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Research Article

Effect of Age on the Tympanometric Parameters

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Abstract

Background: As individuals become older, their middle ear may undergo physiological changes that cause variations in the tympanometric parameters. ***Objectives***: To determine the effect of age on tympanometric parameters and to establish normative data for both young and elderly age groups. ***Methods***: A cross-sectional study was carried out from October 2024 to March 2025 at the Clinical Otolaryngology and Audio-Vestibular Consultation Unit. Participants with normal otoscopic findings were classified into young and old age groups. Tympanometric assessments were performed using the Amplivox Otowave 102 device, measuring ear canal volume (ECV), tympanometric peak pressure (TPP), static acoustic admittance (Ytm), and tympanometric width (TW). ***Results***: The study included 143 young individuals with a mean age of 25.32±3.92 years and 144 old people with a mean age of 76.84±8.90 years. The statistical analysis revealed that age affected ear canal volume, acoustic admittance, tympanometric peak pressure, and tympanometric width compared to the younger group. Those 85 years of age and older exhibited significantly greater ear canal volume and tympanometric width among the older age subgroups. Nevertheless, there were no significant differences between the left and right ears in any of the tympanometric data. ***Conclusions***: The results demonstrated a notable age-related change in tympanometric parameters and provided credence to the use of age-specific normative data for accurate assessment.

Keywords: Age, Ear, Elderly, Middle ear, Tympanometry.

تأثير العمر على معلمات قياس الطبلة

الخلاصة

الخلفية: مع تقدم الأفراد في السن ، قد تخضع أذنهم الوسطى لتغيرات فسيولوجية تسبب اختلافات في معلمات الطبلة. **الأهداف**: تحديد تأثير العمر على المعلمات الطبلية وإنشاء بيانات معيارية لكل من الفئات العمرية للشباب وكبار السن. **الطرائق**: أجريت دراسة مقطعية من أكتوبر 2024 إلى مارس 2025 في وحدة طب الأنف والأذن والحنجرة السريرية والاستشارات السمعية الدهليزية. تم تصنيف المشاركين الذين لديهم نتائج تنظير الأذن الطبيعية إلى فئات عمرية صغيرة وكبار. تم إجراء تقييمات قياس الطبلة باستخدام جهاز Amplivox Otowave 102، وقياس حجم قناة الأذن (ECV)، وضغط الذروة الطبلية (TPP)، والقبول الصوتي الثابت (Ytm)، وعرض الطبلة (TW). **النتائج**: شملت الدراسة 143 شابا بمتوسط عمر 25.32±3.92 سنة و 144 من كبار السن بمتوسط عمر 76.84±8.90 سنة. كشف التحليل الإحصائي أن العمر أثر على حجم قناة الأذن، والقبول الصوتي ، وضغط الذروة الطبلية، وعرض الطبلة مقارنة بالمجموعة الأصغر سنا. أظهر أولئك الذين تبلغ أعمارهم 85 عاما فما فوق حجما أكبر بكثير لقناة الأذن وعرض طبلة الأذن بين الفئات الفرعية العمرية الأكبر سنا. ومع ذلك ، لم تكن هناك فروق ذات دلالة إحصائية بين الأذنين اليسرى واليمنى في أي من بيانات قياس الطبلة. **الاستنتاجات**: أظهرت النتائج تغيرا ملحوظا مرتبطا بالعمر في معلمات قياس الطبلة وأعطت مصداقية لاستخدام البيانات المعيارية الخاصة بالعمر من أجل التقييم الدقيق.

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INTRODUCTION

Goodhill first introduced the term ‘conductive presbycusis’ in 1969 to describe age-related changes affecting middle ear function. According to him, presbycusis is not just sensorineural loss; if aging processes take place in muscle and ligament, then conductive alterations in the middle ear are both possible and highly likely to occur [1]. Age-related changes include auricle enlargement, the ear canal sinking due to less adipose tissue, increased hair growth, and thickened cerumen leading to wax impaction [2]. The eardrums showed less vascularization and more rigidity [3]. Osteoporosis (OP) of the middle ear ossicles (malleus, incus, and stapes) [4]. As age increases, hyaline deposits first appear on the articular discs of the incudomalleolar and incudostapedial joints, followed by calcium deposits [5]. Numerous middle ear problems affect how the middle ear functions. Tympanometry tests are used to identify this disorder and record how this energy-transfer function is changed [6]. It provides details on the tympanic membrane's movement (static admittance), the pressure at which it moves the most (peak pressure), and the amount of air that exists between the tympanic membrane and the ear canal opening (ear canal volume) [7]. It also provides details on the tympanometric width or gradient, an objective metric that describes how steep the slope of the tympanogram is close to the peak [8]. As the

