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TYMPANOMETRIC NORMATIVE DATA OF MIDDLE EAR IN YOUNG ASIAN ADULTS BASED ON HEIGHT AND HEAD CIRCUMFERENCE.

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ABSTRACT

Objectives: Tympanometry is a useful clinical test to identify middle ear disorders in an objective manner. The aim of the present study was to determine the possible influence of body size variables (height and head circumference) on tympanometric results in healthy adults. **Materials and Methods:** Sixty young Asian adults (30 males and 30 females) with mean age of 22.1 ± 1.3 years were enrolled. All of them underwent a standard 226 Hz tympanometric assessment for determining their middle ear function. Outcomes of tympanometric parameters including static admittance (SA), ear canal volume (ECV), tympanometric peak pressure (TPP) and tympanometric width (TW) were computed. In addition, height and head circumference were measured from each subject. **Results:** Females were found to produce significantly lower SA and ECV values than males. Among the tympanometric parameters, only ECV outcomes were influenced by height. Significant influences of head circumference on SA and ECV were found. In contrast, TPP and TW values were not affected either by gender or body size. **Conclusion:** Tympanometric results can be influenced by height and head circumference. Gender-specific normative data and regression-based normative data derived from the present study can be useful for clinical diagnosis involving the Asian population.

Keywords: Middle ear, Tympanometry, Asian, Gender, Head circumference, Height

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Keywords: Middle ear, Tympanometry, Asian, Gender, Head circumference, Height

INTRODUCTION

Middle ear diseases that contribute to conductive hearing loss are common in children and in adults. [1, 2] Clinically, for determining the middle ear function in an objective manner, tympanometry is used. The tympanometric results are interpreted based on four parameters: static admittance (SA), ear canal volume (ECV), tympanometric peak pressure (TPP) and tympanometric width (TW). Based on the tympanometric outcomes, different types of middle ear disorders can be conveniently identified. In this respect, its sensitivity (i.e. ability to accurately diagnose middle ear disorders) can be as high as 96%. [3]

Gender disparities in tympanometric results have been well documented. [4, 5] In particular, females are found to produce lower SA and ECV values than males. [4, 5] Anatomical dissimilarities between genders have been suggested as the influencing factors, particu-

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larly the head circumference. [4] Nevertheless, information regarding the influence of other factor, such as height, on the tympanometric results is limited. The present study, therefore, aimed to determine the association between body size variables (height and head circumference) and tympanometric results in Asian adults. As such, specific normative data for tympanometry would be derived based on the study outcomes.

METHOD

Study Design, Population and Sample: In this prospective cross-sectional study, Asian students and staff members of University Hospital were invited to participate in the study through email and advertisement on University message board. Sixty participants comprising of students and staff members were recruited. All of the participants were healthy and reported no history of hearing loss or middle ear disorders. Informed consent for voluntary participation was obtained from each participant prior to the data collection. All procedures performed in the present study were approved by the Human Ethics Committee of Universiti Sains Malaysia, which is in accordance with the 1975 Declaration of Helsinki and its later amendments. Prior to the data collection, otoscopic examination was performed by an experienced otologist to check the status of external and middle ears. All of the participants were found to have healthy ears. Pure tone audiometry (GSI-61 by Grason-Stadler, United States) was also conducted to determine the hearing status of each participant. None of the participants had hearing loss and the air conduction thresholds were within the normal range (≤ 20 dBHL) with insignificant air-bone gaps (≤ 10 dB) across the tested frequencies.

Body size measurement: Using a non-elastic measuring tape, the height of each participant was measured according to the standard clinical practice. The head circumference was then measured using the standard clinical procedure, whereby the head circumference was measured from halfway between the eyebrows and the hairline to the back of head using a non-elastic measuring tape. [6]

Middle ear assessment: For measuring the middle ear function, AT235 Middle Ear Analyzer (Interacoustics, Denmark) device was used. It was calibrated in accordance with EN 60645-5/ANSI S3.39 (1987). The standard tympanometric assessment (with 226 Hz test frequency) was carried out on all subjects. While the probe was in the ear, the pressure was swept from +200 daPa to -400 daPa (pump speed of 150 daPa/sec). Based on the tympanograms obtained, SA (in ml), ECV (in ml), TPP (in daPa) and TW (in daPa) values for left and right ears were computed. All the measurements took place in the Audiology Clinic, University Hospital.

