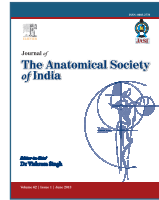




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Original article

Anthropometric measurements of external ear of medical students in Uttarakhand Region

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KEYWORDS

External ear, Anthropometry, Morphometric measurements, Ear lobule, Human auricle.

ABSTRACT

Objective: This study aimed at determining the mean values of the different morphometric measurements from right and left ears and at giving information about sex-related dimensions of ear, right–left symmetry, and age-related changes. **Methodology:** Measurements are taken from 177 healthy young medical students (84 women and 93 men) aged 17–25 years using a vernier calliper. The parameters measured were total ear height (TEH), ear width (EW), lobular height (LH), and lobular width (LW) for each subject's right and left ears. **Result and conclusion:** The mean values for TEH, EW, LH and LW, ear and lobular index in female subjects were found to be respectively 5.77 ± 0.38 cm, 2.87 ± 0.28 cm, 1.68 ± 0.21 cm, 1.95 ± 0.22 cm, 49.79 ± 4.75 cm, 116.86 ± 15.01 cm for left ear, and 0.74 ± 0.38 cm, 2.88 ± 0.22 cm, 1.67 ± 0.24 cm, 1.92 ± 0.21 cm, 50.26 ± 4.09 cm, 117.33 ± 19.28 cm for the right ear. However, in the male subjects, these values were, respectively, 6.03 ± 0.33 cm, 3.06 ± 0.25 cm, 1.69 ± 0.20 cm, 1.96 ± 0.23 cm, 50.75 ± 3.92 cm, 117.33 ± 16.70 cm for left ear, and 6.04 ± 0.36 cm, 3.02 ± 0.21 cm, 1.66 ± 0.20 cm, 1.96 ± 0.20 cm, 50.21 ± 3.88 cm, 119.07 ± 14.60 cm for the right ear. Comparisons were performed by independent t-test and paired samples t-test. All ear dimensions were significantly larger in males than in females ($p < 0.001$) and a significant effect of age was found.

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1. Introduction

Anthropometry refers to the measurement of living human body dimensions for the purpose of understanding human physical variation as it plays an important role in plastic surgery, prosthetics, and so on for data collection. Statistical data about the distribution of body dimensions in the population are useful for apparel sizing, forensics, and optimize products.

Many studies have defined human body parts and their proportions to each other morphometrically. In human, ear is the defining feature of the face and its structure shows the signs of age and sex. The human ear is divided into external,

middle, and internal parts. Pinna and external acoustic meatus form the external ear. The lateral surface of the pinna is irregularly concave, faces slightly forward and displays numerous eminences and depressions. These structures do not merely act as trumpet; they are the first of series of stimulus modifiers in the auditory apparatus.¹ The importance of anthropometric data was stressed by Abeysekera and Shahnavaaz when they stated that a piece of equipment designed to fit 90% of the male United State population would fit about 90% of Germans, 80% of Frenchmen, 65% of Italians, 45% of Japanese, 20% of Thais, and 10% of Vietnamese.² Roebuck et al noted that anthropometric data vary considerably for individuals within a family or a nation and between nations.³

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Similarly, Saha observed that there were differences in anthropometric data of people from different regions in India.⁴ Jung and Jung surveyed the dimensions and characteristics of Korean ears and found that age, gender, and different ethnic populations were determinants of ear dimensions.⁵

A study carried out in India observed that North-West Indians have smaller ear lobules when compared to Caucasian and Japanese populations but similar to those found among the Onge tribe of Andhra (India) and Newars of Nepal by Sharma et al.⁶

Since anthropometric data should be established for the user population as anthropometric data for Uttarakhand region is scant, the present study attempts to provide this anthropometric data for the ear. The study is intended to describe the anatomical height and width of ear and lobule amongst medical students (aged 17–25 years). From these data, it is envisaged that anatomical and morphological differences and changes of the ear in relation to age and sex in our population would be established.

