Original Article

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Tympanometric Findings in the Normal Nepali Population Visiting a Tertiary Care Hospital

ABSTRACT

Aims and Objectives: Tympanometric parameters are influenced by several factors, including age, gender, ethnicity, and altitude. Normative values of the parameters have not been established in the Nepali population. This study aims to establish normative values of tympanometric parameters in a large sample

Methods: Tympanometric assessments were conducted on 793 participants (1586 ears) with normal middle ear function at a tertiary hospital in Kathmandu (altitude ~1350 m). Measures included ear canal volume (ECV), peak compensated static acoustic admittance (Ytm), tympanometric peak pressure (TPP), and tympanometric width (TW), recorded using a 226 Hz probe tone. Statistical analyses examined age- and gender-related differences.

Results: Mean ECV was 1.26 ± 0.40 cc, Ytm 0.78 ± 0.35 mmho, TPP –5 ± 21 daPa, and TW 63 ± 26 daPa. ECV and Ytm significantly increased from adolescence to early adulthood, with a slight decline in ECV in older adults. Males showed significantly larger ECV than females ($p < .001$). No significant differences were observed between ears. Compared to Chinese and Caucasian normative values, Nepali participants exhibited higher Ytm and narrower TW.

Conclusion: This study provides the first tympanometric normative data for the Nepali population and highlights the influence of age, gender, and altitude. These values are essential for accurate diagnosis and should be used in clinical practice within similar geographic regions.

Keywords: Admittance; Compliance; Ear canal volume; Middle ear; Tympanometry.

INTRODUCTION

Tympanometry has been used clinically since the early 1970s to identify middle ear abnormalities. [1,2]Tympanometric data typically include the equivalent ear canal volume (ECV), peak compensated static acoustic admittance (Ytm), tympanometric peak pressure (TPP), and tympanometric width (TW). Several variables can influence tympanometric outcomes, including age, gender, ethnicity, and anatomical differences.[3-5] With age, changes in middle ear structures such as tympanic membrane elasticity and ossicular ligament integrity can affect compliance and other tympanometric measures[6,7]. Gender differences have also been documented, particularly for ECV and Ytm, with males typically showing larger ear canal volumes.[3,5,8] Ethnicity has a significant impact as well.[4,9,10]Studies comparing Chinese and Caucasian populations found statistically significant differences in all tympanometric parameters, underscoring the need for population-specific norms.[11] Another factor is ear asymmetry. Differences in tympanometric measures between the right and left ears have been noted, but they were not clinically significant. [12]

Finally, the barometric pressure decreases with increasing elevation, which can influence middle ear pressure regulation and tympanometric variables, particularly ECV and TPP.[13] In regions such as Kathmandu, located at approximately 1350 meters above sea level, this moderate altitude may contribute to subtle variations in measured values, even in individuals with normal middle ear function.

Normative values for tympanometry have not been obtained for the Nepali population to date. No study has been conducted regarding the development of the same. The absence of localized norms may reduce the diagnostic accuracy of tympanometry, leading to potential under- or over-referral. This study aims to address this gap by establishing age- and gender-specific tympanometric norms for the Nepali population residing in the Kathmandu Valley, and to highlight the influence of moderate altitude on these values.

METHODS

This cross-sectional study was conducted with the approval of the Institutional Review Committee, Institute of Medicine

(516 (6-11)E2). The study is based in the largest tertiary hospital in the country, Kathmandu, Nepal. The participants in the study were individuals referred for audiological consultations to the audiology unit of the hospital. The study was conducted for a duration of 6 months. Individuals with either normal hearing sensitivity or sensorineural hearing loss were recruited for the study. All participants met specific criteria, including the absence of external or middle ear issues, no earwax blockages or structural abnormalities, and an air-to-bone conduction threshold gap of 10 dB or less in at least one ear. Individuals who did not meet these criteria in both ears were excluded from the study.

All tests were performed in a tertiary hospital in the Kathmandu valley, Tribhuvan University Teaching Hospital (TUTH). Pure tone audiometry was performed using Amplaid A177 plus, Amplaid A137, or Elkon Eda 3N3 Millie diagnostic audiometers. Pure tone audiometry was performed by either audiometrists or BASLP students under the supervision of audiologists. For tympanometry, the MAICO TouchTym MI 34 was used, and all tests were performed at a 226 Hz probe tone frequency.

Tympanometry was conducted in a double-walled sound suite, ensuring a hermetic seal of the probe in the ear canal using a 226 Hz probe tone in both ears. Once the hermetic seal is achieved and maintained for a few seconds, the tympanometer automatically displays the 4 parameters: equivalent ear canal volume (Vea): the admittance value measured at +200 daPa, tympanometric peak pressure (TPP): the ear canal pressure corresponding to peak admittance, tympanometric width (TW): the width of the curve at 50% of its peak amplitude, peak compensated static acoustic admittance (Peak Ytm): it is the peak admittance value minus the value at +200 daPa. The demographic information and tympanometric results were entered into an Excel sheet.

