, BMI, and body composition indices as measured by dual energy X-ray absorptiometry.

Table 1: Demographic and other characteristics of the study population

Variable	Boys (57)		Girls (40)		All (97)		*p* value
	Mean	SD	Mean	SD	Mean	SD	
Age (Years)	10.8	2.4	10.3	2.6	10.6	2.5	0.35
Height (cm)	143.0	11.8	142.0	13.6	143.0	12.5	0.54
Weight (Kg)	53.5	13.4	51.8	14.3	52.8	13.7	0.64
BMI (Kg/m^2)	25.7	3.4	25.2	4.1	25.5	3.7	0.53
FM DXA (Kg)	21.8	6.1	22.1	7.1	21.9	6.5	0.81
% FM DXA	41.4	3.6	43.2	4.2	42.1	3.9	0.21
FFM DXA (Kg)	29.5	7.4	27.5	7.5	28.7	7.5	0.09

Receiver operating characteristic (ROC) curve was generated for the modified STOP-Bang scores of overweight and obese children (Figure 1). The discrimination of OSA measured by area under the curve (AUC) for the ROC was acceptable at 0.775 (95% CI; 0.661 - 0.889). STOP-Bang score of obese children was also associated with a sensitivity of 89% and specificity of 58%.

Potential risk factors for OSA are described in Table 2. Males (21.6%) had a significantly higher risk compared to females (6.1%) in developing OSA. BMI greater than 95th percentile for age, obesity for age and sex, neck circumference greater than 95th percentile for age, neck/ height ratio and waist/ hip ratio were considered as risk factors that determined OSA in the study population. It was interesting to note that fat mass and percentage fat mass measured by dual energy X-ray absorptiometry were not significant among the groups detected with mild, intermediate and high risk of OSA.

Table 3 summarizes the results of logistic regression analysis after including age, gender and significant covariates from the unadjusted models.

Multivariate analysis showed that only the obesity more than 95th percentile was associated with OSA.

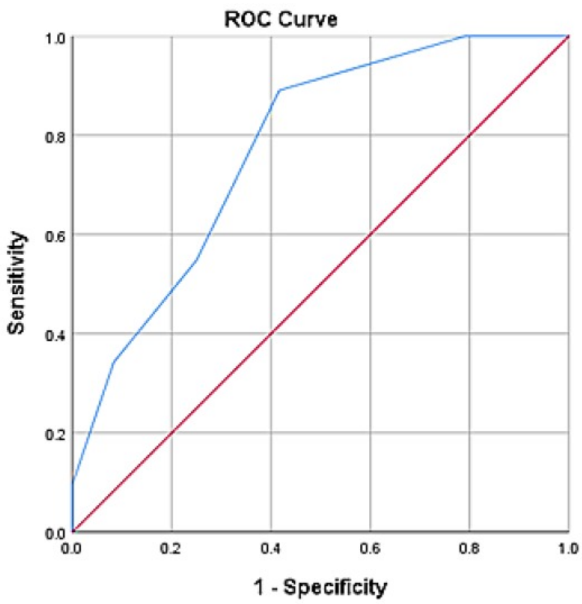

Figure 1: Receiver operating characteristics of modified STOP-Bang score of obese children

Table 2: Potential risk factors for obstructive sleep apnoea for obese children

	Low risk	Intermediate risk	High risk	*p* value
	n (%)	**n (%)**	**n (%)**	
Gender				
Male	11 (11.3)	25 (25.8)	21 (21.6)	
Female	11 (11.3)	23 (23.7)	6 (6.2)	0.061
Obese	8 (8.2)	40 (41.2)	25 (25.8)	**<0.001**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
BMI (Kg/m^2)	23.19 ± 4.80	25.57 ± 4.53	26.55 ± 4.07	**0.032**
Neck circumference	31.00 ± 4.00	32.00 ± 3.00	34.00 ± 3.00	**0.001**
Fat mass	19.57 ± 8.21	21.20 ± 8.27	24.34 ± 9.77	0.203
Percentage fat mass	40.91 ± 3.43	42.56 ± 3.55	42.41 ± 4.76	0.244
Neck/ height ratio	0.22 ± 0.02	0.23 ± 0.02	0.24 ± 0.02	**<0.001**
Waist/ hip ratio	0.92 ± 0.05	0.92 ± 0.06	0.95 ± 0.03	**0.019**
Android fat mass	3287.00 ± 975	3244.00 ± 1356	3804.00 ± 1707	0.133
Gynoid fat mass	6984.27 ± 1701.61	6834.56 ± 1769.84	7619.55 ± 2179.63	0.217
Android/ Gynoid ratio	1.06 ± 0.07	1.05 ± 0.07	1.09 ± 0.08	0.123

Table 3: Univariate analysis of risk factors for obstructive sleep apnoea in children