2. Material and methods

2.1 Subjects

This study was carried out on 177 medical students of Government Medical College Haldwani, Uttarakhand, with no evidence of congenital ear anomalies or previous ear surgeries. The study cohort consisted of 84 females and 93 males, aged 17–25 years. The purpose of study was explained to them. Willingness and cooperation of the subjects to participate in the study were considered. Clearance of institutional ethical committee was obtained before starting the work.

2.2 Anthropometric measurements

Bilateral sizes of auricles were measured. Standardized measurements of the ear pinna were taken according to the landmarked points defined by De Carlo et al⁷ and the methodology was adopted from McKinney et al⁸ and Brucker et al.⁹ The parameters measured were total ear height (TEH), ear width (EW), lobular height (LH), and lobular width (LW) for each subject's right and left ears, when the head was in the Frankfort horizontal plane. Figure 1 shows the measurement of ear reference points used for anthropometric measurements. The TEH was measured as the distance from the most inferior projection of the ear lobule (L) to the most superior projection of the helix (H). The EW is measured as the distance between the most anterior (A) and posterior (P) points of the ear. The LH was taken as the distance from the most inferior end of the lobule (L) to the base of the tragal notch (T). The LW was measured as the transverse or horizontal width of the lobule (C–D). Figure 2 shows the measurement of ear by a vernier calliper.

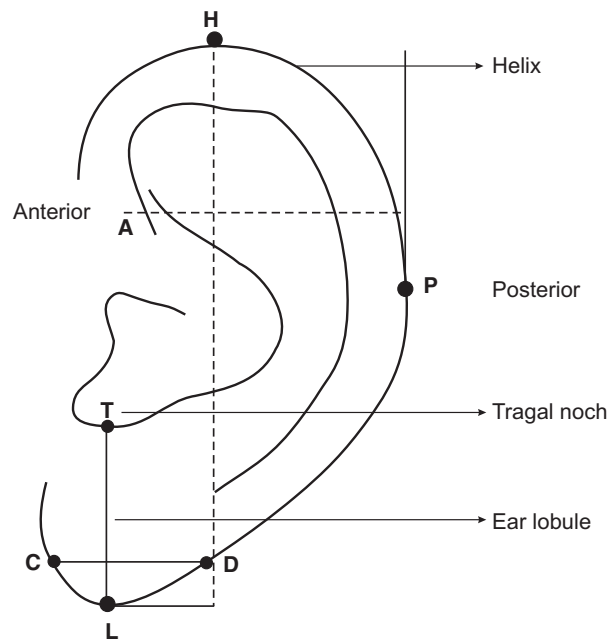


Fig. 1 – Reference points used for anthropometric measurements of ear (total ear height = L–H, ear width = A–P, lobular height = L–T, lobular width = C–D).

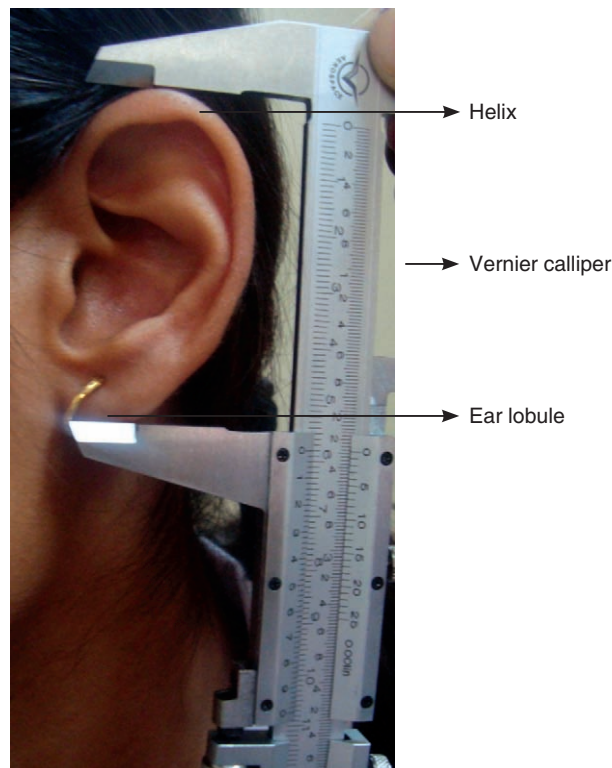


Fig. 2 – The measurement of ear by a vernier calliper (total ear height).

