

Anthropometric Study of Human External Ear and Sexual Dimorphism in Medical Students

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Abstract

Background: The ear is an organ of hearing as well as equilibrium. The present study aimed to determine the normal anthropometric measurements of the external ear in males and females and their comparison on both sides and in either sex.

Methods: The study was carried out on 120 medical students of M. P. Shah Government Medical College, Jamnagar, out of which 60 were females and 60 were males. The students having congenital ear malformations or previous surgeries were excluded. All parameters were measured with the help of a digital vernier calliper taken in centimetres. Parameters were ear length, ear breadth, distance from tragus to helix, distance from tragus to antitragus, lobular height, lobular breadth, face height and width. Mean $\pm$ SD of all the parameters were measured and compared it with either sex and on both sides.

Results: The results showed that ear length and ear breadth were higher in males as compared to females, which was statistically significant ($p < 0.05$). Lobular height and lobular breadth were higher in males and statistically significant ($p < 0.05$). Ear length and breadth, both in males and females, were higher on the right side, which was not statistically significant ($p > 0.05$). Face height and width were higher in males, which was statistically significant ($p < 0.05$).

Conclusions: Knowledge of normal auricular dimensions is important for ruling out congenital malformations, syndromes, and acquired deformities. This study has implications for cosmetic surgery, the correction of malformations, and the design of headphones, earphones, and hearing aids.

Keywords: External Ear, Anthropometry, Sexual dimorphism.

Introduction

The major concern of the forensic anthropologist is to identify people by estimating age, sex and height. Biometrics has been very important in helping with identification. Face, fingerprints, iris, gait, ear, voice, etc., are some of the personal characteristics of humans that can be used as biometrics¹

The external ear is one of the most distinctive features on an individual's face. Its look stays the same no matter how someone expresses their face.

The morphological features such as the shape of the ear, the shape of the earlobe, whether or not there's Darwin's tubercle, and more make each ear unique. Because of this, the ear is considered an important part of biometrics. The human ear is bigger than other biometric features like the iris, retina or fingerprints, so it's easy to see from a distance.²

The human ear could be studied because it has different shapes and sizes and also shows differences between the left and right sides, between males and females, and between different individuals.

The external part of the ear includes the pinna, the external acoustic meatus and the auditory canal³.

The part of the external ear, which is also called the pinna, is made up of three main parts³

1. The helix and antihelix complex
- 2.2. The conchal complex, and
- 3.3. The lobule.

In the floor of the concha, there is an opening called the external acoustic meatus. This opening is in front of a conical shape called the tragus. The tragus is separated from another elevation called the antitragus, which is located in a small indentation. The ear pinna is made up of yellow elastic cartilage, which gives it its distinctive shape. The ear lobule is just a fold of skin that contains

fibrous and fatty tissue. The ear pinna develops during the 4th and 6th weeks of gestation.³

The present study aims to describe the different measurements of the ear in a population from Gujarat. It also looks into differences between males and females, as well as asymmetry between the left and right ears in these measurements.

Materials and Methods

Study Design: An observational Analytical cross-sectional study.

Study Settings

- The sample for the present study comprised 120 first-year MBBS medical students of Shri M. P. Shah Government Medical College, Jamnagar, Gujarat, of whom 60 were females and 60 were males.
- The general information and basic details about the participant's demographics were collected using a questionnaire, and written consent was obtained first.
- The students with a previous history of any developmental defects of the pinna, abnormalities such as congenital anomalies, ear disease, ear trauma, maxillofacial deformity or ear surgery were excluded.

