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Auricular Morphometry and Its Forensic Significance among the Okrika Tribe of Rivers State, Nigeria

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Abstract

Background: The external ear plays a significant role in clinical, surgical, and forensic sciences. Anthropometric data are essential for surgeries, hearing aid design, and forensic identification. Ethnic diversity influences auricular morphology, emphasizing the need for population-specific data. This study provides data on the Okrika tribe, exploring sexual dimorphism and applications in clinical and forensic practice. ***Aim:*** To establish anthropometric auricular parameters for the Okrika tribe, with potential applications in clinical and forensic contexts. ***Materials and Method:*** This descriptive cross-sectional study recruited 450 Okirika indigenes (245 males, 205 females) aged 18+ years with no ear abnormalities or previous surgeries. Digital vernier calipers measured ear length, width, lobular length, and lobular width on both ears. Measurements were taken with subjects sitting upright and head in Frankfort horizontal plane. Data were analyzed using R programming environment, with sex differences assessed via independent sample T-test and correlations with stature via Pearson's/Spearman's correlation. $P < 0.05$ was considered statistically significant. ***Results:*** The study enrolled 450 Okirika participants (245 males, 205 females). Males were significantly taller, while females had higher BMI and greater central obesity. Males had larger right lobule width (17.3mm vs 16.3mm) and left ear width (31.1mm vs 30.3mm). Ear width measurements showed prominent sexual dimorphism. Sexual dimorphism was most pronounced in ear width measurements, with males having larger dimensions. External ear dimensions didn't correlate with stature in males and females. Ear size and height are independent traits, making ear measurements unreliable for predicting stature. ***Conclusion:*** This study provides valuable insights into Okrika tribe's external ear morphology, highlighting significant sexual dimorphism in auricular width dimensions. The findings offer a valuable reference for clinicians and forensic experts, guiding reconstructive surgery and sex estimation. The study contributes to external ear morphometry knowledge, emphasizing the need for population-specific research in diverse populations.

Keywords: Auricular parameters, stature, forensics, sexual dimorphism.

INTRODUCTION

Anthropometry, the scientific measurement of human body dimensions, serves as an indispensable tool in clinical, surgical, and forensic sciences. Among various anatomical structures, the external ear (auricle or pinna) holds particular significance due to its distinct morphology, accessibility, and inter-individual variability. The dimensions, shape, and orientation of the external ear are influenced by genetic, environmental, and ethnic factors, making it a valuable anatomical landmark for population-based studies (Standring, 2016; Kumar & Gopichand, 2017). Clinically, auricular morphometry provides essential data for reconstructive and aesthetic surgeries such as otoplasty, as well as for the design of hearing aids and prosthetic devices (Meijerman *et al.,* 2007). Deviations from normative ear measurements may also indicate congenital or syndromic conditions, including microtia, anotia, and craniofacial anomalies (Sforza *et al.,* 2009). In forensic science, the external ear has emerged as a reliable biometric identifier because its structure remains relatively stable throughout life and demonstrates individuality comparable to fingerprints and dental patterns (Purkait, 2007). Ear dimensions and contours are increasingly applied in personal identification, criminal investigations, and disaster victim identification using both two-dimensional and three-dimensional analytical approaches. Ethnic and racial diversity significantly influence auricular

morphology. Studies conducted among different populations have shown measurable variations in ear size and shape, underscoring the importance of establishing population-specific reference data (Eboh & John, 2016). Despite numerous anthropometric investigations among major Nigerian ethnic groups such as the Igbo, Yoruba, and Hausa, the Okrika tribe—an indigenous population of Rivers State in the Niger Delta region—remains underrepresented in morphometric research. Existing data on the Okrika population are limited, and no comprehensive study has examined the relationship between auricular dimensions, sex, and stature. Such a knowledge gap presents challenges in both clinical and forensic contexts. In reconstructive or prosthetic ear surgeries, the absence of population-specific reference standards may compromise aesthetic symmetry and functional outcomes. Likewise, in forensic identification, the lack of auricular biometric data reduces the accuracy of sex and stature estimation among Okrika individuals. Therefore, this study aims to provide detailed anthropometric data on the external ear of the Okrika tribe. Specifically, it seeks to determine sexual dimorphism in ear dimensions, explore correlations between auricular parameters and stature, and highlight their potential applications in clinical, surgical, and forensic practice. Establishing normative auricular data for the Okrika population will contribute valuable reference standards for both medical and forensic professionals working within and beyond the Niger Delta region. This study aimed to establish anthropometric auricular parameters for the Okrika tribe, with potential applications in clinical and forensic contexts.

