RESEARCH ARTICLE

The effects of ethnic origin and gender dimorphism on auricular morphometry: A cross-sectional study

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Abstract

Objective: To analyse the auricular in terms of ethnicity and gender by morphometric measurements.

Method: The cross-sectional study was conducted at Sakarya University, Sakarya, Turkiye, from January 2022 and January 2023, and comprised students of Turkish and African descent. Isolated ear photographs of the subject were analysed using the ruler software, and anatomical measurements, such as ear length, length of the ear above and below the tragus, ear width, concha length, and the distance between otobasion superior and otobasion inferior, were noted. Data was analysed using SPSS 26 software.

Results: Of the 68 subjects, 34(50%) were Turkish with mean age 20.37±3.1 years, while 34(50%) were of Africans with mean age 20.19±3.2 years. Both the groups had an equal number of male and female participants. Gender-based differences among Turkish participants were significant, with Turkish males exhibiting higher values than females ($p<0.05$). The gender-based differences were not significant among African subjects ($p>0.05$). Significant differences were found between the groups in terms of tragus-to-ear length, tragus-to-lobe length, tragus height, and the distance between otobasion superior and otobasion inferior ($p<0.05$).

Conclusion: Auricular anthropometry exhibited significant variations based on gender and ethnicity.

Keywords: Anthropometry, Auricula, Ear measurements, Gender differences, Morphometry. (JPMA 76: 520; 2026)

DOI: https://doi.org/10.47391/JPMA.22143

Introduction

The human ear is a complex anatomical structure that exhibits considerable variability among individuals, contributing significantly to facial recognition processes. Ear anthropometry serves as a crucial method for analysing these variations across different populations and genders. Recent studies have demonstrated that auricular dimensions not only vary with age and gender, but also show distinct morphometric patterns across different ethnic groups, providing insights into both clinical and forensic applications.[1,2] The auricula (pinna) holds great significance for personal identification and aesthetic evaluations.[3,4] Research indicates that ear measurements are influenced by genetic, environmental and ethnic factors. For instance, a recent three-dimensional (3D) morphometric study demonstrated significant gender dimorphism and population-based variability in ear and facial features throughout life.[5] Another study comparing auricular parameters between Egyptians and Malaysians indicated that auricular parameters are valuable tools for distinguishing between the ethnic groups.[6] Similarly, significant differences in auricular dimensions have been observed between Indian and Nepalese students.[7] Furthermore, studies have also identified significant differences in ear morphometric measurements between genders and between the right and left ears.[8-10] Additionally, research suggests that the auricula carries age-related information.[11]

The current study was planned to analyse the auricular in terms of ethnicity and gender by morphometric measurements.

Subjects and Methods

Approved by the Sakarya University Faculty of Medicine Non-Interventional Ethics Committee (Ref: E-71522473-050.01.04-64774-456), the cross-sectional study was conducted at Sakarya University, Sakarya, Türkiye, between January 2022 and January 2023, and comprised students of Turkish and African descent. Using G*Power 3.1,[12] the sample size was determined based on a medium effect size (d=0.5), alpha level 0.05, and statistical power 80%. The minimum required number of participants per group was 34, resulting in a total of 136 (right and left) ear measurements. The sample was raised using purposive sampling method, aiming for equal gender and ethnic representation. Those included were students of the Faculty of Dentistry aged 18-30 years who had no history of craniofacial trauma or congenital ear deformities, and belonged to self-identified Turkish or African ethnicity for at least two generations. Those excluded were students having prior ear surgery or significant trauma, those with mixed ethnicity or unclear ethnic background, and those

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Submission completed: 18-10-2024 **1st Revision received:** 18-02-2025
Acceptance: 20-12-2025 **Last Revision received:** 19-12-2025

having any dermatological condition or anomaly affecting the external ear.

After taking informed consent from all the subjects, data was collected using a predesigned data collection form through one-on-one interviews while adhering to social distancing rules in the wake of the coronavirus disease-2019 (COVID-19).

Subsequently, an investigator took isolated ear photographs of the participants. All photographs were taken in the same setting (Frankfurt plane, with a fixed seating area, and consistent distance). A digital camera mounted on a tripod was used to capture lateral views of the ears from a distance of 100cm between the participant and the camera lens.