Additionally, indices defining the proportions of the ear such as ear index (ear width/ear height \times 100) and lobule index (lobule width/lobule height \times 100) were calculated.

All the measurements were taken by a single investigator using standard vernier callipers capable of measuring to the

nearest 0.1 mm. For each subject, the measurements were carried out twice to ascertain accuracy and the arithmetical mean of the two measurements was used for each dimension. Secondly, all the measurements were carried out by the same investigator in order to minimize bias and error of identification of the parts of the ear pinna involved in the measurements.

The numerical data were analyzed using a Statistical Package for Social Sciences Version (SPSS) 20.0. Comparisons of the measurements according to gender were performed using an independent samples t-test. Comparison of measurements taken from the right and left ears of a given sex was performed using a paired samples t-test.

3. Results

The measurements and comparison of results for the right and left ears according to age group subjects who participated in the study are shown in Table 1. The mean of TEH, EW, LH, and LW were found to be increasing with advancing age in both the sexes.

According to Table 2, all parameter values are more in left ear than right but not significant statistically. Although all the measurements were higher more in males than in females on both sides, TEH and EW were found to be significantly greater ($p < 0.001$) (Table 3).

The left ear indices were found to be higher than the right ones for all the subjects but in female subjects, the right indices were found to be greater than the left ones. No significant difference was found in the ear index of males and females. The right lobular indices were found to be higher than the left ones for all the subjects (Table 2).

4. Discussion

The TEH is important in the evaluation of congenital anomalies (Down syndrome).^{10,11} The ear reaches its mature height at 13 years in males and at 12 years in females.¹² McKinney et al study addressed specifically the treatment of the ear and earlobe in esthetic surgery and obtained data from 100 normal volunteers and found a mean ear height of 6.50 cm and a mean LH of 1.80 cm, with no significant correlation between

Table 1 – Different morphometric ear measurements in relation to age.

Measurements		Age group (n)		
		17–19 years (104)	20–22 years (61)	23–25 years (12)
		Mean ± SD	Mean ± SD	Mean ± SD
Right ear	TEH (cm)	5.83 ± 0.42	5.97 ± 0.35	6.10 ± 0.35
	EW (cm)	2.94 ± 0.23	2.96 ± 0.22	3.12 ± 0.22
	LH (cm)	1.64 ± 0.23	1.69 ± 0.21	1.71 ± 0.26
	LW (cm)	1.92 ± 0.18	1.97 ± 0.22	1.99 ± 0.26
Left ear	TEH (cm)	5.83 ± 0.40	5.96 ± 0.33	6.20 ± 0.24
	EW (cm)	2.93 ± 0.26	2.99 ± 0.31	3.14 ± 0.24
	LH (cm)	1.67 ± 0.21	1.71 ± 0.18	1.74 ± 0.28
	LW (cm)	1.95 ± 0.22	1.95 ± 0.23	1.99 ± 0.28

SD: Standard deviation; TEH: Total ear height; EW: Ear width; LH: Lobular height; LW: Lobular width.

Table 2 – Right and left ear measurements and comparison of the results.

