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Research Article

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Body Mass Index, a Silent Determinant of Eustachian Tube Function

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ABSTRACT

Background: The body mass index (BMI) is the metric currently in use for defining anthropometric height/weight characteristics in adults and for categorizing them into groups. It is a convinient indicator of body fat and it correlates sufficiently well with direct measures of total body fat. Eustachian tube (ET) is a fibrocartilagenous structure consisting of two parts: the first solidly connected with the temporal bone, close to the tympanic cavity; the second soft, partly ligamentous, partly cartilaginous, directed towards the nasopharynx. ET functions to protect the middle ear against nasopharyngeal pressure variations, ascending secretions, and microorganisms. Change in BMI with resultant change in adipocyte tissue around the tube (Ostmann's fat) can affect the normal ET function that would manifest in the change in tympanometric parameters.

Aim: The aim of this study was to determine the effects of body mass index on tympanometric parameters.

Materials and methods: This is a descriptive community based cross sectional study conducted on adult population aged (18-60 years) in Kano metropolis, northwestern Nigeria. Participants with no history of chronic ear disease, ear surgery or active upper respiratory tract infection were selected using simple random sampling technique. A total of eighty (80) participants and hundred and sixty (160) ears were examined. Each participant had detailed otoscopy, nasal endoscopy, throat examinations, Rinne's and Webar tests and tympanometry. Each participant had weight and height measured and BMI calculated. Findings were recorded and analyzed.

Results: The mean height of the participants was 1.62±0.11M while the mean weight of the participants was 55.96±10.78kg. There was statistically significant difference between the tympanometric parameters of the right and left ears $p<0.05$. There was statistically significant difference between the tympanometric parameters of male and female participants $p<0.05$. Tympanometric peak pressure (TPP) was found to be more positive in participants with lower BMI and (ECV) was found to be higher in participants with higher BMI.

Discussion: This study found ECV was higher for the right ears compared with the left ears. TPP was also found to be more positive in the right ears compared to the left, however, no statistically significant difference was found in the static compliance (SC) of the right and left. TPP, ECV and SC were all found to be higher in male participants than in female participants. TPP was found to be more positive in participants with lower BMI and more negative as the BMI was increasing, similarly ECV was found to be increasing as the BMI was increasig, with statistically significant correlation.

Conclusion: This study established statistically significant relationship between tympametric parameters of the right and left side, with parameters on the right side showing statistically higher values. A statistically significant relationship was equally established between tympanometric parameters of the male and female participants, affirming the effect of genger on tympanometric parameters. BMI was found to have statistically significant relationship with tympanometric parameters, with participant with higher BMI showing more negative TPP and lower SC, signifying higher risk of developing eustachian tube dysfunction (ETD) among overweight and obesse individulas.

Keywords: Body Mass Index, Tympanometry, Adults, Eustachian Tube, Middle Ear

Introduction

The body mass index (BMI) is the metric currently in use for defining anthropometric height/weight characteristics in adults and for categorizing them into groups [1]. The common interpretation is that it represents an index of an individual's fatness. It also is widely used as a risk factor for the development of or the prevalence of several health issues [1].

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The BMI is a convinient indicator of body fat and it correlates sufficiently well with direct measures of total body fat. It serves as a public health tool for monitoring progress in dealing with the obesity epidemic and it is attendent complications [2].

BMI is being used as the method of utilizing an adult's height and weight to broadly place them into underweight, normal weight, overweight and obese categories. An individual's BMI is important in the determination of potential future health issues and has been widely used as a factor in the determination of various public health policies [3].

World Health Organization (WHO) classified adults based on their BMI into the following categories; Severely Underweight: <16 kg/m2. Underweight: 16.0 to 18.4 kg/m2. Normal weight: 18.5 to 24.9 kg/m2. Overweight: 25.0 to 29.9 kg/m2. Moderately Obese: 30.0 to 34.9 kg/m2. Severely Obese: 35.0 to 39.9 kg/m2. Morbidly Obese: ≥40.0 kg/m2 [4].

Eustachian tube (ET) is a fibrocartilagenous structure consisting of two parts: the first solidly connected with the temporal bone, close to the tympanic cavity; the second soft, partly ligamentous, partly cartilaginous, directed towards the nasopharynx [5].

