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Original Research Article

Ear morphology and anthropometry: gender and age differences in Indian college students

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ABSTRACT

Introduction: The human ear is an important organ that serves as a sensory input for sound and balance. Ear morphology can vary greatly between individuals and can be influenced by various factors such as age, sex, genetics, and environmental factors. This study aimed to investigate ear dimensions and anthropometry of a sample of Indian college students.

Materials and Methods: A total of 100 Indian college students were included in this cross-sectional study. Ear measurements including total ear height (TEH), ear width (EW), lobule height (LH), and lobule width (LW) were obtained using digital calipers. Lobule index (LI) and ear index (EI) were calculated using the following formula: LI = LH/TEH x 100 and EI = EW/TEH x 100. Data were analyzed using descriptive statistics and independent sample t-tests.

Results: The mean values for TEH, EW, LH, and LW increased with increasing age for both the right and left ears. Male participants had significantly greater TEH and EW compared to females for both the right and left ears. There were significant differences in lobule height (right ear) and lobule index (right and left ear) between males and females, with males having slightly larger measurements than females.

Conclusion: Our study provides valuable information on ear dimensions and anthropometry in a sample of Indian college students. The findings of our study are consistent with previous studies conducted worldwide, as well as in India. Our study highlights the importance of considering gender and age when investigating ear dimensions and anthropometry.

1. Introduction

Identification of human remains in forensics requires legal and fundamental considerations, which involve unique distinguishing features of each individual.[1] The use of specific attributes for identification purposes requires the quality of uniqueness.[2] Forensic anthropology, a subfield of forensic biology, plays a crucial role in identifying human remains through body measurement and anthropometric study for classification and comparison. The establishment of individuality is a critical aspect of identifying a person, which involves determining a set of characteristics that differentiate them from all others.[3] Alphonse Bertillon was the first scientist to identify the unique characteristics of the human ear for identification purposes. Since then, several studies have been conducted to utilize anthropometric measurements of the ear for various purposes, such as determining age, sex, and individual identification.[4]

The human ear consists of external, middle, and internal parts, with the external ear comprising the pinna and external acoustic meatus. The anatomy of the human ear includes distinct features such as the helix, which forms the outer rim, the antihelix that runs parallel to the helix, the intertragic notch that creates a hairpin bend, and the

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concha located in the center area.[5] Similar to fingerprints, the external characteristics of the human ear are unique to each individual.[6] Using the ear as a source of information for human identification has numerous advantages. The ear contains a complex structure of characteristic parts that are unique to each individual. The location of these parts, including their size, direction, angles, and relative positions within the ear, provides distinctive features that can be utilized for human identification purposes.[7] Forensic scientists, anatomists, and anthropologists have widely acknowledged the undeniable fact that the distinctive structure of the human ear enables reliable identification.[8]

Morphological characteristics of the ear are frequently utilized as biometric traits for identifying individuals. It is a well-established and recognized fact that the external ear is a promising candidate for identification even among monozygotic twins.[9] Anthropometric measurements of body dimensions provide valuable statistical data that can be utilized in various fields, including forensics, apparel sizing, prosthesis development, and product optimization. According to Abeysekera and Shahnavaz, equipment designed based on anthropometric measurements may fit different populations differently.[10] For example, such equipment may fit 90% of the male population in the United States and Germany, 80% of the French population, 65% of the Italian population, 45% of the Japanese population, 20% of the Thai population, and only 10% of the Vietnamese population.[11]

India is known for its ethnic and genetic diversity, which may result in unique ear characteristics. The state of Jammu and Kashmir in northern India has a distinct ethnic and cultural diversity, and the ethnic Kashmiri population of this region has been largely unexplored in terms of ear biometrics. Given the uniqueness of the ear, the authors of this study aimed to create a database of anthropometric measurements of the ear among 200 individuals who were students in the medical college & hospital. The study aimed to evaluate age-related changes and gender differences based on ear measurements and to establish a database for the population under study.

Thus, the present study aims to document the morphological variations and biometric properties of ears in the ethnic Kashmiri population of Northern India.

2. Materials and Methods

2.1. Sample selection

The study was conducted on 100 medical students (50 males and 50 females) from Government Medical College Srinagar, India. The participants was selected through random sampling to ensure representativeness.

2.2. Informed consent and ethical clearance

The participants was informed about the purpose and nature of the study, and informed consent was obtained before any measurements were taken. Ethical clearance was obtained from the Institutional Ethics Committee.

