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Comparison of Allergic Rhinitis and Bronchial Asthma Impacts on Tympanometric Parameters in Children at Kano, Nigeria

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Abstract

Background: Allergic rhinitis (AR) is a multifocal IgE-mediated type I hypersensitivity reaction that affects sino-nasal mucosa and is characterized by excessive sneezing, watery rhinorrhea, nasal itching, nasal stuffiness and eyes itching. Bronchial asthma (BA) is one of the common childhood diseases that affects the respiratory system characterized by recurrent cough, wheezing, chest tightness and difficulty with breathing. The two conditions are different manifestations of allergic disease of the airway; the composition of the inflammatory substrate in the mucosa of allergic patients is similar to the late-phase allergic response seen elsewhere in the respiratory tract, such as in bronchial asthma. **Aim:** The aim was to compare the impacts of allergic rhinitis and bronchial asthma on tympanometric parameters in children. **Patients & Methods:** This is a hospital based comparative cross-sectional study. Two groups of participants aged 4 - 12 years, one group with documented clinical diagnosis of allergic rhinitis and the other group with documented clinical diagnosis of bronchial asthma were consecutively selected from ear, nose and throat (ENT) and pediatrics cardiopulmonary outpatient clinics of Aminu Kano Teaching Hospital Kano respectively. Equal number of children aged 4 - 12 years with no history of ENT diseases or bronchial asthma that were selected from elementary schools within the same community served as a control group. An interviewer-administered questionnaire was filled out for all the participants, complete ENT and chest examinations were carried out and subsequently all the selected participants had tympanometry done, findings were recorded and analyzed. **Results:** The mean age of participants with bronchial asthma was found to be 7.5 ± 2.6 years while participants with allergic rhinitis had the mean age of 6.8 ± 2.1 years. The mean middle ear pres-

sure (MEP) of participants with bronchial asthma was found to be −15.22 dapa and −40.32 dapa in those with allergic rhinitis. Acoustic reflex was found to be absent in 15.4% of the participants with bronchial asthma and 29.6% of allergic rhinitis participants. Type B tympanogram was found in 2.8% of bronchial asthma participants and 7.3% in participants with allergic rhinitis. Type C tympanogram was found in 4.6% of participants with bronchial asthma and 15.5% of participants with allergic rhinitis. Type A tympanogram was found in 90% of participants with bronchial asthma and 75% of participants with allergic rhinitis. The difference between type A, B and C tympanograms of participants with bronchial asthma and those with allergic rhinitis was found to be statistically significant (Type A $\chi^2 = 14.62$, df = 4, p value = 0.01, Type B $\chi^2 = 14.06$, df = 4, p value = 0.01, Type C $\chi^2 = 17.01$, df = 6, p value = 0.01). **Conclusion:** Participants with allergic rhinitis were found to have more abnormalities of tympanometric parameters compared to participants with bronchial asthma which signifies allergic rhinitis conferred an increased risk of having middle ear diseases and otitis media with effusion compared to bronchial asthma.

Keywords

Allergic Rhinitis, Bronchial Asthma, Tympanometry, Middle Ear, Children

1. Introduction

Allergic rhinitis (AR) is a multifocal IgE-mediated type I hypersensitivity reaction that affects sino-nasal mucosa and is characterized by excessive sneezing, watery rhinorrhea, nasal itching, nasal stuffiness and eyes itching [1]. The diagnosis of allergic rhinitis is clinical and the confirmation is by using tests that include skin prick, nasal smear, serum IgE assay amongst others [1]. However, the use of symptoms score for allergic rhinitis (SFAR) in the diagnosis has been validated [2] [3]. SFAR has been found to be a simple and valid diagnostic tool of allergic rhinitis with sensitivity and specificity of 94.8% and 95.1% respectively [2]. Allergic rhinitis affects 10% - 30% of the population worldwide, with the highest frequency found in children and adolescents [1]. The prevalence of allergic rhinitis is increasing worldwide, with western countries having the highest prevalence [4]. Similarly, the prevalence of allergic rhinitis was also found to be increasing even in developing countries, a study conducted in Ibadan Nigeria revealed a prevalence of 11.3% among children 6 - 7 years of age [5].