ET is normally closed, and it opens only during swallowing, yawning, sneezing or other artificial maneuvers like Valsava and Toynbee, a function that is essential for good functioning of the middle ear, because it provides ventilation from the nasopharynx to the middle ear, and, at the same time clearance of secretions from the middle ear-mastoid unit to the nasopharynx. Moreover, the ET protects the middle ear against nasopharyngeal pressure variations, ascending secretions, and microorganisms [6].

Factors involved in tubal dysfunction include loss of adipocyte tissue around the tube (Ostmann's fat), abnormal activity of peritubal muscles (tensor and elevator veli palatine and salpingopharyngeus), and inability of pterygoid venous plexus to assist the closure of the tube [7].

The diagnosis of eustachian tube dysfunction (ETD) is based on a combination of clinical history, physical examination, tympanometry, audiometry, and other diagnostic tests. A recent clinical consensus statement specifically defined ETD based on patient history and/or evidence of negative middle ear pressure [8]. Both subjective assessments and objective evaluations are critical for the differential diagnosis of ETD subtypes. However, standardized diagnostic protocols remain lacking in this field, underscoring the need for further research and consensus development [9].

Tympanometry is a clinical tool used for indirectly characterizing tympanic membrane compliance and estimating middle ear air pressure by means of electroacoustic and manometric measurements. It gives an information concerning the status of middle ear transmission system including ET [10].

The main objective of this study is to determine if increased body fat deposit as indirectly measured by BMI affects the function of the ET.

The novelty of this study lies in the fact that it highlighted the negative impact of obesity not only to the commonly studied systems like cardiovacular, endocrine and central nervous system, but also to the function of the ear.

Materials and Method

Study design: This is a descriptive community based cross sectional study

Study population: The study population was adult population aged (18-60 years) from Kano metropolis, northwestern Nigeria.

Sample size determination

The study's minimum sample size was calculated from the Fischer's formula, appropriate for a study population of > 10,000, using the formula:

$$N = \frac{Z^2 pq}{d^2}$$

Where
N = desired sample size
Z = standard deviation set at 1.96 corresponds to 95% confidence Interval
P = Prevalence
Q = 1 – p
D = degree of accuracy desired; set at 0.5
P value of 0.06 was used from similar study [11].

$$N = \frac{(1.96)^2 (0.06)\ (1.0\ -\ 0.06)}{(0.05)^2}$$

$$N = \frac{3.8416 \times 0.0564}{0.0025} = \frac{0.2167}{0.0025} = 87$$

Using attrition rate of 10%, N= 80

Study protocol

Sampling technique; Simple random sampling technique was used to select the participants that satisfied the inclusion criteria

Inclusion Criteria:

- Adults aged (18-60 years) in Kano metropolis, with no history of chronic ear disease or surgery

Exclusion criteria

- Participants with history of chronic ear disease, ear surgery and those with ative ear, nose or upper respiratory tract infection

Specially designed forms were used to record the participant's bio data and anthropometric measurements which include identification number, age, sex, weight and height. Participant's ear, nasal and throat symptoms including past medical and surgical history were also recorded. A detailed otoscopy, nasal endoscopy and throat examinations were performed on each participant. Those ears with debris and wax were treated with cerumenolytic agents (cerumol and olive oil). Rinne's and Webar tests were carried out and subsequently tympanometry done and recoreded. Three of the parameters; static compliance (SC), tympanometric peak pressure (TPP), and ear-canal volume (ECV) were measured automatically at a standard 226 Hz frequency.

Data analysis; Data obtained was analysed using the Statistical Packages for Social Sciences (SPSS) Version 22. Quantitative variables (Age, SC, TPP, ECV, Weight, Height, BMI) were expressed as mean and standard deviation (SD) and student t-test was used to test the statistical significance. Qualitative variables (Gender, Tympanogram) were expressed as frequencies and percentages; Chi-squared test was used to test the statistical significance. P-value of 0.05 or less was considered statistically significant. The study was carried out between January, 2023 and April, 2023

Results

This study was conducted on a total of eighty (80) participants, with fifty two (52) males constituting 65% of the total participants and twenty eight (28) females constituting 35% of the total participants.