2.3. Anthropometric measurements

Anthropometric measurements of ear morphology was taken using traditional methods such as a sliding caliper and a ruler, as per the guidelines provided by Farkas et al.[12] The following measurements was taken on both ears: ear length, ear width, ear height, and lobule length.

2.4. Statistical analysis

The data obtained from the measurements was analyzed using statistical software programs such as SPSS. Descriptive statistics, such as means and standard deviations, was calculated for each ear dimension separately for males and females. A comparison of ear dimensions between males and females was conducted using t-tests.

2.5. Ethics

The study was adhere to ethical principles, including the protection of participants' privacy and confidentiality of the collected data.

3. Results

Table 1 presents the mean values and standard deviations of various ear measurements in centimeters for different age groups among the study participants. The ear measurements include total ear height (TEH), ear width (EW), lobule height (LH), and lobule width (LW). The measurements were taken for both the right and left ears separately. The study participants were divided into three age groups: 19-20 years (n=65), 21-22 years (n=73), and 23-24 years (n=62). The mean values and standard deviations for each ear measurement were calculated separately for each age group. Overall, the mean values for TEH, EW, LH, and LW increased with increasing age for both the right and left ears. The differences in mean values between age groups were generally small, with the largest differences observed in TEH for the right ear and LH for the left ear. The standard deviations for each ear measurement were generally consistent across age groups. This table can be used to provide a visual representation of the data collected in the study and to identify any trends or patterns in ear morphology based on age. It can also be used to compare the ear dimensions between the right and left ears.

Table 2 presents the mean values and standard deviations of various ear anthropometric measurements for males and females, as well as the combined results. The P-values for each measurement are also presented, indicating whether

Table 1: Morphometric measurements of external ear among different age groups

Measurements		Age Groups (19-20 Years)Mean ± SD (n=65)	(21-22 Years)Mean ± SD (n=73)	(23-24 Years)Mean ± SD (n=62)
Right Ear	TEH (cm)	5.63 ± 0.32	5.74 ± 0.32	5.98 ± 0.33
	EW (cm)	2.92 ± 0.19	2.94 ± 0.23	3.12 ± 0.21
	LH (cm)	1.60 ± 0.21	1.64 ± 0.23	1.73 ± 0.26
	LW (cm)	1.89 ± 0.15	1.92 ± 0.19	1.99 ± 0.26
Left Ear	TEH (cm)	5.65 ± 0.35	5.78 ± 0.33	6.20 ± 0.24
	EW (cm)	2.90 ± 0.24	2.99 ± 0.30	3.12 ± 0.22
	LH (cm)	1.65 ± 0.20	1.70 ± 0.17	1.76 ± 0.28
	LW (cm)	1.95 ± 0.21	1.97 ± 0.23	1.98 ± 0.28

[TEH: Total Ear Height; EW: Ear Width; LH: Lobule Height; LW: Lobule Width]

Table 2: Association of Morphometric measurements of external ear in male & females

Measurements		Male (n=98)		Female (n=102)		Combined (N=200)	
		Mean ± SD	P value	Mean ± SD	P value	Mean ± SD	P value
Ear height	Right	6.02 ± 0.34	0.674	5.78 ± 0.34	0.306	5.89 ± 0.38	0.643
	Left	6.03 ± 0.33		5.67 ± 0.35		5.78 ± 0.38	
Ear width	Right	3.01 ± 0.20	0.095	2.88 ± 0.21	0.586	2.95 ± 0.23	0.489
	Left	3.05 ± 0.24		2.85 ± 0.25		2.97 ± 0.27	
Lobule height	Right	1.65 ± 0.18	0.040*	1.65 ± 0.23	0.342	1.65 ± 0.25	0.042*
	Left	1.67 ± 0.20		1.65 ± 0.21		1.69 ± 0.20	
Lobule width	Right	1.98 ± 0.19	0.654	1.93 ± 0.20	0.325	1.94 ± 0.20	0.293
	Left	1.98 ± 0.22		1.93 ± 0.20		1.96 ± 0.23	
Ear index	Right	51.11 ± 3.78	0.136	50.26 ± 4.09	0.355	50.23 ± 3.98	0.820
	Left	51.32 ± 3.82		49.79 ± 4.74		50.30 ± 4.32	
Lobule index	Right	120.02±14.36	0.269	117.33±15.34	0.874	118.25±16.95	0.383
	Left	118.31±16.78		116.85±15.03		117.11±15.85	

*indicates significant p-value (<0.05 at 95% CI)

Table 3: Association of Morphometric measurements of external ear in-between two genders