MATERIALS AND METHOD

This study was a descriptive cross-sectional study. Convenient sampling method was employed to recruit 450 (245 males, 205 females) indigenes of Okirika (18 years and above), with no history of ear abnormalities or previous ear surgeries. Non-indigens of Okirika tribe, indigens with previous ear surgeries were excluded from the study. The procedure was explained to the subjects, consent was given and measurements were taken using the digital venier caliper, with the subjects sitting upright. The following ear parameters; ear length t (EL), ear width (EW), lobular length (LL) and the lobular width (LW) for both right and left ears with the head of the subject in Frankfort horizontal plane. The ear length was measured as a vertical distance from the tip of the helix to the base of the lobule. The ear width was measured across the auricle, at the level of the tragus to the opposite side, where the anthelix or the posterior part of the ear meets the auricular cartilage. Lobular length was measured from the junction where the lobe attaches to the rest of the ear (near the inferior margin of the auricle) to the bottom of the earlobe. Lobular width was measured as the horizontal distance of the earlobe, typically taken at its widest point. Ear length was measured from the highest point of the auricle to the lowest point of the auricle. Ear width was measured as the distance between the most anterior and posterior points of the external ear. Lobular length was measured from the midpoint of the base of the intertragic notch to the lowest point of the lobule. Lobular width was measured as horizontal width of lobule.

Data obtained were analyzed using statistical R programming environment (version 4.3.2). Descriptive statistics (means, standard deviations, interquartile ranges) were computed. Continuous variables were presented as mean±SD, while categorical variables were presented in frequency and percentage. Sex differences were determined using independent sample T-test. The association between auricular measurements (EL, EW, LL, LW) and stature (height) was assessed using Pearson's correlation coefficient for normally distributed variables and Spearman's rank correlation for non-normally distributed variables. The strength and direction of correlations were interpreted based on the correlation coefficient (r) and corresponding p-values. Confidence interval was set at 95% and $P < 0.05$ was considered statistically significant.

RESULTS

A total of 450 participants were enrolled, comprising 245 males (54.5%) and 205 females (45.5%). The mean age of male participants was 38.5 ± 13.5 years, with an interquartile range (IQR) of 21 years, while that of females was 38.7 ± 15.6 years (IQR = 24 years). There was no statistically significant difference in age distribution between the sexes (p = 0.757). In addition, males' participants were significantly taller than females (mean height = 1.55 ± 0.12 m vs. 1.52 ± 0.10 m; p = 0.002). Although males weighed slightly less on average (69.1 ± 15.3 kg) compared to females (71.1 ± 15.5 kg), this difference was not statistically significant (p = 0.219).

The body mass index (BMI) was significantly higher in females (31.1 ± 7.44 kg/m²) compared with males (29.1 ± 6.9 kg/m²), indicating that females were more likely to be overweight or obese (p = 0.006).

Overall, these findings reveal that although males were significantly taller, females had higher BMI, which may reflect a greater predisposition to central obesity. The absence of significant differences in age and weight suggests that observed differences in BMI are largely attributable to body composition and fat distribution rather than overall body size or age differences. This pattern is consistent with known sex-specific anthropometric variations and may have implications for cardiometabolic risk profiling within the Okrika population.