The ear photographs were taken in isolation without including the participants' facial profiles, and were numbered and uploaded onto the Marcus Bader-Ruler (MB-Ruler) software, a photo analysis programme that calculates distances between marked points on images. This minimised the time the participants had to spend in the study. Auricular anthropometric measurements were completed by calculating the distances between 10 anatomical landmark points (Figure). The anatomical landmark points included superaurale (Sa), which was the highest point of the auricula, subaurale (Sba), which was the lowest point of the auricula, postaurale (Pa), which was the outermost point of the auricula's posterior curve, preaurale (Pra), which was the anterior edge of the auricula at the level of the helix attachment, tragus (T), otobasion superior (Obs), otobasion inferior (Obi), anterior cymba cancha (C), incisura intertragica (Int), and the most posterior point of the earlobe (H). Distances between these points were measured to calculate anthropometric measurements of the auricula bilaterally. The distance between Sba and Sa indicated total ear length, the distance between Sa and T indicated tragus-above ear length, the distance between T and Sba indicated tragus-below ear length, Distance between T and Int was taken as the tragus height, the distance between Pa and Pra was taken as the ear width, concha length was the distance between C and Int, concha width was the distance between Ant and T, lobulus auricula height was the distance between Sba and Obi, lobulus auricula width was the distance between H and Obi, and otobasion superior-otobasion inferior distance was the distance between Obs and Obi.

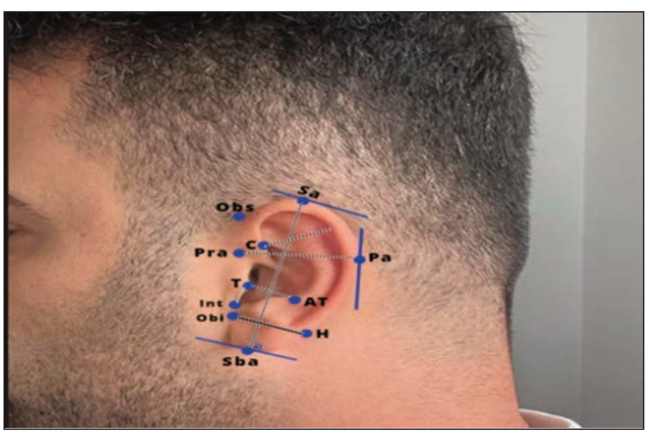

Figure: An auricula image taken in the lateral position/Frankfurt plane, demonstrating measurement Of Auricula landmark points, including Superaurale (Sa), Subaurale (Sba), Postaurale (Pa), Preaurale (Pra), Tragus (T), Otobasion superior (Obs), Otobasion inferior (Obi), Anterior cymba cancha (C), Incisura intertragica (Int), the most posterior point of the earlobe (H), Right auricula (R) and Left auricula (L).

Data was analysed using SPSS 26. Data was expressed as frequencies and percentages or as mean±standard deviation, as appropriate. Independent sample t-tests was used to compare the ear measurements between the two ethnic groups. P<0.05 was taken as statistically significant.

Results

Of the 68 subjects, 34(50%) were Turkish with mean age 20.37±3.1 years, while 34(50%) were of Africans with mean age 20.19±3.2 years. Both the groups had an equal number of male and female participants.

There were significant differences in the measurements of total ear length, tragus-below ear length, tragus height and lobulus auricula height for both the right and left ears ($p<0.05$) (Table 1).

Gender-based comparison revealed significant differences for the right ear in the measurements total ear length, tragus-above ear length, tragus-below ear length, ear width, lobulus auricula width, and otobasion superior-

Table-1: Right and left auricula comparison in terms of ethnic origin.

	Ethnic Origin	Mean±SD	Std. Error Mean	*p*-value
R_Sba_Sa	Turkish	59.76576±4.309818	0.739128	*0,032
	African	61.93935±3.856152	0.661325	
R_T_Sba	Turkish	25.15497±2.752076	0.471977	*0,005
	African	26.86947±2.000148	0.343023	
R_T_Int	Turkish	7.80126±1.103850	0.189309	*0,015
	African	8.24965±1.421281	0.243748	
R_Sba_Obi	Turkish	11.08618±2.897196	0.496865	*0,024
	African	12.55426±2.288554	0.392484	
L_Sba_Sa	Turkish	59.77559±5.558593	0.953291	*0,016
	African	62.53668±3.400685	0.583213	
L_T_Sba	Turkish	25.10047±2.781886	0.477089	*0,003
	African	26.94094±1.992438	0.341700	
L_T_Int	Turkish	7.64609±1.110670	0.190478	*0,003
	African	8.41762±0.904417	0.155106	
L_Sba_Obi	Turkish	11.05300±3.385591	0.580624	*0,046
	African	12.38185±2.391804	0.410191	

Sa: Superaurale, Sba: Subaurale, Pa: Postaurale, Pra: Preaurale, T: Tragus, Obs: Otobasion superior, Obi: Otobasion inferior, C: Anterior cymba cancha, Int: Incisura intertragica, H: The most posterior point of the earlobe, R: Right auricula, L: Left auricula.]; *$p<0.05$.