Bronchial asthma in childhood is defined as a disease characterized by wide variations over a short period of time in resistance to flow in intrapulmonary airways and manifests by recurrent attacks of cough, wheeze or difficulty with breathing separated by symptom free intervals [6]. The prevalence of bronchial asthma in children was found to be 1.4% among Swedish children [7], 3.5% in Taiwan [8], 4.8% in Aberdeen [8], 9.9% in Birmingham [7], 7.8% in Tanzania [8], and 2.4% in Nigeria [9].

There has been a sharp increase in the global prevalence, morbidity, mortality

and economic burden associated with bronchial asthma over the last 40 years particularly in children [10]. The prevalence of bronchial asthma increases by 50% every decade [10].

Allergic rhinitis and bronchial asthma are different manifestations of allergic disease of the airway [11]. Both conditions can exist together or as a separate disease entity in an individual [11]. The prevalence of bronchial asthma-allergic rhinitis comorbidity varies from one region to another; Navarro *et al.* found between 20% - 40% of patients with allergic rhinitis have bronchial asthma, and about 30% - 50% of patients with asthma have concomitant allergic rhinitis [12].

Previous investigations suggested the immunopathologic mechanism underlying the development of inflammatory phase in patients with allergic rhinitis and those with bronchial asthma is largely due to the effects of T-helper cells mediators [13]. The composition of the inflammatory substrate in the mucosa of patients with allergic rhinitis is similar to the late-phase allergic response seen elsewhere in the respiratory tract, such as in bronchial asthma. Hence, it is postulated that bronchial asthma alone can stimulate similar inflammatory reactions elicited by allergic rhinitis that can affect the middle ear, the consequence of which may result in middle ear inflammation, eustachian tube dysfunction and otitis media with effusion (OME) [13].

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 [14].

Allergic rhinitis has been found to negatively affect middle ear function with higher prevalence of abnormal tympanometric parameters and increase risk of developing middle ear inflammation including otitis media with effusion, which failure to identify and appropriately manage can negatively affect the physical, emotional and social wellbeing of the affected children [20]. Because of the established similarities in the pathogenesis of BA and AR, there is an assumption that both conditions have similar risk of causing middle ear diseases, thus, both require routine screening.

The main objective of this study is to establish if bronchial asthma exerts similar negative effects on tympanometric parameters of children like allergic rhinitis does. Most studies done in this environment focused on the effects of allergic rhinitis on tympanometric parameters of children. There are few studies that tried to evaluate the tympanometric findings in patients with bronchial asthma without allergic rhinitis.

The prevalence of both bronchial asthma and allergic rhinitis has been increasing in this environment, thereby stretching the capacity of the healthcare system of a developing country to adequately cater for the proper screening of OME [5] [6].

The novelty of this study lies in the fact that findings revealed bronchial asthma is not an independent risk factor for developing middle ear inflammation as it was previously believed. This will have significant impact on the clinical practice especially in a resource constrained setting of developing countries. Adop-

tion of these findings will drastically reduce the pressure on the healthcare system as those with bronchial asthma only will not require routine screening for OME as it was previously being practiced.

2. Patients & Methods

Study design: This is a descriptive, hospital-based comparative cross-sectional study.

Sample size determination: The study's sample size was calculated using comparative study formula;

$$n = \frac{\left(Z_{\alpha+}Z_{1-\beta}\right)^2 \left\{\left(p_1q_1\right)+\left(p_2q_2\right)\right\}}{\left(p_1-p_2\right)^2}$$

where,

n = minimum sample size required in each group,

Z_α = standard normal deviate corresponding to 5% level of significance = 1.96 (obtained from normal distribution table),

$Z_{1-\beta}$ = standard normal deviate corresponding to a power of 80% = 0.84, (Obtained from normal distribution table),

p_1 = prevalence of bronchial asthma in Nigerian children obtained from previous study is 2.4% [9],

p_2 = prevalence of allergic rhinitis in Nigerian children obtained from previous study is 11.3% [5].

$$n = \frac{\left(1.96+0.84\right)^2 \left\{\left(0.024\times 0.976+0.113\times 0.887\right)\right\}}{\left(0.024-0.113\right)^2}$$

$$n = \frac{0.969}{0.008} = 121$$

Attrition of 10% was added

$$\text{n= } 133$$

Hence, the sample size was approximated to 130.