number of people over 65 was predicted to increase and many World War II individuals were living well into their 80s and 90s, audiologists needed to rethink the aging population and reassess their approaches to deal with it [9]. According to the World Population Prospect (WPP), 761 million individuals were 65 years of age or older in 2021; by 2050, that number will increase to 1.6 billion, and by 2100, it might reach 2.5 billion [10]. In Iraq, the percentage of adults over 60 is 4.4% in 2023 [11]. Additionally, determining normative immittance values is made more difficult by the fact that immittance values vary with age, sex, and ethnicity [12]. Therefore, we conducted this study because, according to our knowledge from data research in the last few years, a number of research studies have yielded varying results about how middle ear function varies as people age. Some findings show no change in parameters with age; other researchers have observed a change. Additionally, we want to provide age-specific normative tympanometric data for both young and elderly Iraqi individuals.

METHODS

Study design and setting

A cross-sectional study was carried out at the clinical Otolaryngology, and audio-vestibular consultation unit over a five-month period (from 30 October 2024 to 30 March 2025). Participants were gathered using a convenient sampling technique.

Inclusion criteria

The inclusion criteria were a young age group with normal hearing thresholds (typically ≤25 dB HL across all frequencies) and an elderly age group of 65 and above [13] (with a mild hearing threshold of 26-40 dB HL at 500, 1000, and 2000 Hz speech frequency and mild to moderate high-frequency loss), both groups with normal otoscopic findings and type A tympanograms.

Exclusion criteria

Exclusion criteria comprised evidence of active or inactive middle ear disorders (e.g., tympanic membrane perforation, otorrhea), uncontrolled chronic disease, recent trauma or ear surgery, suspected Eustachian tube dysfunction (e.g., allergic rhinitis), absent or elevated acoustic reflexes, air-bone gaps >10 dB HL in pure tone audiometry, and family history of otosclerosis. Information about middle ear pathology is provided by a structured questionnaire with closed-ended questions, including binary (Yes/No) items, and open-ended questions to allow for additional responses that are not captured by fixed choices. The researcher developed and modified it in light of previous studies and literature reviews. However, several elements were modified to accommodate the current study. The following sections make up the questionnaire: Section 1, the patients' sociodemographic details, such as their age, sex, and occupation. Section 2, auditory health, medical, family, medication, and surgical history. Section 3, physical examination filled out by the researcher. Ten people took part in a pilot testing project in order to ascertain the feasibility of the questionnaire and gather further feedback regarding the questionnaire's contents.

Data collection and outcomes measurement

After completion of the questionnaires, each participant underwent an otoscopic examination to assess the tympanic membrane and ear canals. People with normal otoscopic findings were seated in a quiet room, and 512 Hz tuning forks were used to compare air conduction (AC) and bone conduction (BC) in order to confirm clinical evidence of conductive hearing loss in each ear. The participants hearing thresholds were assessed using a diagnostic Amplivox model 240 audiometer in a sound booth that met the acceptable background noise levels set by the American National Standards Institute (ANSI). Bone conduction thresholds were evaluated at frequencies between 500 and 4000 Hz, while air conduction thresholds were measured at octave frequencies between 250 and 8000 Hz. Then the individual was examined with a tympanometry (Amplivox Otowave 102) device, which employs a probe tone of 226 Hz, 85 dB SPL (+/- 2 dB), and pressure levels of +200 to −400 daPa, with a sweep speed of 200-300 daPa/sec. Device calibration was carried out in line with National Standard Institute S 3.39 (1987) [14] (Figure 1).