Measurements		Males (n = 93)		Females (n = 84)		Combined (n = 177)	
		Mean ± SD	p value	Mean ± SD	p value	Mean ± SD	p value
Ear height	Right	6.04 ± 0.36	0.681	5.74 ± 0.38	0.307	5.90 ± 0.40	0.645
	Left	6.03 ± 0.33		5.77 ± 0.38		5.91 ± 0.38	
Ear width	Right	3.02 ± 0.21	0.098	2.88 ± 0.22	0.595	2.95 ± 0.23	0.489
	Left	3.06 ± 0.25		2.87 ± 0.28		2.97 ± 0.28	
Lobule height	Right	1.67 ± 0.20	0.040	1.66 ± 0.24	0.375	1.66 ± 0.22	0.042
	Left	1.69 ± 0.20		1.68 ± 0.21		1.69 ± 0.21	
Lobule width	Right	1.96 ± 0.20	0.671	1.92 ± 0.21	0.325	1.94 ± 0.21	0.294
	Left	1.96 ± 0.23		1.95 ± 0.22		1.96 ± 0.23	
Ear index	Right	50.21 ± 3.88	0.135	50.26 ± 4.09	0.355	50.23 ± 3.97	0.840
	Left	50.75 ± 3.92		49.79 ± 4.75		50.30 ± 4.35	
Lobule index	Right	119.07 ± 14.60	0.269	117.33 ± 19.28	0.831	118.25 ± 16.95	0.391
	Left	117.33 ± 16.70		116.86 ± 15.01		117.11 ± 15.87	

p-value calculated using paired samples t-test.
SD: Standard deviation.

Table 3 – Comparison of the measurements according to gender (n = 177).

Measurements	Male (n = 93)	Female (n = 84)	p value
	mean ± SD	mean ± SD	
Right ear height	6.04 ± 0.36	5.74 ± 0.38	0.000
Right ear width	3.02 ± 0.21	2.88 ± 0.22	0.000
Right lobule height	1.67 ± 0.20	1.66 ± 0.24	0.850
Right lobule width	1.96 ± 0.20	1.92 ± 0.21	0.269
Right ear index	50.21 ± 3.88	50.26 ± 4.09	0.934
Right lobule index	119.07 ± 14.60	117.33 ± 19.28	0.476
Left ear height	6.03 ± 0.33	5.77 ± 0.38	0.000
Left ear width	3.06 ± 0.25	2.87 ± 0.28	0.000
Left lobule height	1.69 ± 0.20	1.68 ± 0.21	0.792
Left lobule width	1.96 ± 0.23	1.95 ± 0.22	0.645
Left ear index	50.75 ± 3.92	49.79 ± 4.75	0.141
Left lobule index	117.33 ± 16.70	116.86 ± 15.01	0.906

p-value calculated using independent samples t-test.
SD: Standard deviation.

the earlobe height and aging.⁸ In a study consisting of North American whites, it was observed that the total height of the left ear was 62.4 mm in men and 58.5 mm in women, and that the same measurement was 70.1 mm in Japanese people.¹³

In the study of Bozkir et al, the height of the left ear was found to be 63.1 mm in men and 59.7 mm in women.¹⁴ Brucker et al on their morphometric study of the external ear, age- and sex-related differences, obtained a mean TEH of 6.30 cm.⁹ In our study, the TEH of left ear is 6.03 cm in males and 5.77 cm in females which is increasing with age and found to be significantly ($p < 0.001$) higher in males. These studies show that the mean height of the external ear in males is higher than that in females in various population and age groups and support our study. Also according to the study by Barut and Aktunc, the mean height of the ears on both sides was significantly higher in males than in females.¹⁵

