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Correlating Body Mass Index with Tympanograms of Children with Symptomatic Adenoidal Hypertrophy in Owerri, South-East Nigeria

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ABSTRACT

Childhood obesity poses a well-known risk to health. Almost as much as being overweight, being underweight can potentially cause medical problems. It has been inferred that being overweight/obese can contribute to abnormal middle ear pressure and possibly lead to development of otitis media with effusion in children through multiple complex mechanisms such as changes in cytokines levels, immune system dysfunction, structural and functional Eustachian tube changes via adipocytes accumulation as well as gastroesophageal reflux. These may ultimately produce otologic symptoms including hearing impairment with potential consequences in children like poor speech development and impaired learning ability.

We conducted a 6-month prospective cross-sectional evaluation of children with symptomatic adenoid hypertrophy attending the Ear, Nose and Throat (ENT) clinic of Federal University Teaching Hospital, Owerri, Nigeria between January and June 2023. There were age and sex matched controls drawn from symptomless children attending Kindergarten, Nursery and Primary School sections of the nearby Alvan Ikoku Federal College of Education, Owerri, Nigeria.

Both groups comprised one hundred and thirty-four (134) children each, with a male to female ratio of 1.23:1. The test group mean adenoidal-nasopharyngeal ratio (ANR) was 0.75 (S.D ± 0.13). Majority of the symptomatic children had Sade grade III adenoidal hypertrophy (58.2%) while 41.8% had grade II. The prevalence of abnormal tympanograms was 52.9% in the test group and 33.5% among the control subjects. The prevalence of abnormal body mass index (BMI) among the test group was 61.0% (underweight - 30.5%, obese - 15.6%, overweight - 14.9%) compared to 36.6% among the control group (overweight - 21.6%, obese - 9.0%, underweight - 6.0%). We found statistically significant correlation between BMI, ANR, tympanic membrane compliance and middle ear pressure. Children who were obese or overweight had more proportions of type B tympanograms (overweight - 17.6% and obese - 37.5%) whereas the underweight had more type C tympanograms (C1 - 31.7% and C2 - 12.2%). Overall, majority of children with adenoid hypertrophy (38.8%) had normal BMI, although a significant proportion (30.5%) were underweight. The underweight children with adenoid hypertrophy had the highest prevalence of abnormal tympanograms (35.2%), followed by the obese (28.2%) and the overweight (22.5%).

We conclude that prevalence of abnormal tympanograms in our study was higher among children with abnormal body habitus suggesting that abnormal BMI in children correlates with development of otitis media with effusion (OME).

Keywords

Obesity, Immune system dysfunction, Gastroesophageal reflux.

Introduction

Childhood underweight, overweight and obesity are serious concerns for public health. Globally in 2020, an estimated 194

million children under the age of 5 years were suffering from underweight and stunting, while 38.9 million were overweight or obese [1]. This is a likely reflection of nutritional and epidemiological transitions, demographic changes, urbanization, unhealthy lifestyles and consumption of highly processed diets; an emerging trend in various developing countries including Nigeria [1,2]. This current pattern is worrisome: literatures suggest that in Nigeria, about 9% of children aged 5-9 years are estimated to be obese or overweight [3,4].

Being obese or overweight are established risk factors for several health disorders. Among other health challenges, studies indicate that overweight and obese children are more prone to suffer from otorhinolaryngological conditions than children with normal body status [2,5]. Obesity occurs from the excessive accumulation of fat in various tissues, particularly in the hypodermal tissues. It is generally defined by body mass index (BMI) often with associated elevated serum triglyceride (TG) and total cholesterol (TC) concentrations [1].

There have been previous works by several authors seeking to determine a correlation between various body mass categories and otitis media with effusion in children. One of such studied 55 children aged 2-9 years in South Korea, finding significantly higher incidence of abnormal tympanograms among the obese and overweight children [6]. Another in the middle east, evaluated 112 children aged 2-17 years also found that being obese or underweight impacted prevalence of OME [7]. Similar researches in North America and West Africa have found identical outcomes linking body habitus in children with tympanometric outcomes [8,9].