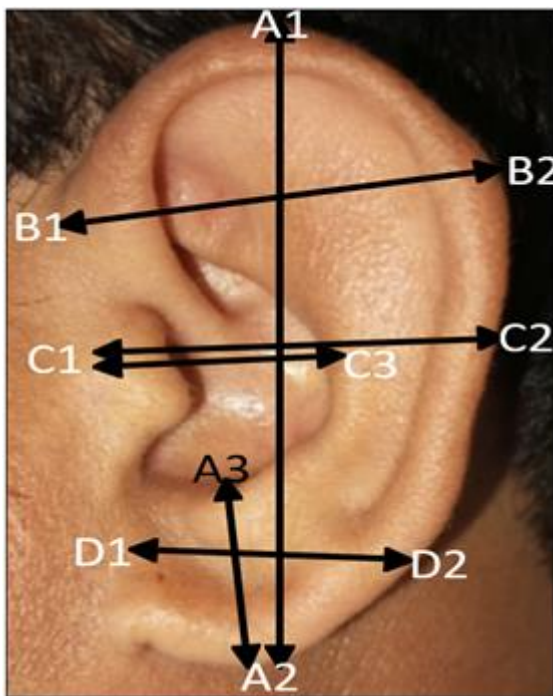
Anthropometric Measurements of the Ear

- Before placing markers on the human ear and measuring different parts of the ear, it's important to understand its different physical characteristics. The students, as participants, were asked to sit in a straight, relaxed position with their head aligned in the Frankfurt horizontal plane.
- The anthropometric landmarks were then identified on the students with careful inspection, and the same were marked with a pencil.
- The standardised anthropometric measurements of the ear were taken with precision and accuracy using sliding digital callipers. Seven measurements of the

human auricle were taken and recorded by one investigator (DR) on both ears to evaluate the bilateral differences in the study sample. For each ear measurement, the concurrent reading was obtained, and the mean values were calculated.

- The landmarks used and various measurements taken in the study were depicted in Figure 1.
- The linear measurements included physiognomic ear length, physiognomic ear breadth, ear length above tragus, distance from tragus to antihelix, distance from tragus to the helix, lobule height, and lobule width. All the measurements included in the present study were shown (Figure 1) and described as follows:

Figure 1: Reference points for various anthropometric measurements on the human ear:



A1-A2- Ear length; A3-A2- Lobular length; B1-B2- Ear breadth; C1-C2- Distance from tragus to helix; C1-C3- Distance from tragus to antihelix; D1-D2- lobular width.

Measurements & Definition

Anthropometric measurements and their definitions used in the study⁴:

Ear length (EL) = point from the uppermost part of the pinna to the point at the lower part of the lobule (A1-A2).

Ear breadth (EB) = Point taken from the root of the ear to the maximum convexity of the helix (B1-B2).

Distance from tragus to helix = Point from the highest part on the tragus to the point on the outer curvature of the helix (C1-C2).

Distance from tragus to antihelix = point from the highest part on the tragus to the point on the outer curvature of the antihelix (C1-C3).

Lobule height = The measurement starts from the lowest point where the outer ear attaches to the head and extends all the way to the outer edge of the earlobe (A4-A2).

Lobule breadth = The measurement starts from the lowest point where the earlobe attaches to the head and goes to the widest part of the earlobe from side to side (D1-D2).

□Furthermore, by using these measurements, the following indices were calculated⁴:

Auricular Index = Ear breadth / Ear length x 100

Lobular Index = Lobular width / Lobular length x 100.

Statistical Analysis

The collected anthropometric data were recorded in Microsoft Excel and analysed using Epi Info software. Descriptive statistics were used to calculate the Mean and Standard Deviation (SD) for all parameters. For the comparison of ear measurements and indices between males and females, the Independent (Unpaired) Student's t-test was applied. The Paired Student's t-test was utilised to compare the measurements between the right and left sides within the same individuals. A p-value of less than 0.05 ($p < 0.05$) was considered statistically significant for all comparisons.

Results

In the present study, ear parameters were studied in 120 participants: 60 males and 60 females. Each parameter was studied for anthropometric findings.

Selection Criteria of Participants

Inclusion Criteria

- The students studied in the first year of MBBS in Shri M.P. Shah Government Medical College, Jamnagar, Gujarat.

Exclusion Criteria

- Participants with a previous history of any developmental defects of the pinna, abnormalities such as congenital anomalies, ear disease, ear trauma, maxillofacial deformity, or ear surgery were excluded.

The normality of the data was determined using descriptive statistics; the mean and standard deviation (SD) of linear anthropometric measurements and indices of both ears for both sexes were shown in Table 1, Table 2 and Table 3:

Table 1: Different Anthropometric Ear Measurements (in centimetres) and Comparisons of the Results

Variable	Side	EAR (120)
		Mean $\pm$ SD
EL	Right	5.95 $\pm$ 0.47
	Left	5.95 $\pm$ 0.49
EB	Right	3.30 $\pm$ 0.30
	Left	3.22 $\pm$ 0.32
DfTtH	Right	3.08 $\pm$ 0.37
	Left	3.15 $\pm$ 0.30
DfTtAH	Right	2.19 $\pm$ 0.35
	Left	2.37 $\pm$ 2.01
LH	Right	1.88 $\pm$ 0.29
	Left	1.83 $\pm$ 0.27
LB	Right	2.13 $\pm$ 0.29
	Left	2.19 $\pm$ 0.29
FH	-	11.19 $\pm$ 0.81
FW	-	11.37 $\pm$ 0.74

EL = Ear Length ,EB = Ear breadth,DfTtH = Distance from Tragus to Helix,DfTtAH = Distance from Tragus to Anti-helix,LH = Lobular height,LB = Lobular breadth,FH = Face Height,FW = Face Width

Table 2: Different Anthropometric Right and Left Ear Measurements (in centimetres) and Comparisons of the Results in males and females.