Table-2: Right and left auricula comparison in terms of gender.

	Gender	Mean±SD	Std. Error Mean	*p*-value
R_Sba_Sa	Male	62.3±3.77	0.47	*0.003
	Female	59.37±4.13	0.47	
R_Sa_T	Male	39.27±3.35	0.42	*0.001
	Female	36.74±2.19	0.30	
R_T_Sba	Male	26.76±2.51	0.34	*0.014
	Female	25.26±2.36	0.28	
R_Pa_Pra	Male	35.37±2.60	0.29	*0.000
	Female	32.96±2.14	0.32	
R_H_Obi	Male	19.50±2.83	0.39	*0.020
	Female	18.03±2.20	0.30	
R_Obs_Obi	Male	46.60±4.58	0.51	*0.001
	Female	43.12±3.27	0.36	
L_Sba_Sa	Male	62.75±4.70	0.56	*0.005
	Male	59.56±4.35	0.46	
L_Sa_T	Female	38.73±3.57	0.40	*0.005
	Male	36.63±2.20	0.27	
L_T_Sba	Female	26.74±2.58	0.34	*0.019
	Male	25.29±2.38	0.26	
L_Pa_Pra	Female	35.34±2.81	0.30	*0.000
	Male	32.53±1.68	0.29	
L_C_Int	Female	22.81±1.75	0.21	*0.003
	Male	21.59±1.42	0.15	
L_H_Obi	Female	18.85±3.10	0.38	*0.046
	Male	17.59±2.61	0.27	
L_Obs_Obi	Female	46.09±4.75	0.54	*0.000
	Male	42.37±3.36	0.38	

Sa: Superaurale, Sba: Subaurale, Pa: Postaurale, Pra: Preaurale, T: Tragus, Obs: Otobasion superior, Obi: Otobasion inferior, C: Anterior cymba cancha, Int: Incisura intertragica, H: The most posterior point of the earlobe, R: Right auricula, L: Left auricula.]; *$p<0.05$.

Table-3: Gender-based comparison between Turkish and African participants.

Ethnic Origin	Gender	Mean±SD	Std. Error Mean	*p*-value
Turkish				
Sba_Sa	Male	62.52594±5.070066	1.229672	*0.002
	Female	57.02524±4.684765	1.136222	
Sa_T	Male	39.51347±3.333688	0.808538	*0.001
	Female	35.70147±2.690205	0.652471	
T_Sba	Male	26.35912±2.614133	0.634020	*0.006
	Female	23.84182±2.400283	0.582154	
Pa_Pra	Male	35.99971±1.954106	0.473940	*0.000
	Female	31.77876±1.662652	0.403252	
C_Int	Male	23.11088±1.924916	0.466861	*0.000
	Female	20.71776±1.506351	0.365344	
Obs_Obi	Male	47.49976±4.736446	1.148757	*0.000
	Female	41.48900±4.104850	0.995572	
African				
Sba_Sa	Male	62.97465±4.459083	1.081487	0.461
	Female	62.09871±1.887079	0.457684	
Sa_T	Male	37.95765±3.733905	0.905605	0.678
	Female	37.56571±0.951745	0.230832	
T_Sba	Male	27.13541±2.573281	0.624112	0.577
	Female	26.74647±1.218846	0.295614	
Pa_Pra	Male	34.69206±3.405853	0.826041	0.126
	Female	33.29541±1.359203	0.329655	
C_Int	Male	22.51112±1.578661	0.382881	0.936
	Female	22.47859±0.500297	0.121340	
Obs_Obi	Male	44.69424±4.465498	1.083042	0.242
	Female	43.25629±2.187990	0.530666	

Sa: Superaurale, Sba: Subaurale, Pa: Postaurale, Pra: Preaurale, T: Tragus, Obs: Otobasion superior, Obi: Otobasion inferior, C: Anterior cymba cancha, Int: Incisura intertragica, H: The most posterior point of the earlobe, R: Right auricula, L: Left auricula.]; * Indicates statistically significant differences ($p<0,05$).

otobasion inferior distance ($p<0.05$)> For the left ear, significant differences were found in the measurements of total ear length, tragus-above ear length, tragus-below ear length, ear width, concha length, lobulus auricula width, and otobasion superior-otobasion inferior distance ($p<0.05$) (Table 2).