The sample size was approximated to 130, and this was applied for all the participants with bronchial asthma and those with allergic rhinitis.

Sampling technique: Participants were selected from patients attending ENT and paediatric cardiopulmonary outpatient clinics using consecutive sampling technique. An informed consent/assent was obtained from the patients/caregivers.

Study protocol: Ethical approval was sought for and obtained from the Ethics Review Committee of Aminu Kano Teaching Hospital, Kano (NHREC/21/08/2008/AKTH/EC/2166). Study population was children aged 4 - 12 years with clinical diagnosis of allergic rhinitis and those with clinical diagnosis of bronchial asthma attending ENT and paediatric cardiopulmonary outpatient clinics of Aminu Kano Teaching Hospital, Kano. Equal number of children aged 4 - 12 years with no history of ENT diseases or bronchial asthma that were selected from elementary schools within the same community served as a control group.

SFAR questionnaire was used in selecting participants with allergic rhinitis. The questionnaire has a total score of 13 and score of 6 and above was considered diagnostic for the purpose of this study [15]. International Study of Asthma and Allergy in Childhood (ISAAC) Questionnaire was used in selecting participants with bronchial asthma. The questionnaire has a total of five symptoms and presence of three symptoms and above was considered diagnostic for the purpose of this study [16]. Interviewer-administered questionnaire was filled out for all participants as they come, subsequently, each participant had tympanometry done. The tympanometer was used to deliver a tone, the information of which was displayed and printed on a graph form as a tympanogram. The tympanometric parameters obtained using tympanogram were middle ear pressure (MEP), static compliance (SC), ear canal volume (ECV) and acoustic reflex (AR). Modified Jerger's nomenclature was used to classify the tympanograms into types A, As, Ad, B and C. Type A was considered normal, types As & Ad were considered abnormal variants of Type A, while type B was used as an indicator to represent middle ear effusion and type C indicates eustachian tube dysfunction for the purpose of this study.

Acoustic reflexes were also recorded from the tympanometry machine by delivering a sound of 85 - 105 dB to the test ear at 500, 1000, 2000 and 4000 Hz. Appearance of a well-defined amplitude in at least three of the test frequencies was considered normal and was denoted as "AR present", while appearance of the amplitude in only two or less of the test frequencies, or an absence of response following stimulation was considered an abnormal response and was denoted as "AR absent". Effort was made to minimize any discomfort that could have arisen from the procedure.

About 30% of participants with bronchial asthma-allergic rhinitis comorbidity were encountered and excluded from the study, also participants with acute infection, bronchial asthma attack in the last three months, adenoid hypertrophy, tympanic membrane perforation and congenital craniofacial anomalies were excluded from the study.

Data analysis: Data obtained was analysed using the Statistical Packages for Social Sciences (SPSS) Version 21. Quantitative variables (Age, MEP, SC, ECV) were expressed as mean and standard deviation (SD) and student t-test was used to test the statistical significance. Qualitative variables (Gender, Tympanogram, Acoustic reflex) 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 April, 2019 and October, 2020.

3. Results

The age range of the participants was between 4 years and 12 years. The mean age of the participants with bronchial asthma was 7.5 ± 2.6 years while that of participants with allergic rhinitis was 6.8 ± 2.1 years. The mean difference was 0.7 and was not statistically significant (t = 2.35, df = 258, p-value = 0.20). Sixty-one percent (61%) of participants with bronchial asthma were males and thirty-

nine percent (39%) were females. Fifty-nine percent (59%) of participants with allergic rhinitis were males and forty-one percent (41%) were females. There was no statistically significant difference between the gender of the two groups ($\chi^2 = 0.08$, df = 1, p value = 0.77). Hausa-Fulani being the predominant tribe in the study area accounted for 65% of the participants with bronchial asthma and 71% of participants with allergic rhinitis, this was followed by Yoruba ethnic group who accounted for 19% of participants with bronchial asthma and 15% of those with allergic rhinitis. Table 1 shows socio-demographic distribution among the participants.