The proposed pathophysiology of the effect of weight and body habitus on middle ear pressure in children has been linked to increased susceptibility to infections due to lowered immunity, mucosal damage and invasion by pathogens [1]. Some workers seem to believe that adenoid size influences this relationship. It has been postulated that obstructive adenoids, when associated with sleep-disordered breathing in children, can cause failure to thrive through a myriad of processes including but not limited to reduced nocturnal growth hormone secretion, persistent hypoxemia with respiratory acidosis, snoring-related increase in respiratory effort resulting in excessive calorie utilization as well as poor feeding from anorexia, dysphagia or alteration of olfactory function [1,2]. The effect of failure to thrive may be more pronounced in developing countries where malnutrition is still considerably a problem. Coupling this with the knowledge that major middle ear pressure changes in children can cause otologic problems like hearing impairment with potential consequences on speech development and learning, it becomes imperative to promptly identify and correct weight anomalies early enough in a child's life.

In spite of available data on the impact of BMI on child health, researchers continue to seek answers especially regarding its relationship with middle ear pressure which still has knowledge gaps especially in our tropical, developing setting. We set out with this study to help add to the body of knowledge by prospectively evaluating body mass indices of children with symptomatic adenoidal hypertrophy and correlating it with their tympanograms.

Methodology

There were two groups in this study; both comprised children aged 1-12 years. The test group was recruited from children with symptomatic adenoid hypertrophy attending the ENT clinic of Federal Teaching Hospital, Owerri, Nigeria, while the control group were age and sex-matched asymptomatic children attending the Department of Early Childhood Care/Primary Education arm of the nearby Alvan Ikoku Federal College of Education, Owerri, Nigeria. The test group had clinical assessment and scoring as well as postnasal space X-ray with adenoidal-nasopharyngeal ratios (ANR) calculated using the Fujioka method [10]. The clinical symptoms (CS) recorded include parent/guardian-reported mouth-breathing, snoring, gaps in breathing, sleep fragmentation and restless sleep. Each index was allotted a score of 0 or 1 when present or absent respectively [11]. Body habitus was classified using their BMI as recorded on the growth chart appropriate for age and gender as obese (BMI ≥ 95th percentile), overweight (BMI ≥85th <95th percentile), normal weight (BMI ≥ 5th < 85th percentile) and underweight (BMI < 5th percentile). Clinical symptoms and BMI were recorded for the control group and all recruits from both groups had tympanometry with middle ear pressures recorded and correlated with BMI. Data was analyzed with IBM SPSS software version 25.0. Statistical significance was set at $p < 0.05$.

Results

A total of 268 ears of 134 children with adenoid hypertrophy were evaluated. An equivalent number was also analysed among the control group. The age of the participants ranged from 12 to 120 months with mean age of 47.13 ± 26.30 months. Majority (44.8%), were aged 25 to 48 months, followed by those aged 12 to 24 months (21.6%) while children aged 97 to 120 months accounted for only 3.0%. There was no statistically significant difference found in the age distribution ($p = 0.996$).

Majority of the participants (55.2%) were males with 44.8% being females. There was no statistically significant difference found in the sex distribution ($p = 0.843$). The table below summarizes the demographic characteristics of the study participants.

Table 1: Demographic characteristics of the study participants.

	Cases n = 134, (%)	Control n = 134, (%)	Chi-square (p-value)
Sex			
Female	60 (44.8)	59 (44.0)	0.015 (0.843)
Male	74 (55.2)	75 (56.0)	
Mean age ± SD (months)	47.13 ± 26.30	46.64 ± 26.18	0.154 (0.878)
Age groups (in months)			
12-24	29 (21.6)	28 (20.9)	0.64 (0.996)
25 – 48	60 (44.8)	62 (46.3)	
49 – 72	21 (15.7)	22 (16.4)	
73 – 96	20 (14.9)	18 (13.4)	
97 – 120	4 (3.0)	4 (3.0)	

In the study group, 30.5% of the participants had normal BMI, 30.5% were underweight, 14.9% were overweight and 15.6% were obese. In the control group, 63.4% had normal BMI, 6.0% were underweight, 21.6% were overweight while 9.0% were obese. There was statistically significant difference in the BMI distribution of both groups (p <0.001). Table 2 highlights the BMI distribution of the participants.

Table 2: Body Mass Index (BMI) of participants.

	Cases n = 134 Median (IQR)	**Control n = 134** Median (IQR)	**Test statistic**	**p-value**
BMI (kg/m²)	16.0 (14.0 – 17.8)	16.5 (15.0 – 17.8)	-2.280†	0.028
BMI categories (No, %)				
Underweight	41 (30.5)	8 (6.0)	30.617‡	<0.001
Normal	52 (38.8)	85 (63.4)		
Overweight	20 (14.9)	28 (21.6)		
Obese	21 (15.6)	13 (9.0)		

† Mann-Whitney U test, ‡Chi-square test

Mean (SD) BMI values: Study group - 16.24 ± 2.61 kg/m², Controls: 16.65 ± 1.80 kg/m²; p = 0.136.