Variable	Side	MALE (60)	FEMALE (60)
		Mean $\pm$ SD	Mean $\pm$ SD
EL	Right	6.16 $\pm$ 0.43	5.74 $\pm$ 0.43
	Left	6.155 $\pm$ 0.43	5.75 $\pm$ 0.47
EB	Right	3.40 $\pm$ 0.29	3.20 $\pm$ 0.27
	Left	3.34 $\pm$ 0.29	3.10 $\pm$ 0.31
DfTtH	Right	3.18 $\pm$ 0.32	2.99 $\pm$ 0.38
	Left	3.25 $\pm$ 0.25	3.05 $\pm$ 0.31
DfTtAH	Right	2.23 $\pm$ 0.36	2.14 $\pm$ 0.33
	Left	2.62 $\pm$ 2.82	2.12 $\pm$ 0.34
LH	Right	1.93 $\pm$ 0.33	1.82 $\pm$ 0.23
	Left	1.88 $\pm$ 0.28	1.77 $\pm$ 0.24
LB	Right	2.225 $\pm$ 0.29	2.03 $\pm$ 0.25
	Left	2.30 $\pm$ 0.30	2.07 $\pm$ 0.22
FH	-	11.49 $\pm$ 0.81	10.88 $\pm$ 0.69
FW	-	11.57 $\pm$ 0.73	11.17 $\pm$ 0.70

Table 3: Comparisons of the Indexes (in centimetres) in males and females and on both sides

Variable	Side	Male (60)	Female (60)
		Mean $\pm$ SD	Mean $\pm$ SD
Lobular Index	Right	118.51 $\pm$ 25.79	111.34 $\pm$ 14.80
	Left	121.80 $\pm$ 15. 70	115.98 $\pm$ 16.15
Auricular Index	Right	55.11 $\pm$ 5.013	54.80 $\pm$ 5.74
	Left	54.44 $\pm$ 4.63	53.85 $\pm$ 5.08

Discussion

In the present study, anthropometric measurements of the external ear showed clear evidence of sexual dimorphism among medical students. Ear length and ear breadth were greater in males than in females, and these differences were statistically significant ($p < 0.05$). Similar male predominance was also observed for lobular height and lobular breadth, both of which showed statistically significant differences between the sexes ($p < 0.05$). Face

height and face width were likewise higher in males than females, with statistically significant differences ($p < 0.05$). These findings support the usefulness of auricular and facial measurements in assessing sex-related anthropometric variation.

Comparison between the right and left sides showed that ear length and ear breadth were slightly higher on the right side in both males and females; however, this bilateral

difference was not statistically significant ($p > 0.05$). The auricular index was also higher in males than females, but the difference was not statistically significant ($p > 0.05$). In contrast, the lobular index was higher in males than females and showed statistical significance ($p < 0.05$). When side-to-side variation was considered, both auricular index and lobular index were higher on the left side in males and females; the difference was not significant for auricular index ($p > 0.05$), whereas lobular index showed a statistically significant difference ($p < 0.05$).

The findings of the present study were further compared with previous studies on external ear anthropometry. The observed values for ear length were comparable with those reported by Maitreyee M. et al.[6], Sidra Shireen et al.[7], Yadav Vishva Deepak et al.[8], Deepika Rani et al.[9], and Swati Patil et al.[10]. In most of these studies, males showed greater ear length than females, supporting the pattern observed in the present study. Similarly, ear

breadth values were broadly consistent with previous reports by Maitreyee M. et al.[6], Sidra Shireen et al.[7], Yadav Vishva Deepak et al.[8], Deepika Rani et al.[9], and Swati Patil et al.[10], although minor variations may be attributed to differences in sample size, age group, ethnicity, regional population characteristics, and measurement techniques.

The comparison of auricular and lobular indices also demonstrated findings similar to earlier studies. The auricular index in the present study was close to values reported by Maitreyee M. et al.[6], Yadav Vishva Deepak et al.[8], and Deepika Rani et al.[9]. The lobular index showed a pattern comparable to the observations of Yadav Vishva Deepak et al.[8] and Deepika Rani et al.[9]. Overall, the present study reinforces the role of external ear measurements and indices as useful anthropometric parameters for evaluating sexual dimorphism, forensic identification, reconstructive planning, and population-specific anatomical variation.