The MEP was found to be more negative in participants with allergic rhinitis with minimum of −344 dapa, maximum of 80 dapa and mean of −40.32 dapa, whereas minimum MEP was −367 dapa, maximum of 98 dapa and mean of −15.22 dapa in participants with bronchial asthma. This signifies increasing negativity in participants with allergic rhinitis in comparison to those with bronchial asthma. The mean static compliance (SC) was found to be slightly lower in participants with allergic rhinitis compared to bronchial asthma participants with values of 0.64 cm^3 and 0.68 cm^3 respectively. The difference in MEP between the two groups was found to be statistically significant, however, no statistically significant difference was found in SC and ear canal volume (ECV) between the participants with bronchial asthma and those with allergic rhinitis. Table 2 shows tympanometric parameters among the participants.

Type B tympanogram was found in 7.3% of participants with allergic rhinitis and in 2.8% in participants with bronchial asthma (Table 5). Type A tympanogram was found in 75% of participants with allergic rhinitis and 90% in participants with bronchial asthma. This implies that more negative middle ear pressure leading to more abnormal tympanograms was found in participants with allergic rhinitis compared to participants with bronchial asthma. Table 3 & Table 4 show comparison of tympanogram of the right and left ears between the two groups.

Table 1. Socio-demographic distribution among the participants.

Variables	Bronchial asthma (n = 130)		Allergic rhinitis (n = 130)	
Age (years) Mean ± SD	7.5 ± 2.6		6.8 ± 2.1	
(t = 2.35, df = 258, p-value = 0.20)				
Gender	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Males	79	61%	77	59%
Females	51	39%	53	41%
($\chi^2 = 0.08$, df = 1, p value = 0.77)				
Tribe				
Hausa-Fulani	85	65.4%	93	71.5%
Yoruba	24	18.5%	20	15.4%
Igbo	15	11.5%	10	7.7%
Others	6	4.6%	7	5.4%

Table 2. Tympanometric parameters of the participants.

Variables	Bronchial asthma participants (n = 130)				Allergic rhinitis participants (n = 130)			
	Min	Max	Mean	SD	Min	Max	Mean	SD
MEP	−367	98	−15.22	62.37	−344	79.5	−40.32	60.44
SC	0.05	2.25	0.68	0.31	0.20	1.00	0.64	0.24
ECV	0.20	1.90	1.14	0.35	0.40	1.90	1.23	0.40

MEP = middle ear pressure; ECV = ear canal volume; SC = static compliance. *Significant (MEP was found to be significantly lower in those with allergic rhinitis).

MEP t = 3.24, df = 258, p-value = 0.001.
SC t = 1.02, df = 258, p-value = 0.42.
ECV t = -2.16, df = 258, p-value = 0.06.

Table 3. Comparison of Tympanogram of the Right Ears between the two groups.

Variables	Bronchial asthma (n = 130)	Allergic rhinitis (n = 130)
Type A	119 (91.5%)	96 (73.8%)
Type B	3 (2.4%)	10 (7.7%)
Type C	5 (3.8%)	20 (15.5%)
Type As	2 (1.5%)	2 (1.5%)
Type Ad	1 (0.8%)	2 (1.5%0)

Table 4. Comparison of Tympanogram of the Left Ears between the two groups

Variables	Bronchial asthma (n = 130)	Allergic rhinitis (n = 130)
Type A	117 (90%)	98 (75.4%)
Type B	4 (3.1%)	9 (6.9%)
Type C	7 (5.4%)	20 (15.4%)
Type As	2 (1.5%)	2 (1.5%)
Type Ad	0 (0.0%)	1 (0.8%)

Table 5. Comparison of Overall Tympanogram between the two groups

Variables	Bronchial asthma (n = 130)	Allergic rhinitis (n = 130)
Type A	90.7%	74.6%
Type B	2.8%	7.3%
Type C	4.6%	15.5%
Type As	1.5%	1.5%
Type Ad	0.4%	1.1%

Type A $\chi^2 = 14.62$, df = 4, p value = 0.01; Type B $\chi^2 = 14.06$, df = 4, p value = 0.01; Type C $\chi^2 = 17.01$, df = 6, p value = 0.01.

Table 5 shows comparison of the overall tympanograms between the two groups.

Seventy percent (70%) of participants with allergic rhinitis had acoustic reflex present while eighty five percent (85%) of participants with bronchial asthma had acoustic reflex present. This implies that allergic rhinitis is more likely to affect the inner ear leading to the absence of acoustic reflex compared with bronchial asthma. There was no statistically significant difference between the tympanometric parameters of the right and left ears for both the bronchial asthma and allergic rhinitis participants. Table 6 shows comparison of the acoustic reflex between the two groups.