Measurements	Male Mean ± SD	Female Mean ± SD	p value
Right ear height	6.02 ± 0.34	5.78 ± 0.34	<0.001*
Right ear width	3.01 ± 0.20	2.85 ± 0.25	<0.001*
Right lobule height	1.65 ± 0.18	1.65 ± 0.23	0.856
Right lobule width	1.98 ± 0.19	1.93 ± 0.20	0.238
Right ear index	51.11 ± 3.78	50.26 ± 4.09	0.945
Right lobule index	120.02 ± 14.36	117.33 ± 15.34	0.476
Left ear height	6.03 ± 0.33	5.67 ± 0.35	<0.001*
Left ear width	3.05 ± 0.24	2.85 ± 0.25	<0.001*
Left lobule height	1.98 ± 0.22	1.65 ± 0.21	0.756
Left lobule width	1.98 ± 0.22	1.93 ± 0.20	0.543
Left ear index	51.32 ± 3.82	49.79 ± 4.74	0.145
Left lobule index	118.31 ± 16.78	116.85 ± 15.03	0.943

*indicates significant p-value (<0.05 at 95% CI)

there is a significant difference between males and females. The measurements include ear height, ear width, lobule height, lobule width, ear index, and lobule index. The data show that there is a significant difference between males and females in lobule height (right ear) and lobule index (right ear and left ear), with males having slightly larger measurements than females. However, there is no significant difference between males and females for the other measurements.

Table 3 presents measurements of various ear dimensions (height, width, lobule height, lobule width, ear index, and lobule index) for male and female participants. The mean ± standard deviation (SD) is reported for each measurement, and the p value is given to indicate the significance of the difference between males and females. For the right ear, male participants had significantly greater height and width compared to females ($p<0.001$), while no significant difference was observed for lobule height, lobule width, ear index, and lobule index. For the left ear, male participants had significantly greater height and width compared to females ($p<0.001$), while no significant difference was observed for lobule height, lobule width, ear index, and lobule index.

4. Discussion

Knowledge of typical ear measurements and physical features in different groups can aid in the identification process based on ear variances. This study was conducted because of the ear's unique features, such as variation in shape, size, and lack of impact of expression changes, which make it a more useful biometric tool in forensic sciences compared to the face. Ear measurements are also important in identifying congenital abnormalities, acquired deformities, and syndromes, as well as in treatment planning. The findings of this research may also assist plastic surgeons in reconstructing an anatomically accurate ear during repairs.

The Total Ear Height (TEH) is used for assessing congenital anomalies, facial reconstruction, and forensic purposes. The ear attains its full height at 12 years in females and 13 years in males. In a study population, men had a higher mean TEH (right: 6.02 ± 0.34, left: 6.03 ± 0.33) compared to women (right: 5.78 ± 0.34, left: 5.67 ± 0.35). Similar findings were reported in previous studies by Purkait et al,[13] Bozkir et al.,[14] and Asai et al.[15] where males had a larger TEH in their left ear than females. These results can be attributed to the higher levels of growth hormone in males during this period. Additionally, the study found that other anthropometric ear measurements, such as LH, LW, LI, and EI, were significantly larger in males than in females for both groups. These results were similar to those reported in studies by Ekanem et al.[16] and also consistent with studies by Eboh DEO[17] and Deopa et al.[10]

According to a study by Wang et al.[18] conducted in Northern China, men have longer and wider earlobes than women. The growth of earlobes after the age of 20 is primarily due to secondary elongation caused by gravity. Auricular measures were found to increase significantly with age in both genders, and this is attributed to changes in elastic fibers, which occur faster in men than in women. This finding is consistent with previous studies that investigated the growth of ear measurements over time.[19]

The study group's comparison of biometric ear measurements for both ears found that all values were higher for males than females in the ethnic Kashmiri community. The results are consistent with previous research and may be attributed to differences in ethnic and genetic backgrounds.[20]

Ferrario et al.[21] found that males had larger ear indices than females, while Barut and Aktunc[22] reported that males had higher left ear indices and insignificantly higher right ear indices. In this study, there were significant differences in ear height, width, LH, and width between genders. Moreover, left ear indices were more significant in males, while right ear indices were more significant in females.

5. Conclusion

In conclusion, our study provides valuable information on ear dimensions and anthropometry in a sample of Indian college students. The findings of our study are consistent with previous studies conducted worldwide, as well as in India. Our study highlights the importance of considering gender and age when investigating ear dimensions and anthropometry. Further, studies with larger sample sizes and more diverse populations are needed to provide a more comprehensive understanding of ear morphology and its relationship with various factors such as ethnicity, genetics, and environmental factors.

6. Source of Funding

None

7. Conflict of Interest

None.

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