Table 1.1: The mean and standard deviation of tympanometric parameters of the participants for right and left ears, with both TPP and ECV higher in the right ears than in the left ears

Mean±SD Parameters	Right ears	Left ears
TPP (daPa)	4.23±37.32	3.82±40.90
ECV (ml)	1.09±0.35	0.84±0.16
SC (cm^3)	0.94±0.40	0.78±0.21

Table 2: The mean and standard deviation of tympanometric parameters of the male and female participants

Mean±SD Parameters	Males	Females
MEP (daPa)	5.44±40.14	8.26±45.08
ECV (ml)	1.25±0.30	0.78±0.26
SC (cm^3)	0.90±0.34	0.76±0.28

Table 3: The mean and standard deviation for body height and body weight of the participants

Parameters	Mean±SD
Height (M)	1.62±0.11
Weight (Kg)	55.96±10.78

Table 4: Pearson's Correlation between Body Height and Tympanometric Parameters of the Participants

	Height (M)	
	r value	P value
Right TPP	0.00**	-0.312
Left TPP	0.642	0.027
Right SC	0.161	0.041
Left SC	0.014	0.084
Right ECV	0.027	0.678
Left ECV	0.034	0.248

Table 5: Pearson's Correlation between Body Weight and Tympanometric Parameters of the Participants

	Weight (Kg)	
	r value	P value
Right TPP	-0.267**	0.001
Left TPP	0.07	0.022
Right SC	0.124	0.143
Left SC	0.058	0.313
Right ECV	0.015	0.828
Left ECV	0.016	0.622

Table 6: Pearson's Correlation between BMI and Tympanometric Parameters of the Participants

	BMI (Kg/m^2)	
	r value	P value
Right TPP	-0.03	0.017
Left TPP	-0.138	0.021
Right SC	-0.02	0.312
Left SC	0.159	0.152
Right ECV	-0.04	0.042
Left ECV	-0.004	0.034

Discussion

Body Mass Index (BMI) has been useful in population-based studies by virtue of its wide acceptance in defining specific categories of body mass as a health issue [11]. Some of the co-morbidities related to overweight and obesity include cancers, type 2 diabetes, hypertension, stroke, coronary artery disease, congestive heart failure, bronchial asthma, chronic back pain, osteoarthritis, pulmonary embolism, gallbladder disease, and also an increased risk of disability [12].

Negative changes in tympanometric parameters may lead to ETD, the patient may present with symptoms of pressure disequilibrium in the affected ear, specifically symptoms of 'aural fullness' or 'popping' or discomfort/pain. Patients may also report pressure, clogged or 'under water' sensation, crackling, ringing, autophony and muffled hearing [13]. Increasing number of studies are suggesting change in body weight could trigger some of these symptoms [14,15].

This study found ECV was higher for the right ears compared with the left ears. TPP was also found to be more positive in the right ears compared to the left, however, no statistically significant difference was found in the SC of the right and left. These results were in keeping with the findings of the previous study that found statistically significant difference between right and left TPP and ECV with right ears having higher values than thsignificante left ears [16].

TPP, ECV and SC were all found to be higher in male participants than in female participants. These results were similar to what was found in similar studies, which showed all tympanometric parameters were higher in males than in females. This could be explained by the fact that sexual dimorphism is in favor of males than females, with larger body build up [17,18].

TPP was found to be more positive in participants with lower BMI and more negative as the BMI was increasing, similarly ECV was found to be increasing as the BMI was increasing, with statistically significant correlation, this is similar to what was found in a similar study in which as the BMI increased, the ECV increased and the resonance frequency decreased $p<0.05$ [18].

This study established overall negative impact on ET as the BMI is increasing, this is in keeping with a similar study that euqally established BMI has a negative effect on auditory function [19].

Limitations

The study was carried out on a small sample size; larger study would be required to further validate the findings Clinical examination was used to exclude conditions that could affect the tympanometry

Conclusion

This study established statistically significant relationship between tympametric parameters of the right and left side, with parameters on the right side showing statistically higher values. A statistically significant relationship was equally established between tympanometric parameters of the male and female participants, affirming the effect of genger on tympanometric parameters.

BMI was found to have statistically significant relationship with tympanometric parameters, with participant with higher BMI showing more negative TPP and lower SC, signifying higher risk of developing ETD among overweight and obesse individulas.

Contribution to knowledge

This study established a relatioship between ET function and BMI, which is a developing area on new and growing concern in the scientific world, the findings of this study would open more rooms for similar studies and ignite a growing interest in this area of public health importance

Conflict of interest

The authors declare that there's no conlict of interest in this study

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