Tables 7-9 showed tympanometric parameters of the control group. The mean

Table 6. Comparison of acoustic reflex between the two groups.

Variables	Bronchial asthma (n = 130)		Allergic rhinitis (n = 130)	
	Present	Absent	Present	Absent
Right ear	104 (80%)	26 (20%)	84 (64.6%)	46 (35.4%)
Left ear	116 (89.2%)	14 (10.8%)	99 (76.2%)	31 (23.8%)
Total	84.6%	15.4%	70.4%	29.6%

$\chi^2 = 7.77$, df = 1, p value = 0.001.

Table 7. Tympanometric parameters of the control.

Parameters	Mean ± SD
MEP (daPa)	−7.70 ± 47.61
ECV (ml)	0.92 ± 0.27
SC (cm^3)	0.58 ± 0.44

95% CI, SD = Standard deviation.

Table 8. Right and left ears tympanometric parameters of the control.

Parameters	Mean ± SD	
	Right ears	Left ears
MEP (daPa)	−4.23 ± 47.32	−11.12 ± 47.90
ECV (ml)	0.99 ± 0.27	0.84 ± 0.26
SC (cm^3)	0.58 ± 0.40	0.58 ± 0.48

95% CI, SD = Standard deviation.

Table 9. Tympanogram of the control

Variables	Control (n = 130)
Type A	93.0%
Type B	2.5%
Type C	3.6%
Type As	0.5%
Type Ad	0.4%

MEP was −7.70 dapa which was slightly higher than that of participants with bronchial asthma −15.22 dapa, however, the difference was not statistically significant. A statistically significant difference was found between the means MEP of controls and that of participants with allergic rhinitis. There was no statistically significant difference between ECV and SC of the controls and those with either bronchial asthma or allergic rhinitis. The prevalence of type B and C tympanograms for the control group was found to be 2.5% and 3.6% respectively, which was slightly lower than that of participants with bronchial asthma but with no statistical significance, however, it was statistically significantly lower than in participants with allergic rhinitis.

4. Discussion

Bronchial asthma in children affects all the age groups from infants to adolescents [7]. Age range of 4 - 12 years with mean age of 7.5 ± 2.6 years was used in this study. This is similar to a study conducted by Garba *et al.* [17], that used 4 - 15 yeras of age, but differ from a study conducted by Aderele who used 10monhs to 13 years [9] [18]. This age range was used to increase the sensitivity of the diagnosis as the clinical diagnosis of bronchial asthma was found to be more sensitive from the age of 3 years and 50% to 80% of children with bronchial asthma develop symptoms before the age of five. Asthma Predictive Index (API) was found to be higher in older children [19].

Allergic rhinitis in children can occur from the age of one, and the sensitivity of clinical diagnosis will continue to increase as the child is getting older, by age of six 62% of children with allergic rhinitis had symptoms [20]. Age range of 4 - 12 years with mean age of 6.8 ± 2.1 years was used in this study. This is similar to a study conducted by Pau *et.al* that also used 4 - 12 years of age, however, slightly differed from the age range of 2 - 12 years and mean age of 7.8 years that was used by Kayhan *et al.* [21] [22]. There was no statistically significant difference between the age range of participants with bronchial asthma and those with allergic rhinitis ($t = 2.35$, $df = 258$, p-value = 0.20).

Bronchial asthma affects both males and females a with slight male preponderance [9]. Male:Female ratio was found to be 1.6:1 in this study. This is similar to ratio of 1.6:1 found by Aderele, but differs from the findings of Falade *et al.*, who found ratio of 1.2:1 [5] [9]. This is likely to be explained by the difference in male to female ratio in the study area. Similarly, allergic rhinitis also affects both males and females with male preponderance [22]. This is in keeping with the boy/girl ratio of 1.4:1 that was found in this study. This is similar to boy/girl ratio of 1.4:1 found by Kayhan *et al.* [22]. There was no statistically significant difference between gender of subjects with bronchial asthma and those with allergic rhinitis ($\chi^2 = 0.08$, $df = 1$, p value = 0.77).