Normal tympanograms were recorded in 47.0% of study group participants while 53.0% had abnormal tympanograms 36.6% bilateral and 16.4% unilateral – see Figure 1. In the control group, 66.5% had normal tympanograms while 33.5% had abnormal tracings (6.7% bilateral and 26.9% unilateral).

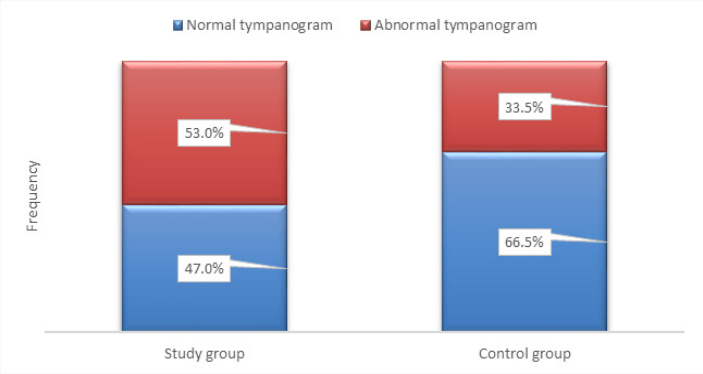

Figure 1: Prevalence of normal and abnormal tympanograms among study participants.

Type A tympanograms were more prevalent among participants within normal BMI (84.7% and 57.6% in the control and study groups respectively). There was notably more Type B tympanograms among the obese/overweight in both groups (for control group, 37.5% among the obese and 17.6% among the overweight while for the study group, 80.0% among the obese and 45.0% among the overweight). Similar patterns were found for type C tympanograms as summarized in figure 3 below.

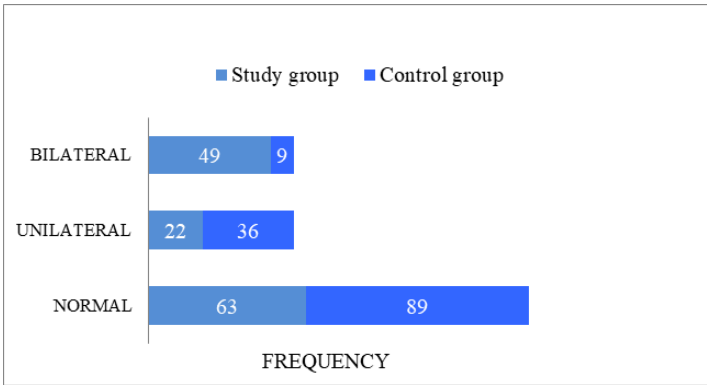

Figure 2: Distribution of tympanograms (figures are number of participants).

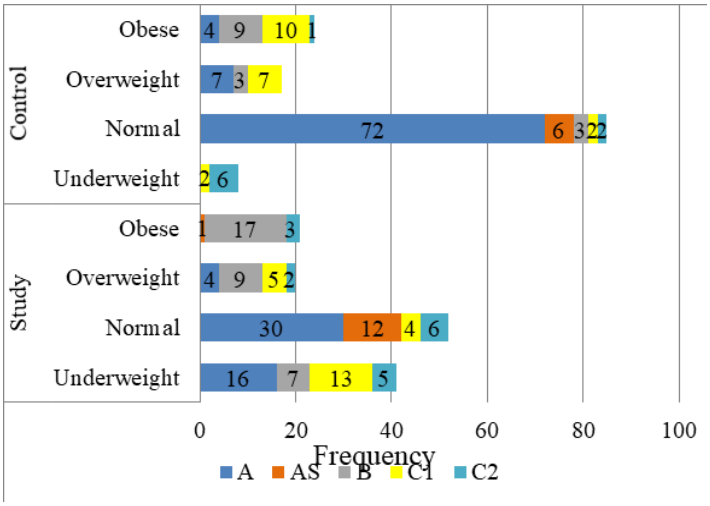

Figure 3: Distribution of tympanograms among various BMI classes (figures are number of participants).