Table 4: Comparison of Ear length between different authors in both sexes:

Authors	Side	Ear Length (Male)	Ear Length (Female)
1. Sidra Siren et al. (2015) ⁷	Right	6.42 ± 0.61	6.34 ± 0.39
	Left	6.19 ± 0.44	6.14 ± 0.45
2. Maitreyee M. et al. (2018) ⁶	-	5.96 ± 0.43	5.60 ± 0.37
3. Swati Patil et al. (2018) ¹⁰	Right	5.99 ± 0.35	5.77 ± 0.29
	Left	5.83 ± 0.38	5.73 ± 0.30
4. Yadav Vishva Deepak et al. (2019) ⁸	Left	5.83 ± 0.38	5.73 ± 0.30
	Left	6.03 ± 0.54	5.48 ± 0.38
5. Deepika Rani et al. (2021) ⁹	Right	6.12 ± 0.36	5.79 ± 0.28
	Left	6.04 ± 0.34	5.76 ± 0.30
6. Present study	Right	6.16± 0.43	5.74 ± 0.43
	Left	6.15± 0.43	5.75 ± 0.47

Table 5: Comparison of Ear breadth between different authors in both sexes:

Authors	Side	Ear Breadth (Male)	Ear Breadth (Female)
1. Sidra Siren et al. (2015) ^[7]	Right	2.94 ± 0.28	2.79 ± 0.25
	Left	2.87 ± 0.49	2.74 ± 0.26
2. Maitreyee M. et al. (2018) ^[6]	-	3.18 ± 0.0.28	2.98 ± 0.36
3. Swati Patil et al. (2018) ^[10]	Right	2.88 ± 0.22	2.57 ± 0.25
	Left	2.88 ± 0.23	2.57 ± 0.24
4. Yadav Vishva Deepak et al. (2019) ^[8]	Right	3.24 ± 0.34	2.80 ± 0.37
	Left	3.09 ± 0.39	2.65 ± 0.36
5. Deepika Rani et al. (2021) ^[9]	Right	3.32 ± 0.23	3.04 ± 0.24
	Left	3.26 ± 0.22	3.05 ± 0.24
6. Present study	Right	3.40± 0.29	3.20 ± 0.27
	Left	3.34± 0.29	3.10 ± 0.31

Table 6: Comparison of Auricular index (AI) between different authors in both sexes:

Authors	Side	AI (Male)	AI (Female)
1. Maitreyee M. et al. (2018) ^[6]	-	53.6385	53.5056
2. Yadav Vishva Deepak et al. (2019) ^[8]	Right	50.39 ± 4.8	59.95 ± 6.35
	left	55.03 ± 4.82	45.17 ± 5.35
3. Deepika Rani et al. (2021) ^[9]	Right	54.45 ± 3.80	52.99 ± 4.15
	left	54.01 ± 3.79	52.66 ± 4.26
4. Present study	Right	55.11± 5.013	54.80 ± 5.74
	left	54.44± 4.63	53.85 ± 5.08

Table 7: Comparison of Lobular index (LI) between different authors in both sexes:

Authors	Side	LI (Male)	LI (Female)
1. Yadav Vishva Deepak et al. (2019) ^[8]	Right	122.35±16.92	107.51±19.34
	Left	106.15±15.59	109.3±18.6
2. Deepika Rani et al. (2021) ^[9]	Right	111.84 ± 17.25	106.61 ± 16.96
	Left	120.30 ± 15.68	108.62 ± 15.86
3. Present study	Right	118.51± 25.79	111.34 ± 14.80
	Left	121.80± 15. 70	115.98 ± 16.15

Conclusion

This study provides the mean values of different morphometric measurements of right and left ears in the

students of MPSGMC, Jamnagar. As a result, the present study has established the existence of sexual dimorphism in external ear dimensions and also the differences

between the auricular indices of both sides. The result shows that there is significant correlation between the ear variables.

Therefore, the use of ear dimensions in anthropometry for characterization of the differences in sex was highlighted in the present study.

Knowledge about the normal auricular dimensions is important in the diagnosis of congenital malformations, syndromes and acquired deformities, thus the study has implications in the reconstructive surgeries, cosmetic surgeries, forensic application, anthropometry, correction of malformations, designing of head phones, ear phones and hearing aids.

Declarations

Ethical Approval: Approved

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