Participants characteristics

Parameters	Male (n=245, 54.5%)			Female (205, 45.5%)			P-value
	Mean	SD	IQR	Mean	SD	IQR	
Age (years)	38.5	13.5	21	38.7	15.6	24	0.757
Height	1.55	0.12	0.10	1.52	0.10	0.20	0.002
Weight	69.10	15.30	23.00	71.10	15.50	24.00	0.219
BMI	29.10	6.90	9.3.00	31.10	7.44	10.80	0.006

External Ear Dimensions in Okirika

The result of the external ear dimension of the auricular parameters in male and female individuals of the Okrika tribe are presented in Table 4.2. The mean right ear length (REL) was 57.2 ± 8.20 mm in males and 57.0 ± 8.13 mm in females, with no statistically significant difference between sexes (p = 0.064). Similarly, right ear width (REW) did not differ significantly between males (31.4 ± 10.3 mm) and females (31.0 ± 10.3 mm; p = 0.759). Right lobule length (RLL) was comparable between sexes (15.9 ± 5.00 mm vs. 16.0 ± 3.14 mm; p = 0.281). However, right lobule width (RLW) was significantly higher in males (17.3 ± 4.53 mm) compared to females (16.3 ± 3.69 mm; p = 0.010).

In addition, no significant difference was observed in left ear length (LEL) between males and females (56.0 ± 8.24 mm vs. 57.1 ± 5.67 mm; p = 0.487). Left ear width (LEW) was significantly greater in males (31.1 ± 6.57 mm) than in females (30.3 ± 5.96 mm; p = 0.010). Left lobule length (LLL) was similar across sexes (p = 0.850). Left lobule width (LLW) was higher in males (18.1 ± 10.8 mm) compared to females (16.7 ± 4.83 mm), but this difference did not reach statistical significance (p = 0.052).

Overall, these results demonstrate that while most external ear measurements were similar between males and females, males exhibited significantly larger right lobule width and left ear width. Other parameters, including ear lengths and lobule lengths, showed no significant sexual dimorphism. This suggests that in the Okrika population, sexual dimorphism in external ear morphology is more prominent in ear width measurements rather than ear length or lobule length.

External ear dimensions in male and female individuals of the Okrika tribe

Parameters	Male			Female			P-value
	Mean	SD	IQR	Mean	SD	IQR	
REL	57.2	8.20	6.6	57.0	8.13	7.20	0.064
REW	31.4	10.3	7.5	31.0	10.3	7.0	0.759
RLL	15.9	5.00	4.2	16.0	3.14	4.4	0.281
RLW	17.3	4.53	4.40	16.3	3.69	3.9	0.010
LEL	56.0	8.24	7.00	57.1	5.67	7.00	0.487
LEW	31.1	6.57	4.7	30.3	5.96	5.4	0.010
LLL	16.3	4.26	4.8	16.4	4.57	4.10	0.850
LLW	18.1	10.8	4.2	16.7	4.83	4.3	0.052

Sexual Dimorphism in External Ear Dimensions

Sexual dimorphism was evaluated using the sexual dimorphism index (SDI) and statistical comparison of external ear measurements between males and females (Table 4.3). The SDI indicated minimal differences in right ear length (REL; SDI = 0.30%) and right ear width (REW; SDI = 1.15%) between males and females, neither of which reached statistical significance (p = 0.064 and p = 0.759, respectively). Right lobule length (RLL) showed a very small negative SDI (-0.10%), also not statistically significant (p = 0.281). In contrast, right lobule width (RLW) was larger in males with an SDI of 5.77%, and this difference was statistically significant (p = 0.010).

Furthermore, left ear length (LEL) exhibited a negative SDI (-1.91%) and was not significantly different between sexes (p = 0.487). Left ear width (LEW) was greater in males (SDI = 2.54%), showing a statistically significant difference (p = 0.010). Left lobule length (LLL) displayed negligible dimorphism (-0.21%, p = 0.850), whereas left lobule width (LLW) had the highest SDI (7.87%) but was marginally non-significant (p = 0.052). Overall, the analysis indicates that sexual dimorphism in external ear dimensions among the Okrika population is most pronounced in ear width measurements, particularly in RLW and LEW, while ear lengths and lobule lengths show minimal or no sex-related differences. SDI values support these findings, highlighting that males tend to have wider ears and lobules, which may reflect sex-specific anatomical variations relevant in anthropometric profiling and forensic applications.