Gender-based differences among the Turkish participants were significant, with Turkish males exhibiting higher values than females ($p<0.05$). The gender-based differences were not significant among African subjects ($p>0.05$) (Table 3).

Discussion

Auricular morphometry is significant for both surgical and anatomical research. In surgical interventions, auricular landmark points play a critical role in ensuring accurate surgical planning. Additionally, because auricular measurements exhibit considerable variability related to genetic, ethnicity, age and gender differences among individuals, they are a key parameter in forensic anthropology for detecting such variables. When interpreting the measurement data in the current study, it is noteworthy that significant gender differences were observed among the Turkish participants in several parameters. In contrast, no significant gender-based differences were found among the African participants. This outcome may be attributed to the homogeneity of the African sample or a lower degree of morphometric variability by gender within this group. These results emphasise the importance of considering inter-population and inter-gender variations in auricular anthropometry, and suggest that biological diversity and genetic background may influence morphometric traits. A study in 2015 on Sudanese adults found that auricular measurements vary significantly across ethnic groups.[8]

Auricular morphometry is also an important parameter in aesthetic and reconstructive surgical planning. For instance, accurate measurement of auricular morphometry during ear reconstruction or aesthetic corrections can assist the surgeon in optimally restoring the patient's physiognomy. A recent study using photogrammetric analysis evaluated how auricular morphology can be influenced by external factors, such as prolonged helmet use, highlighting its relevance in both clinical evaluation and ergonomic considerations.[9]

A study examining the anthropometric variations of auricular morphometry in African adults has explored how auricular anatomy can differ among individuals from different geographical regions, and how these variations may impact clinical applications.[6] The findings indicated that the anthropometric features of the auricula could be investigated for their utility in personal identification. The current study also noted that auricular morphometric features could play a significant role in personal identification. These results are consistent with earlier findings.[13] Similarly, a 2024 study[1] reported that the auricula exhibits morphometric changes based on age and gender.

In the current study, the data acquired from the Turkish population showed consistency with other studies when compared with data from different populations.[14-16] The current study contributed novel data, highlighting how auricular morphometric parameters could enhance population-specific biometric reference databases. A 2016 study[17] showed that ear biometrics and morphological variations could be used as a tool for personal identification, supporting the current findings.

In 2021, a study[18] evaluated variations in human external ear anthropometry from anthropological and forensic perspectives. The current study, which compared auricular morphometry across different ethnic groups, is important for providing data for future larger-scale studies.

A 2016 study[19] investigated Darwin's tubercle as a unique congenital anomaly. The current study is significant in terms of understanding how differences in ear structure are shaped by genetic and environmental factors. The study demonstrated that genetic and ethnic differences can influence auricular morphometry. Although age is known to affect auricular parameters, as reported in a previous study,[17] age-related changes were not analysed in the current study. Although differences were found in the distances between auricular landmark points based on ethnic origin, it is necessary to support these findings with larger-scale studies.

The utility of auricular morphometry in forensic identification continues to be a subject of research. A study in 2021[20] explored whether the ear morphology and morphometry of different ethnic groups in Nigeria could serve as a potential tool for forensic identification. The current study supports these findings, and underscores how ear morphometry can vary among various ethnic groups. A 2022 study[21] determined ear anthropometry between males and females within the Sundanese ethnic group using photogrammetric methods. The current findings align with this study, and support the use of ear anthropometry in gender differentiation. A study in 2022[22] examined ear anthropometry in the Thai population, providing crucial data on how anthropometric differences in ear structure vary across a wide geographic and ethnic range. The current findings underscore the potential of auricular measurements in expanding the forensic toolkit, especially in gender estimation and ethnic classification contexts. However, further large-scale and detailed studies considering inter-population differences, and the effects of environmental factors are needed.

As noted by a 2007 study,[11] ear anthropometry can be a valuable tool for forensic and identification purposes. A 2025 study[23] emphasised that detailed understanding of earlobe anatomy and its variations is crucial for both aesthetic and reconstructive applications, highlighting the importance of precise morphometric analyses. The current study demonstrated the applicability of auricular morphometry for personal identification and biometric analyses. However, further research is needed to explore variations in different populations in more detail.

Conclusion

Auricular anthropometry exhibited significant variations based on gender and ethnicity. Accurate assessment of auricular morphometry and consideration of individual patient characteristics before surgical interventions can enhance clinical outcomes.

Acknowledgement: We are grateful to the students of Sakarya University, Faculty of Dentistry, for their participation in the study.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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Author Contribution:
KK: Writing, final approval and supervision.
ME: Concept, writing, methodology, take photos of participants, writing-original draft and illustrator.
HC: Data analysis, writing and interpretation.