The mean MEP in allergic rhinitis participants in this study was found to be about three times lower than in bronchial asthma participants. This is similar to the findings of Pelikan who found increased in negativity of MEP in subjects

with allergic rhinitis [23]. A statistically significant difference was found between the MEP of subjects with bronchial asthma and those with allergic rhinitis in this study (t = 3.24, df = 258, p-value = 0.001). This implies that allergic rhinitis was found to exert more negative effect on middle ear pressure and less middle ear compliance than bronchial asthma, thereby resulting in higher prevalence of abnormal tympanometric parameters.

In this study the ECV in participants with bronchial asthma was found to be slightly lower than in those with allergic rhinitis. This is similar to findings of Alles *et al.* [24]. There was no statistically significant difference between the ECV of participants with bronchial asthma compared to those with allergic rhinitis. This implies that neither bronchial asthma nor allergic rhinitis significantly affect ECV.

SC in participants with bronchial asthma was found to be slightly higher than that of allergic rhinitis. This is similar to the findings of Alles *et al.* that found SC value of 0.60 cm [3] [24]. However, there was no statistically significant difference between SC of subjects with bronchial asthma and those with allergic rhinitis. This implies that neither bronchial asthma nor allergic rhinitis significantly affect SC.

Type B and C tympanograms were found to be higher in participants with allergic rhinitis compared to those with bronchial asthma. This is similar to the findings in a study conducted by Fasunla *et al.*, who found type B and C tympanograms to be higher in participants with allergic rhinitis than in participants with other forms of atopy [25]. Gerardo *et al.*, also found type B and C tympanogram to be higher in participants with allergic rhinitis [26]. Type A tympanogram was found to be higher in participants with bronchial asthma than in those with allergic rhinitis. This is similar to the findings of Adeyemo *et al.*, who found type A tympanogram to be lower in participants with allergic rhinitis than in those with other forms of atopy [27]. Similarly, Adegbiji *et al.*, found type A tympanogram in participants with bronchial asthma to be 82.2% which is close to what was found in this study [28]. The difference between type B and C tympanograms of subjects with allergic rhinitis and those with bronchial asthma was found to be statistically significant [Type B χ^2 = 14.06, df = 4, p value = 0.01, Type C χ^2 = 17.01, df = 6, p value = 0.01 (statistically significant)].

This study found acoustic reflex to be absent in 29.6% of participants with allergic rhinitis and in 15.4% of participants with bronchial asthma. However, this is lower than in the study conducted by Fernendes *et al.*, who found acoustic reflex to be absent in 66% of subjects with allergic rhinitis [29]. This could be explained by the difference in the age group of the study population and diagnostic criteria used in classifying AR as either present or absent. This finding is also in keeping with the findings of Singh *et al.* and that of Lasisi & Abdullahi who suggested peculiar predisposition to inner ear pathology in patients with allergic rhinitis [30] [31].

The difference between acoustic reflex of participants with allergic rhinitis and those with bronchial asthma was found to be statistically significant (χ^2 = 7.77, df

= 1, p value = 0.01). This implies that participants with allergic rhinitis are more likely to have abnormal acoustic reflex and more prone to develop inner ear pathology than participants with bronchial asthma.

The MEP of the control group was found to be slightly higher than that of participants with bronchial asthma, but significantly higher than in participants with allergic rhinitis, this signifies there is a slight impact of bronchial asthma on eustachian tube function and aeration of the middle ear, however, the difference was not statistically significant to have made bronchial asthma an independent risk factor for the development of middle ear abnormalities. Similarly, type B and C tympanograms of the control group were found to be slightly lower than in participants with bronchial asthma but significantly lower than in participants with allergic rhinitis, this signifies bronchial asthma alone plays an insignificant role in the development of eustachian tube dysfunction and middle ear effusion. Tympanometric parameters of participants with bronchial asthma were generally found to be closely similar to those found in the control group, however those of participants with allergic rhinitis significantly differed from that of control group [32] [33] [34] [35] [36]. Modified Score For Allergic Rhinitis (SFAR) questionnaire, International Study of Asthma and Allergy in Childhood (ISAAC) questionnaire and study questionnaire are attached as **Appendixes I-III** respectively.