RESULTS

The study sample consisted of 793 participants, encompassing 1586 ears with an equal proportion of both genders. There were 396 female and 397 male participants, with a mean age of 38.8 years and a standard deviation of 17.5 years. The age range of participants in the study spanned from 10 to 69 years.

Table 1. Number of participants in each age group classified by gender.

Age range	Female participants	Male participants	Total
10-19	66	65	131
20-29	66	66	132
30-29	67	66	133
40-49	66	67	133
50-59	65	65	130
60-69	66	68	134
Total	396	397	793

The mean, standard deviation (SD), and 95% range values for the tympanometric parameters Ytm, TPP, TW, and ECV were obtained for the sample.

Table 2. Mean, Standard Deviation (SD), and 95% range values for four different measurements.

Variables	mean	SD	95% range
Ear canal volume	1.26	0.4	1.24 to 1.28
Tympanometric peak pressure	-5 dapa	21	-6 to -4
Tympanometric width	63	26	62 to 65
Peak Ytm	0.78	0.35	0.76 to 0.8

The mean, standard deviation (SD), and 95% range values for the tympanometric parameters Ytm, TPP, TW, and ECV were obtained for each of the six age groups.

Table 3. Tympanometric parameters according to age groups.

Age group	Variables	mean	SD	95% range
10-19	Ear canal volume	1.0	0.39	0.98 to 1.07
	Tympanometric peak pressure	-5	27	-8 to -1
	Tympanometric width	67	31	63 to 71
	Peak Ytm	0.70	0.33	0.66 to 0.74
20-29	Ear canal volume	1.25	0.41	1.2 to 1.3
	Tympanometric peak pressure	-4	18	-6 to -2
	Tympanometric width	64	26	61 to 67
	Peak Ytm	0.84	0.36	0.79 to 0.88
30-39	Ear canal volume	1.32	0.36	1.28 to 1.37
	Tympanometric peak pressure	-4	20	-7 to -2
	Tympanometric width	60	25	57 to 63
	Peak Ytm	0.78	0.34	0.74 to 0.82
40-49	Ear canal volume	1.31	0.36	1.27 to 1.35
	Tympanometric peak pressure	-4	21	-7 to -2
	Tympanometric width	61	23	58 to 63
	Peak Ytm	0.77	0.33	0.73 to 0.8
50-59	Ear canal volume	1.38	0.42	1.33 to 1.43
	Tympanometric peak pressure	-7	20	-10 to -5
	Tympanometric width	65	25	62 to 68
	Peak Ytm	0.79	0.35	0.75 to 0.84

60-69	Ear canal volume	1.3	0.35	1.26 to 1.34
	Tympanometric peak pressure	-7	22	-9 to -4
	Tympanometric width	64	26	60 to 67
	Peak Ytm	0.8	0.37	0.76 to 0.85

An independent sample t-test was used to explore the influence of gender in tympanometric variables. The results indicate that there was no significant difference between male and female participants for the tympanometric parameters Ytm, TPP, and TW. There was a statistically significant difference in ECV between male and female participants of the entire sample. The ECV was slightly larger in males than in females, with a difference of 0.1 cc (cubic centimeters). While this difference is small, it was still unlikely to occur by chance and may have some clinical or physiological relevance. The difference in ear canal volume between males and females is significant across all age groups except the 40-49 age group (p-value 0.62). The greatest difference was observed in the ECV of the 50-59 age group, with a mean difference of 0.23 between males and females.

Table 4. Mean, SD, and t-test results of tympanometric variables between males and females.

variables	Mean ± SD	t	df	Sig. (2-tailed)
Ear canal volume	Males: 1.3 ± 0.41			
	Females: 1.2± 0.37	7.44	1584	<0.001*
Tympanometric peak pressure	Males: -5.51± 21.49			
	Females: -4.56± 21.34	-0.88	1584	0.38
Tympanometric width	Males: 64 ±25.9			
	Females: 62.82 ±26.43	0.89	1584	0.37
Compliance Ytm	Males: 0.8±0.35			
	Females: 0.76±0.35	1.95	1584	0.05

A paired t-test was used to determine if significant differences exist between the two ears when tympanometric variables are measured. No significant differences between the ears were noted.

Table 5. paired t-test to compare parameters between two ears.

Variables	Mean ± SD	t	df	Sig. (2-tailed)
Ear canal volume	Right ear: 1.28 0.41			
	Left ear: 1.29 ±0.81	0.22	792	0.83
Tympanometric peak pressure	Right ear: -5.68± 21.72			
	Left ear: -4.31 ±20.84	-1.59	792	0.11
Tympanometric width	Right ear: 63.76± 26.96			
	Left ear: 63.36 ±26.07	0.38	792	0.7
Compliance Ytm	Right ear: 0.79 ±0.36			
	Left ear: 0.78 ±0.35	1	792	0.32

One-way analysis of variance ANOVA test was used to examine whether there were any age-related effects on tympanometry values. The results of the statistical analysis showed statistically significant differences in three tympanometric measures across the different age groups: Ytm (p-value 0), TW (p-value 0.014), and ECV (p-value 0). No significant difference was observed in TPP (p-value 0.26) across the age range. To determine the age groups that differed significantly, a Bonferroni post-hoc analysis at a 0.05 level of significance was performed. The 10-19 age group differed significantly from all other age groups in the measure of ear canal volume.