Statistical analyses: All continuous data were presented as mean (standard deviation (SD)). Both descriptive and inferential statistical analyses were carried out as applicable. Since all data were found to be normally distributed with equal variances (as revealed by Kolmogorov-Smirnov and Levene tests), the parametric analyses were then carried out. Paired t tests were performed to compare the tympanometric outcomes between left and right ears. Independent t tests were conducted to compare head circumference, height and tympanometric results between males and females. To determine the influence of body size variables on tympanometric results, one-way analysis of covariance (ANCOVA) (with height and head circumference as the covariates) was conducted. To further support the ANCOVA results, multiple regression analyses were carried out to determine the association between the body size variables and the tympanometric outcomes. All data were analyzed using the SPSS software version 20 (SPSS Inc, Chicago, IL).

RESULTS

Sixty Asian students and staff members of University Hospital (30 males and 30 females) with mean age of 22.1(1.3) years were recruited to the study. The mean gender based height were 170.6(4.7) cm and 158.3 (5.2) cm for males and females respectively, with males significantly taller than females (p<0.001). A significant difference in head circumference was also found between genders (p<0.001) with males having slighter larger head circumference than females (Head circumference, male =57.2(1.3) cm versus female=55.4(1.6) cm).

The mean (SD) values of all the tympanometric data for male and female participants are shown in Table 1. When the tympanometric data were compared between left and right ears for each participant, there was no statistical difference (p>0.05) for all tympanometric parameters. Mean SA and ECV values in females were noted to be significantly lower than in males (SA: p=0.013; ECV: p=0.007). For SA, this gender difference persisted when height was included in the analysis (p=0.025). Conversely, when head circumference was controlled in ANCOVA, this gender disparity was no longer significant (p=0.088). Similarly, for ECV, the gender difference became non-significant when either height or head circumference was included in the analysis (p>0.05). No notable gender effect was found for TPP and TW either by t test or ANCOVA (p>0.05).

As shown in Table 2, using multiple regression analysis, significant influences of head circumference on SA (p=0.047) and ECV (p=0.003) were noted but only ECV results were influenced by height (p=0.043). No significant associations were found between height and other tympanometric parameters (p>0.05). No such association was observed for TPP and TW (p>0.05). Based on the significant associations between variables and regression equations, regression-based normative data for tympanometry were developed (Tables 3 to 5).

DISCUSSION

In the present study of young Asian adults, significant gender differences were found for SA and ECV parameters of tympanometry, which are consistent with the previous studies.[4, 5] The difference in body size has been suggested as the contributing factor for these gender disparities.[4, 7] Nevertheless, the influence of body size factors was further determined in the present study by looking at the association between the variables. Since height and head circumference values were significantly different between genders, the

Table 1: Mean, standard deviation (SD) and 90% range of tympanometric results by gender. The respective p values (by t test and ANCOVA with height and head circumference as covariates) are shown for gender analysis.

Tympanometric Parameter		Male	Female	P value		
				t test	ANCOVA (Height)	ANCOVA (Head Size)
SA (ml)	Mean (SD)	0.53 (0.14)	0.43 (0.17)	0.013*	0.025*	0.088
	90% Range	0.33 to 0.77	0.23 to 0.70			
ECV (ml)	Mean (SD)	1.27 (0.32)	1.08 (0.18)	0.007*	0.079	0.149
	90% Range	0.88 to 1.92	0.82 to 1.42			
TPP (daPa)	Mean (SD)	-19.00 (14.32)	-18.67 (9.61)	0.916	0.398	0.991
	90% Range	-50.25 to -2.88	-32.60 to -7.50			
TW (daPa)	Mean (SD)	82.83 (19.32)	78.83 (18.31)	0.414	0.727	0.496
	90% Range	54.75 to 121.00	55.00 to 106.63			

*Statistically significant at p<0.05

Table 2: Regression equations for tympanometric parameters with significant statistical outcomes.

Variable	Regression Equation	F-Ratio	P value
Head Circumference vs. SA	y = -0.8569 + 0.02375x	4.103	0.047
Head Circumference vs. ECV	y = -2.1578 + 0.05916x	9.341	0.003
Height vs. ECV	y = -0.3368 + 0.009173x	4.293	0.043

association analyses were indeed relevant to be carried out.

This study confirmed that height has a significant positive correlation with ECV values. This findings is in line with a similar study by Polat et al who investigated the effect of height and weight on wideband tympanometry data among young Turkish adults.[8] They reported that both body size variables (height and weight) were significantly correlated with ECV values. Due to anatomical differences between males and females, they suggested the use of gender-specific normative data for wideband tympanometry for accurately diagnosing middle ear disorders.