Risk factor	OR	*p* value	Lower limit of 95%	Upper limit of 95%
Male gender	1.59	0.34	0.61	4.13
Age >10 years	0.63	0.41	0.21	1.89
Low birth weight <2500kg	1.36	0.71	0.27	6.83
Obesity, BMI >95th percentile	11.38	**<0.001**	3.81	33.98
Neck circumference (cm) > 30cm	3.11	0.12	0.76	12.78
Neck/Height ratio >0.25	3.39	0.12	0.72	15.89
Waist /hip ratio >0.95	2.27	0.14	0.76	6.80

Discussion

Obstructive sleep apnoea (OSA) is an under--diagnosed clinical entity especially in the paediatric population. It is often dismissed and not brought to the attention of the doctor as many parents have the misconception that it is normal for a child to snore especially if the child is obese. Thus, snoring is the hallmark of obstructive sleep apnoea. In majority of cases, OSA is diagnosed when the child is admitted with cor pulmonale or when seen for other complaints such as proteinuria or enuresis. Untreated OSA has adverse consequences which affects the child's school performance, ability to learn, behavioural abnormalities, aggression, pulmonary hypertension and even death (9).

Obstructive sleep apnoea comprises of a spectrum of sleep-disordered breathing that ranges from partial to complete upper airway obstruction. In children, it is defined by the absence of nasal airflow despite the presence of chest wall and abdominal wall movements, for a duration of at least two breaths. Obstructive hypopnea refers to a decrease in nasal airflow by 50% from the baseline accompanied by fall in oxygen saturation of 3% and/or arousal. When measured by polysomnography, the number of apneic and hypopneic events per hour of sleep is expressed as the apnoea/hypopnoea index (AHI). In adults, AHI <5/hour is considered normal. However, in children, AHI > 1 event/hour is regarded abnormal (10).

In this hospital based cohort study, a modified STOP bang questionnaire was used on overweight and obese children as a screening tool on OSA. It was interesting to note that a total of 27.8% children had a higher risk of OSA and 49.5% had an intermediate risk of OSA. As the modified teen STOP-Bang questionnaire was used, a question regarding academic problems was inserted in place of age greater than 50 years that was used in the original version of the STOP-Bang questionnaire used in adults, because learning problems have been shown to be a symptom of sleep-disordered breathing in children (11).

The difference between our study population and the previously published study populations was that our children were generally "asymptomatic" who were on a regular screening program for childhood obesity and its complications (11). Therefore, their parents were nor perturbed by any of the symptoms associated with OSA thus didn't complain of any breathing difficulties or snoring unless enquired. This brought to the attention that although breathing difficulties may be present, parents were not aware of the significance of these symptoms thus not bringing the children to the attention of a doctor leading to under diagnosis.

In a previous study, the same modified STOP bang questionnaire was used in 312 children where they found a high negative predictive value in assessing the likelihood of OSA (11). Same study showed that a low teen STOP-Bang score (less than 3) would suggest that OSA to be unlikely. Additionally, a teen STOP-Bang score of 4 or greater showed increased specificity compared to a score of 3 (94% vs. 82–86%), suggesting that increasing teen STOP-Bang scores may be associated with an increased likelihood of OSA. Increased neck circumference is a well-known risk factor for OSA in adults (12) and was also shown to be a predictive factor in children (13). According to the results obtained in the present study, it was a significant predictive factor in children with OSA in this study population. Therefore, the modified STOP band questionnaire published by Combs et al (10) were applicable to the study population used in our study and this instrument was proven to be useful in screening OSA in overweight and obese children and in recommending children suspected of OSA for polysomnograms for further confirmation of OSA.

A major strength of the study was that it was conducted in a hospital based cohort who were clinically diagnosed for overweight and obesity using multiple anthropometric and body composition indices for the first time in Southern Sri Lanka. There were some limitations associated with this study. Only overweight and obese children were recruited but a control group without any symptoms were not evaluated. This may have led to the higher bias and the high prevalence rate. Modified STOP bang questionnaire was used as a screening tool in this study. However, it is well established that it is difficult to distinguish OSA from primary snoring by clinical assessment and the gold standard is polysomnography. However, polysomnography is an expensive investigation which requires an overnight stay in a hospital and there are practical issues associated with children. Modified STOP bang questionnaire was validated in Caucasian and Hispanic children. Therefore, it is imperative that we validate the questionnaire in an Asian population in the future.

Conclusions & recommendations

According to the Modified STOP bang questionnaire used in the screening of overweight and obese children for OSA, 27.8% children had a higher risk of OSA and 49.5% had an intermediate risk of OSA. According to this study, significant risk factors for OSA in overweight and obese children included, being a male, BMI greater than 95th percentile for age, obesity for age and sex, neck circumference greater than 95th percentile for age, neck/height ratio and waist/hip ratio. Future prospective studies are required to determine the validity of the Modified STOP bang questionnaire in the Sri Lankan overweight and obese children.

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