Table 6. Bonferroni corrected post-hoc analysis at 0.05 level of significance.

	age (I group)	age (J group)	Mean difference (I-J)	Statistical significance
ECV	10-19	20-29	-0.23*	0
		30-39	-0.3*	0
		40-49	-0.29*	0
		50-59	-0.35*	0
		60-69	-0.27*	0
	20-29	50-59	-0.13*	0.003
Compliance	10-19	20-29	-0.14*	0
		50-59	-0.09*	0.031
		60-69	-0.11*	0.007
TW	10-19	30-39	-7.28*	0.021

**significant difference*

DISCUSSION

This study presents normative tympanometric values for the Nepali population, derived from a large sample of participants with clinically normal middle ears. It is the first known attempt to establish such norms specifically for Nepal and provides age- and gender-stratified data using a 226 Hz probe tone. All participants were tested at a tertiary hospital in Kathmandu, which is situated at an elevation of approximately 1350 meters above sea level. This geographic context is important because while the altitude is not extreme, it may still influence certain aspects of middle ear pressure regulation. The normative values reported here are

therefore altitude-adjusted to mid-hill regions and may serve as a standard reference for clinical and research applications in similar altitudinal zones within Nepal.

Across the total sample, the mean ear canal volume (ECV) was 1.26 cc, peak compensated static acoustic admittance (Ytm) was 0.78 mmho, tympanometric peak pressure (TPP) was -5 daPa, and tympanometric width (TW) was 63 daPa. These values fall within the expected clinical range but demonstrate characteristic variations across age and gender. A clear trend was observed with age, where both ECV and Ytm showed statistically significant increases from adolescence into young adulthood. These changes, linked to age-related alterations in the physical dimensions and functional efficiency of the middle ear system, are well-established in existing literature.[14] The greatest changes were evident between the 10–19 and 20–29 age groups, with ECV rising from 1.00 cc to 1.25 cc, and Ytm from 0.70 mmho to 0.84 mmho. This likely reflects anatomical maturation and structural changes in the middle ear during late adolescence. Beyond the third decade of life, the values plateaued, followed by a slight decrease in ECV in the oldest age group. Specifically, ECV peaked in the 50–59-year age group (1.38 cc) and decreased to 1.30 cc in the 60–69 group. This trend may reflect age-related soft tissue atrophy, external auditory canal narrowing due to epithelial changes, or reduced canal patency associated with aging.[15] In a longitudinal study by David et al., ECV declined an average of 0.06 cm^3 during a 16-year interval in older adults.[16]TPP remained relatively stable across age groups and did not show significant age-related shifts. TW was slightly broader in the adolescent group and then stabilized into adulthood.

Gender differences were most prominent in ECV. Males had a significantly higher average ECV than females (1.30 cc vs. 1.20 cc, $p < .001$), consistent across nearly all age groups and in line with known anatomical differences in external auditory canal size. This is consistent with a previous study on the Chinese population.[10] Other parameters, including Ytm, TPP, and TW, did not differ significantly by gender, although compliance showed a marginal trend toward higher values in males. There were no significant differences between right and left ears in any of the tympanometric measures, which confirms the internal consistency of bilateral measurements and aligns with earlier research findings on symmetrical middle ear behavior. This is also consistent with Wan's study.[10] Li et al. found significant differences in ECV between the ears, which they attributed to tester error.[6]

When compared to published tympanometric norms from Chinese and Caucasian populations, the current findings reveal notable differences. In the 20-29 age group, the Nepali sample had a higher ECV than Chinese adults (1.25 cc vs. 1.17 cc)[10] but lower than Caucasians (1.44 cc).[3] Ytm was also higher in Nepalese than in both Chinese (0.84 mmho vs. 0.55 mmho) and Caucasian young adults (0.73 mmho). In the 60-69 age group, the ECV in the Nepali sample remained higher than Chinese norms (1.30 cc vs. 1.06 cc)[17], and compliance was significantly greater (0.80 mmho vs. 0.48 mmho). Compared to general Caucasian adult norms used here in the absence of strictly age-matched data, Nepali values for ECV and Ytm remained comparable. The mean TPP across groups remained within normal clinical limits, though Nepali values tended to be slightly more negative than those of Chinese and Caucasian subjects. Tympanometric width was narrower in the Nepali population compared to both other groups in both age ranges, indicating a sharper tympanogram peak that may reflect anatomical or physiological characteristics unique to this population.

These differences underline the importance of establishing and applying population-specific normative data in clinical audiology and relying on Chinese or Western standards to interpret tympanometric data in the Nepali population risks misclassification, particularly for borderline or subclinical middle ear conditions.

CONCLUSION

This study established the normative values for tympanometry in the Nepali population. The reference values provided by this study should therefore be adopted in clinical settings across Nepal, particularly in regions with similar altitude and demographic characteristics. Future studies are encouraged to explore whether these normative values vary further across Nepal's lowland and high-altitude populations.

Conflict of Interest

The authors declare no conflict of interest.

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