The head circumference was found to be significantly correlated with SA and ECV parameters. This finding is consistent with the previous studies and due to a smaller body size (as well as smaller middle ear cavities), lower SA and ECV values were observed in females than in males.[4, 7] In the present study, the TPP and TW parameters do not appear to be influenced by the head circumference, which is also in line with the previous studies. [4, 5, 9]

Based on the findings from the present study, having gender-specific normative data for tympanometry are essential, particularly for clinical application. Alternatively, since tympanometric results are influenced by body size factors, normative data derived from height and head circumference analyses can also be useful. The present study provides these normative data that are based on the significant associations between the variables. The predicted normative data, 95% confidence interval and 95% predicted interval for SA and ECV by means of head circumference are shown in Table 3 and Table 4, respectively. Table 5 shows the corresponding normative data for ECV based on the height of subject. These normative values will provide baseline data for future studies on tympanometry.

The present study had several limitations. The sample size was modest and perhaps more favorable study outcomes would be obtained if more samples are used. Moreover, the middle ear function of the participants was only assessed with the low-frequency tympanometric testing. The possible influence of height and head circumference on tympanometric results when tested with high frequency tones is not tested, which is subject to future research.

CONCLUSION

To conclude, tympanometric outcomes can be influenced by height and head circumference. When interpreting tympanometric results, these body size variables should be considered. Gender-specific normative data and regression-based normative data derived from the present study can serve as baseline data or normal range for comparison when making clinical diagnosis in a young Asian population. Nevertheless, further research on patients with middle ear disorders is warranted to determine the clinical application of these normative dataset.

Table 3: Regression-based normative data for static admittance (SA) by considering head circumference of subjects.

Head Circumference (cm)	Predicted SA (ml)	95% Confidence Interval (ml)	95% Predicted Interval (ml)
51	0.36	0.23 to 0.49	0.02 to 0.69
52	0.38	0.27 to 0.49	0.05 to 0.71
53	0.40	0.32 to 0.49	0.08 to 0.73
54	0.43	0.36 to 0.49	0.11 to 0.75
55	0.45	0.40 to 0.50	0.14 to 0.77
56	0.48	0.43 to 0.52	0.16 to 0.79
57	0.50	0.46 to 0.54	0.18 to 0.82
58	0.52	0.47 to 0.58	0.21 to 0.84
59	0.55	0.47 to 0.62	0.23 to 0.87
60	0.57	0.48 to 0.67	0.24 to 0.90
61	0.60	0.48 to 0.71	0.26 to 0.93

Table 4: Regression-based normative data for ear canal volume (ECV) by considering head circumference of subjects.

Head Circumference (cm)	Predicted ECV (ml)	95% Confidence Interval (ml)	95% Predicted Interval (ml)
51	0.86	0.64 to 1.07	0.30 to 1.42
52	0.92	0.74 to 1.10	0.37 to 1.46
53	0.98	0.83 to 1.12	0.44 to 1.51
54	1.04	0.93 to 1.15	0.51 to 1.56
55	1.10	1.01 to 1.18	0.57 to 1.62
56	1.16	1.09 to 1.22	00.64 to 1.67
57	1.21	1.14 to 1.29	0.69 to 1.73
58	1.27	1.18 to 1.37	0.75 to 1.80
59	1.33	1.21 to 1.46	0.80 to 1.86
60	1.39	1.23 to 1.55	0.85 to 1.93
61	1.45	1.26 to 1.65	0.90 to 2.00

Table 5: Regression-based normative data for ear canal volume (ECV) by considering height of subjects.

Height (cm)	Predicted ECV (ml)	95% Confidence Interval (ml)	95% Predicted Interval (ml)
146	1.00	0.82 to 1.18	0.44 to 1.57
148	1.02	0.86 to 1.18	0.46 to 1.58
150	1.04	0.89 to 1.18	0.48 to 1.59
152	1.06	0.93 to 1.19	0.51 to 1.61
154	1.08	0.96 to 1.19	0.53 to 1.62
156	1.09	0.99 to 1.20	0.55 to 1.64
158	1.11	1.02 to 1.20	0.57 to 1.66
160	1.13	1.05 to 1.21	0.59 to 1.67
162	1.15	1.08 to 1.22	0.61 to 1.69
164	1.17	1.10 to 1.24	0.63 to 1.71
166	1.19	1.12 to 1.26	0.65 to 1.73
168	1.20	1.13 to 1.28	0.66 to 1.75
170	1.22	1.14 to 1.31	0.68 to 1.77
172	1.24	1.14 to 1.34	0.70 to 1.79
174	1.26	1.15 to 1.37	0.71 to 1.81
176	1.28	1.15 to 1.40	0.73 to 1.83
178	1.30	1.16 to 1.43	0.74 to 1.85
180	1.31	1.16 to 1.47	0.76 to 1.87

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