Discussion

Our study sample size of 134 although larger, compares considerably with similar ones by Olusola et al. [12], Kaya et al. [13] and Kim et al. [5]. The male to female ratio of 1.23: 1 underscores slight male preponderance, again identical to findings by similar studies within the region by Orji et al. [14] (1.3:1) Olusola et al. [12] (1.6:1), Onyeagwara et al. [15] (1.74:1) and Adedeji et al. [16] (2.1:1). The male preponderance is not clearly explicable but can be attributed in part, to the overall slight male population predominance in southern Nigeria. The age distribution in our work is also in tandem with related studies; our reported mean age of 47.13 ± 26.30 months being comparable to the mean ages of 53.5 ± 35.9 months by Onyeagwara et al. [15] and 43.2± 31.2 months by Olusola et al.[12].

We found that majority of participants (38.8%) in the study group had normal BMI for age while 30.5% were underweight, 14.9% were overweight and 15.6%, obese. This differed slightly from the control group where 8 6.0% were underweight, 21.6% were overweight and 9.0% were obese. This difference was statistically different (p <0.001). There is a perceived prominence of the

underweight within the study group. A probable explanation is the pathophysiology of obstructive adenoid hypertrophy - prolonged hypoxia from sleep-disordered breathing may result in reduced nocturnal growth hormone secretion, hypoxemia/respiratory acidosis, sleep-related increased respiratory effort with subsequent increased calorie utilization coupled with poor feeding from dysphagia and possibly reduced olfaction [7,8]. This pattern has also been highlighted by other authors; Saxena et al. in India with 34.31% being underweight [17] and Olusola et al. in Sagamu, Nigeria with 28.2% underweight children [12].

Standard tympanometry was conducted on each ear of the participant totaling 268 ears in each group. The tympanograms were grouped into Types A, B, C1 and C2 using the Jeger's classification [18]. Types B and C tympanograms were considered abnormal while type As and Ad tracings were accepted as normal in our study as the reduced or exaggerated compliance may be due to other factors with the tympanic membrane/ossicular chain rather than middle ear effusion/negative pressure. Some similar studies applied same considerations while determining criteria for assessment of abnormal middle ear pressure [6,12-14]. We found a relatively high prevalence of abnormal tympanograms (52.9%) within the study participants compared to the control group (33.5%) - a nearly two-fold higher prevalence which was statistically significant ($p < 0.001$). Other studies in the region found much higher differences, notably Nwosu et al. in Port-Harcourt, Nigeria [19] with a four-fold difference while evaluating 136 ears and Orji et al. in Enugu, Nigeria reporting a sevenfold increase [14].

Abnormal tympanograms were considerably higher in children with abnormal BMI. Notably, 74.3% of the 82 children with abnormal BMI within the study group had abnormal tympanograms. This pattern was also observed among control group subjects as 77.6% of 49 children with abnormal BMI had abnormal tympanograms. In sharp contrast, children with normal BMI recorded abnormal tympanograms in 19.2% and 8.2% of the study and control groups respectively. These findings show statistically significant relationship between BMI and tympanometric findings ($p < 0.05$). Specifically, type B tympanograms were recorded in 37.5% of the obese and 17.6% of the overweight within the control group and 80.0% of the obese, 45.0% of the overweight and 17.1% of the underweight within the study group. We recorded type C1 tympanograms in 41.7% of the obese and 41.2% of the overweight within the control group while in the study group, it was recorded in 25.0% of the overweight and 31.7% of the underweight. Type C2 tympanograms were more prevalent among participants within the underweight (75.0% and 12.2% within the control and study groups respectively).

The findings among the underweight categories are comparable with those from similar work by Saxena et al. where 59.9% of underweight subjects had abnormal tympanometric outcomes (predominantly type C) [17]. Yazeed et al. also found that participants in the underweight category had high prevalence of abnormal tympanograms (predominantly type C) [9].

Several studies seeking to establish a link between obesity and abnormal middle ear function among children with adenoid hypertrophy have reported a positive link and the evidence appears spread across the globe as demonstrated by research by Abdulaziz et al. in Saudi Arabia [7], Olusola and colleagues in Nigeria [12], Kim and co-workers in South Korea [6], Kuhle and associates in Canada [20] and Kaya and team in Turkey [13]. We believe that the findings in our study adds to this existing evidence. It is clear that anomalous BMI can play a role in the development of abnormal tympanograms in children, however the double fold difference between the study and control groups in our work is likely accounted for by the presence of adenoidal hypertrophy in the former.

Conclusion

Prevalence of abnormal tympanograms in children with adenoid hypertrophy, was higher among those with anomalous body mass index suggesting that abnormal BMI in children may play a role in the development of OME and vice versa.

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