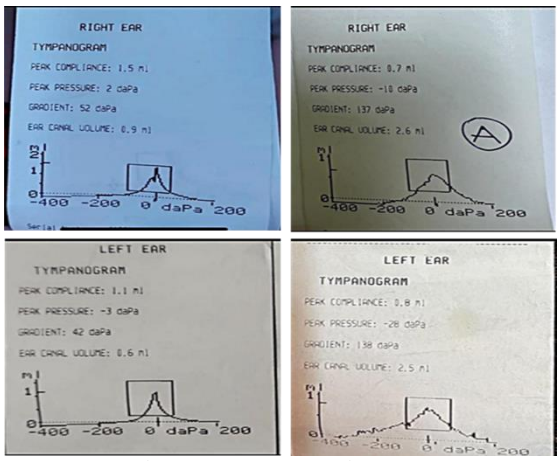

Figure 1: The left panel displays results from younger adults, while the right panel shows data from elderly adults. These tympanogram examples illustrate age-related changes in middle ear function, as indicated by reduced acoustic admittance, more negative tympanometric pressure, increased tympanometric width, and larger ear canal volume in elderly adults.

Finally, to ensure appropriate middle ear function, each ear's ipsilateral acoustic reflex is assessed independently. The range of stimulus intensity was 70–100 dB SPL (±3 dB), with 5- or 10-dB increments. The test was considered normal if the reflex detection threshold showed at least 0.02 mL of movement and was between 85 and 100 dB HL.

Ethical considerations

The study protocol was approved, and official

permission was obtained from the institutional ethical committee (IEC) with certificated ID 8039 on October 29th 2024, and it was carried out according to ethical principles to ensure the research followed ethical standards and safeguarded participants' well-being. The participants were informed of the study's objectives and verbally agreed to participate in the study of their choice. We informed all participants that their identities would remain anonymous and that all information would be kept confidential.

Statistical analysis

The statistical software for social sciences (SPSS-27) was used to analyze the data. The variables were assessed utilizing the following statistical techniques: A) Descriptive analysis**,** expressed in mean, standard deviation (SD), and 90% range. B) Inferential analysis, all of the variables were not normally distributed, according to the results of the Shapiro-Wilk and Kolmogorov-Smirnov tests. The Mann-Whitney U test was used for comparing independent (unpaired) means, the Wilcoxon signed-rank test was used to calculate the difference between the paired observations, and the Kruskal-Wallis test was used for comparing three independent groups. A *p*-value of less than 0.05 is considered significant.

RESULTS

The mean age of 144 elderly individuals was 76.84±8.90, whereas the mean age of the 143 young people was 25.32±3.92. Normative data for both ears in young and elderly age groups are summarized in Table 1, including the mean, standard deviation (SD), and 90% range.

Table 1: Tympanometric normative data for the young and elderly population

Parameters	Young age		Elderly age	
Acoustic Admittance (Ytm) (mmho)	0.93±.37	0.5-1.7	0.68 ± 0.33	0.3-1.4
Tympanometric Peak Pressure (TPP) (daPa)	-12.48±10.87	-28-10	-17.85±15.9	-65-3.0
Tympanometric width (TW) (daPa)	67.18±18.22	35.45-100	92.56±22.56	60-138
Ear canal volume (ECV) (ml)	1.16±0.31	0.7-1.4	1.69±.89	0.9-2.96

Data were expressed as mean±SD and 90% range.

Tympanometric parameters of the 144 elderly participants were compared between the left and right ears using the Wilcoxon Signed-Rank Test. The analysis revealed no significant differences between ears for any of the measured parameters (Table 2). Mann-Whitney U tests revealed significant differences in all four tympanometric parameters of both ears between the young and elderly age groups (Table 3).

Table 2: Comparison of tympanometric parameters between right and left ears in elderly individuals

Pairs	Mean±SD	Mean Rank	Z test	*p*-value
Rt vs Lt ears	0.65±0.22	65.74	-0.48	0.62
Ytm	0.57±0.20	67.35		
Rt vs Lt ears	-19.49±7.58	76.89	-0.93	0.35
TPP	-17.21±14.85	64.11		
Rt vs Lt ears	100.78±8.88	26.81	-0.25	0.79
TW	100.77±9.44	22.70		
Rt vs Lt ears	1.85±0.79	52.83	-1.85	0.063
ECV	1.87±0.77	53.25		

Ya: acoustic admittance, TPP: tympanometric peak pressure, TW: tympanometric width, ECV: ear canal volume.