Among the craniofacial syndromes, disproportionately wide ears are observed mostly in Apert and Crouzon syndromes and narrow ears mostly in cleft lip and palate patients. The mature width of the ear is achieved in males at 7 years and in females at 6 years.¹⁰ A study consisting of 100 males and 100 females found the EW to be 32.4 mm for the left ear and 33 mm for the right ear in men, and to be 31.9 mm for the left ear and 32.4 mm for the right ear in women.¹⁶ However, DellaCroce et al reported the EW to be 30.5 mm.¹⁷ The results of Bozkir et al showed 33.3 mm for the left ear and 33.1 mm for the right ear of 191 young men, as compared with 31.3 mm for the left ear and 31.2 mm for the right ear of 150 young women.¹⁴ In our study, the EW in males for the right ear is 3.02 cm and left ear is 3.06 cm and in females, for the right ear is 2.88 cm and left ear is 2.87 cm. When our results are compared with literature findings, more or less same values of EW are found. In our study, a statistically significant difference is found in the mean width of ear in males and females and it is higher in males ($p < 0.001$). Kalcioğlu et al found no statistically significant differences in the mean width of ears between males and females from 15 to 19 dif-

ferent age groups.¹⁸ Farkas et al found that male subjects had wider ears than those of female subjects, but did not mention any statistical significance.¹⁰

An acquired deformity that develops with aging may include elongation or ptosis of the ear lobe. This condition has been attributed to the loss of elastic fibers and gravitational forces.¹⁹ Earrings are an additional weight on the ears, and they therefore affect ear lobe height.²⁰ Brucker et al observed an average LH to be 1.88 cm and an increase in LH for both sexes.⁹ The measurement found in the study of Bozkir et al was 1.8 cm in young men and 1.7 cm in young women.¹⁴ The LH in our study is 1.69 cm in young men and 1.68 cm in young women. The values are more in males and increase with age. We also explained that the increase in the LH with age is not due to the weight effect of earrings since the majority of the women and none of the men had pierced earlobes in our cohort. These measurements suggest that the lengthening of the ear lobe is likely to be the result of the aging process. In esthetic earlobe reconstruction, the primary aim is to achieve a more youthful appearance.⁹ Therefore, our study group consisted of young adults.

In the analysis of data with regard to sex of the volunteers, it was observed that the ear lobe size did not vary significantly between the men and women.²¹ Brucker et al reported the ear lobe width to be 1.95 cm in men and 1.97 cm in women, and observed that in men, the LH and LW remain nearly identical to those in women and with increasing age, the TEH and LH increase, while the LW decreases.⁹ Whereas in the study of youthful population of Turks by Bozkir et al, these measurements were found to be 1.94 cm in men and 1.85 cm in women.¹⁴ The study by Purkait and Singh on the age group 18–70 years measured the length and width of auricle and lobule to calculate auricular and lobular indices and they found a steady increase in size with age.²² Sharma et al studied on age group 1–80 years in the north-west region of India on ear lobule and observed that the maximum length of the lobule increased appreciably between 6–15 years and 41–80 years.⁶ The breadth of ear lobule increased up to the age of 15 years,

almost static between 16 years and 40 years, increased again from 41 years onward. In our study, LW is 1.96 cm in males and 1.95 cm in females and supports other's studies.

Ferrario et al found that the ear indices of both sides in males were significantly higher than those in females.²³ Barut and Aktunc observed insignificantly higher right ear indices and significantly higher left ear indices in males than in females.¹⁵ In this study, no statistical difference was found in the ear index and lobular index of males and females although the left ear indices were found to be higher than the right ear indices for all the subjects.

When we compare our study with those of others, we find that there is a difference in the values of ear measurement, and these discrepancies could be a result of factors such as race, genetic variables, individual constitution, environment, age, and human error. With regard to the sex difference showed the TEH and EW were significantly higher in men as compared to other measurements.

5. Conclusion

Knowledge about the normal ear dimensions is important in the diagnosis of congenital malformations, syndromes, and acquired deformities, as well as in the planning of treatments and hearing instruments' industry. This study provides the mean values of the different morphometric measurements of the left and right ears in the medical student of the Kumaon region of Uttarakhand. As a result, the data presented in this study have yielded parameters for ear morphology that would prove useful in determining ear anomalies and variations, and may help plastic surgeons to reproduce an anatomically correct ear during its reconstruction. It gives new ear measurements for Uttarakhand population.

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