5. Limitations

This study was limited by relatively low sensitivity of tympanometry in the diagnosis of middle ear effusion especially in smaller children, also other compounding factors that might affect eustachian tube function like adenoid hypertrophy, cleft palate and other craniofacial anomalies were ruled out clinically. Recall bias from some caregivers on the symptoms of the participants was also another limitation encountered.

6. Conclusion

Participants with allergic rhinitis were found to have more abnormal tympanometric parameters than participants with bronchial asthma. The tympanometric parameters of participants with bronchial asthma were found to be closely similar to those of the control group. This implies that, despite similarities that exist in the pathogenesis of allergic rhinitis and bronchial asthma, allergic rhinitis was found to exert more negative effect on middle ear and eustachian tube function compared to bronchial asthma. Similarly, unlike allergic rhinitis, bronchial asthma was found not to independently exert negative effects on tympanometric parameters.

Contribution to Knowledge and Practice

- This study generated a data on tympanometric parameters of children with bronchial asthma in this environment.

- Additional data on tympanometric parameters of children with allergic rhinitis in this environment has also been added to the existing one.
- This study established that bronchial asthma is not a risk factor for the development of OME and other middle and inner ear abnormalities.
- Additional information and supportive data have been found concerning the predisposition to inner ear diseases among patients with allergic rhinitis.
- Routine screening of children with bronchial asthma for eustachian tube dysfunction and OME will no longer be necessary.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix I. Modified Score for Allergic Rhinitis (SFAR) Questionnaire [15]

Symptoms	Score
Blocked nose	1
Runny nose	1
Excessive sneezing	1
Nasal symptoms + itchy-watery eyes (rhinoconjuctivitis)	2
Month of the year in which symptoms are more (Seasonal/Perenial)	1
Triggers (pollens, house dust, mite, epithelia-cats, dog)	2
Previous medical diagnosis of allergy	1
Previous positive test for allergy	2
Family history of allergy	2
Total	13

NB: Score of 6 and above was considered diagnostic.

Appendix II. International Study of Asthma and Allergy in Childhood (Isaac) Questionnaire [16]

Symptoms	Number of attacks
Wheezing	≥3
Breathlessness	≥3
Cough	≥3
Positive family history in first degree relation	
Response to bronchodilator	

NB: Presence of 3 symptoms and above was considered diagnostic.

Appendix III.

Questionnaire

Title: tympanometric parameters among children with bronchial asthma and those with allergic rhinitis in aminu kano teaching hospital, kano.

Section A (Personal Record)

BIODATA

IDNumber……

Address……

Age (years) ☐

Gender: Male ☐ Female ☐

Tribe: Hausa/Fulani ☐ Yoruba ☐ Igbo ☐

Others ☐

Section B (Clinical History)

Ear symptoms	Right	Left
	Y/N	Y/N
1. Ear pain	☐	☐
2. Ear fullness/feeling of fluid in ear	☐	☐
3. Hearing impairment	☐	☐
4. Ear surgery	☐	☐
Nasal/Allergic symptoms	Yes	No
1. Runny nose	☐	☐
2. Nasal blockage	☐	☐
3. Excessive sneezing	☐	☐
4. Itchy watery eyes	☐	☐
5. Month of the year with more symptoms	P ☐	S ☐
6. Trigger (pollens/House dust/mite/epithelia)	☐	☐
7. Previous medical diagnosis	☐	☐
8. Family history of allergy	☐	☐
9. Snoring	☐	☐
10. Mouth breathing	☐	☐
Asthmatic symptoms		
Recurrent wheezing	☐	☐
Recurrent cough	☐	☐
Recurrent breathlessness	☐	☐
Family history of asthma	☐	☐
Response to bronchodilators	☐	☐

Section C (Examination Findings)

Ears	LT	RT		
Normal Pinna	☐	☐		
Clean EAC	☐			
Intact TM	☐			
Nose	Yes	No		
Patency	☐			
Nasal discharge	☐			
Nasal mucosa	Pink ☐	Pale ☐	Bluish ☐	
Nasal turbinates	Normal ☐	Engorged ☐	Atrophied ☐	
Nasal septum	Normal ☐	Deviated ☐		
Throat abnormality				

Section D (Tympanometry Result)

	LT	RT
MEP		
SC		
ECV		
Type of tympanogram		
AR		