Table 3: Comparison of tympanometric parameters between young and elderly age groups

		Right ear				Left ear			
Parameters		Mean±SD	Median	Z	*p*-value	Mean±SD	Median	Z	*p*-value
Ytm	Young	0.95±0.40	0.90	-8.83	0.001	0.91±0.35	0.90	-8.63	0.001
	Old	0.57±0.23	0.60			0.61±0.26	0.60		
TPP	Young	-12.73±11.24	-10.0	0.024	0.024	-12.23±10.53	-15.0	-2.32	0.02
	Old	-19.49±17.58	-15.0			-17.2214.88	-15.0		
TW	Young	66.98±17.84	67.5	-10.28	0.001	67.38±18.64	70.0	-7.76	0.001
	Old	96.90±21.46	96.0			88.22±22.87	88.0		
ECV	Young	1.16±0.31	1.1	-9.93	0.002	1.15±0.31	1.10	-9.93	0.001
	Old	1.94±0.92	1.70			1.94±0.94	1.70		

Ytm: acoustic admittance, TPP: tympanometric peak pressure, TW: tympanometric width, ECV: ear canal volume.

The elderly age group was divided into three age subgroups: it includes 46 individuals in group 1 (65–74 years old), 47 individuals in group 2 (75–84 years old), and 51 individuals in group 3 (85+ years old). Tympanometric parameters across these subgroups were compared using the Kruskal–Wallis H test. Only tympanometric width and ear canal volume (ECV) demonstrated significant differences across the elderly age subgroups (Table 4). In order to pinpoint the exact age group exhibiting this tendency, the Mann-Whitney test was used to compare the tympanometric width and ear canal volume for both ears across elderly age subgroups. We discovered that there was significant variation between groups 1 and 3 (65–74 and 85+), groups 2 and 3 (75–84 and 85+), and no discernible difference between groups 1 and 2 (65–74 and 75–84) (Table 5).

DISCUSSION

Tympanometry is a common and efficient diagnostic technique, and more reliable findings will be obtained when comparing the age effect among groups of the same ethnicity [15,16].

Table 4: Comparison of tympanometric parameters across elderly age subgroups

		Right ear			Left ear		
Parameters	Age (year)	Mean±SD	Median	*p*	Mean±SD	Median	*p*
Ytm	65-74	0.61±0.40	0.60		0.68±0.20	0.70	
	75-84	0.60±0.36	0.55	0.053	0.68±0.25	0.66	0.894
	85+	0.51±0.43	0.48		0.66±0.20	0.60	
TPP	65-74	-17.16±15.20	-15.0		-16.87±16.62	-10.0	
	75-84	-18.45±19.06	-19.0	0.107	-15.35±10.11	-15.50	0.630
	85+	-22.85±18.12	-20.0		-16.43±14.37	-16.0	
TW	65-74	83.62±13.94	85.0		77.33± 20.79	80.0	
	75-84	92.85±16.87	96.0	0.001	86.75± 18.13	87.0	0.001
	85+	104.25±20.47	100.0		100.60±23.46	92.50	
ECV	65-74	1.52±0.33	1.61		1.51±0.36	1.60	
	75-84	1.67±0.60	1.53	0.001	1.69± .63	1.55	0.001
	85+	2.61±1.10	2.31		2.63±1.15	2.35	

Ya: acoustic admittance, TPP: tympanometric peak pressure, TW: tympanometric width, ECV: ear canal volume.

Table 5: Comparative analysis of tympanometric width and ear canal volume among old age subgroups

	ECV						TW					
	Right ear			Left ear			Right ear			Left ear		
Groups (year)	Mean Rank	Z	*p*	Mean Rank	Z	*p*	Mean Rank	Z	*p*	Mean Rank	Z	*p*
65–74	52.73	-1.49	0.31	45.98	-0.89	0.37	40.74	-2.73	0.06	43.36	-1.8	0.07
75–84	44.27			51.02			56.26			53.64		
75–84	42.78	-2.01	0.04	35.58	-4.55	0.01	34.64	-4.88	0.02	35.50	-4.54	0.01
85+	54.22			61.42			62.36			60.42		
65–74	31.55	-5.83	0.03	31.03	-6.14	0.01	31.03	-6.15	0.01	30.19	-3.98	0.01
85+	65.45			65.97			65.97			59.81		

ECV: ear canal volume, TW: tympanometric width.

Ethnicity can affect tympanometric parameters for several reasons, such as anatomical, physiological, and genetic. For instance, the differences in the function of the tympanic membrane's flexibility can result in variations in compliance and pressure readings [17]. Ethnicity may also reveal the prevalence of specific illnesses. The low incidence of otitis media (OM) observed in research involving individuals of African descent could be caused by various middle ear mechano-acoustical characteristics or anatomical anomalies in the Eustachian tube [18]. Because of this, we analyzed the tympanometric results in Iraqi Arab participants in light of the fact that they are the largest ethnic group in the country. Tympanometric measurements between right and left ears did not differ significantly, which is in line with recent research [19]. Even while some earlier studies have indicated that the left ear's ear canal volumes are somewhat bigger than the right [20]. This difference is often negligible and is often attributed to variation in tester technique. Compared to young age groups, older people had higher negative tympanometric peak pressures (TPP) consistent with a previous study [21]. This may be attributed to the Eustachian tube's structural alterations, specifically the shortening of the tensor veli palatini muscle's attachment in relation to the cartilaginous component of the tube that makes it more difficult to regulate pressure. Additionally, we observed a decrease in acoustic admittance (Ytm) with increasing age in line with previous research [22]. Degenerative alterations such as ossicular chain calcification, otosclerosis, arthritis, or tympanic membrane stiffening might be the cause of this decrease. Furthermore, atrophy of the tensor tympani and stapedius muscles might impair the middle ear's dynamic responsiveness, which lowers compliance. Age-related hearing loss is exacerbated by this decreased mobility, which reduces the effectiveness of sound waves reaching the cochlea. An additional significant finding was the rise in ear canal volume (ECV) among older individuals as compared to young age groups, which was confirmed by previous studies [23]. This could be the consequence of soft tissue shrinking surrounding the ear canal and age-related decrease of skin elasticity. However, according to certain research, there was no appreciable difference in ECV between young and old people, which might be due to different testing techniques or tympanometric tools [24]. At the end we found that tympanometric widths (TW) were broader in older age groups, a pattern consistent with earlier findings [25]. A wider tympanometric curve indicates a more gradual pressure change response, reflecting reduced middle ear compliance. This may point to decreased Eustachian tube function, which, if persistent, could predispose individuals to fluid buildup or conductive hearing loss. While such changes might reflect normal middle ear aging, in symptomatic individuals, they may suggest underlying pathology. According to a prior study, tympanometric parameters did not significantly differ across elderly age subgroups [26]. But according to other research, there were considerable changes in acoustic admittance and tympanometric peak pressure, especially in those between the ages of 71 and 80, as well as significant changes in ear canal volumes in both ears between the ages of 61 and 80 only [27]. In contrast, our results showed that there were notable variations in tympanometric width and ear canal volume between the 65–74 and 85+ age groups, as well as between the 75–84 and 85+ age groups. These results suggest that aging-related changes in the middle ear are progressive and vary among individuals. Based on our data, the tympanometric width and ear canal volume may significantly change beyond the age of 75, especially

after the age of 85 years. The observed changes reinforce the value of early detection, routine screening, and appropriate hearing care in geriatric populations. In summary, our study indicates that aging has a significant impact on tympanometric parameters, particularly in the oldest age groups, indicating that age- and ethnicity-specific normative data are necessary in clinical assessments. However, the relatively small sample size and brief duration of the study may have limited the ability to detect gradual, age-related changes in middle ear function. More comprehensive insights could be gained by tracking these changes over time through a longitudinal cohort study.

Conclusion

Our results demonstrate significant differences in tympanometric parameters between elderly and younger adults. Elderly adults showed more negative tympanometric pressure (TPP), wider tympanometric width (TW), larger ear canal volume (ECV) values, and lower peak acoustic admittance (Ytm) values than their younger adult counterparts. Additionally, there are distinct discrepancies between the two groups' lower- and upper-90 percent normal range values. As the global elderly population continues to rise, establishing such age-specific normative data will become increasingly important for ensuring accurate diagnosis and appropriate management of middle ear conditions in elderly individuals.

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Conflict of interests

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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