Sexual dimorphism in external ear dimension within the Okrika population

Parameters	Male		Female		SDI (%)	P-value
	Mean	SD	Mean	SD		
REL	57.2	8.20	57.0	8.13	0.30	0.064
REW	31.4	10.3	31.0	10.3	1.15	0.759
RLL	15.9	5.00	16.0	3.14	-0.10	0.281
RLW	17.3	4.53	16.3	3.69	5.77	0.010
LEL	56.0	8.24	57.1	5.67	-1.91	0.487
LEW	31.1	6.57	30.3	5.96	2.54	0.010
LLL	16.3	4.26	16.4	4.57	-0.21	0.850
LLW	18.1	10.8	16.7	4.83	7.87	0.052

Correlation Between External Ear Measurements and Stature

The relationship between external ear dimensions and participants' height was examined using correlation and presented in Table 4.4. For male, the mean right ear length (REL) was 57.2 ± 8.20 mm and the mean right ear width (REW) was 31.4 ± 10.3 mm; for females, the corresponding values were 57.0 ± 8.13 mm and 31.0 ± 10.3 mm, respectively. Correlation analysis revealed that none of the right ear measurements were significantly associated with height, with REL showing a weak positive correlation ($r = 0.043$, $p = 0.359$), REW nearly zero ($r = 0.006$, $p = 0.893$), RLL weakly negative ($r = -0.088$, $p = 0.062$), and RLW weakly positive ($r = 0.042$, $p = 0.372$).

For the left ear, mean left ear length (LEL) and width (LEW) were 56.0 ± 8.24 mm and 31.1 ± 6.57 mm in males, and 57.1 ± 5.67 mm and 30.3 ± 5.96 mm in females, respectively. Left lobule length (LLL) and width (LLW) were similarly measured. Correlation analysis showed no significant associations between any left ear measurement and height, with correlation coefficients ranging from -0.075 to 0.025 (all $p > 0.05$).

Overall, the findings indicate that external ear dimensions do not significantly correlate with stature among either male or female participants of the Okrika tribe. This suggests that ear size and height are largely independent anthropometric traits in this population, and external ear measurements cannot reliably predict stature.

The correlation between external ear dimension and stature among the Okrika

Parameters	Male		Female		Correlation	P-value
	Mean	SD	Mean	SD		
REL	57.2	8.20	57.0	8.13	0.043	0.359
REW	31.4	10.3	31.0	10.3	0.006	0.893
RLL	15.9	5.00	16.0	3.14	-0.088	0.062
RLW	17.3	4.53	16.3	3.69	0.042	0.372
LEL	56.0	8.24	57.1	5.67	0.009	0.850
LEW	31.1	6.57	30.3	5.96	-0.075	0.111
LLL	16.3	4.26	16.4	4.57	-0.017	0.727
LLW	18.1	10.8	16.7	4.83	0.025	0.598

Potential clinical applications of the external ear dimensions

The descriptive and comparative analyses of external ear dimensions in the Okrika population revealed clear patterns of sexual dimorphism primarily in ear width measurements. Males exhibited significantly greater right lobule width (RLW) and left ear width (LEW), whereas ear lengths and lobule lengths showed minimal sex differences. The sexual dimorphism index (SDI) further supported these observations, indicating that ear width may be the most reliable anthropometric trait for differentiating between sexes.

Correlation analysis demonstrated no significant associations between ear dimensions and stature, suggesting that ear size is largely independent of overall body size. This independence is important in clinical practice because it allows ear reconstruction or aesthetic interventions to be planned based on localized measurements rather than relying on generalised anthropometry.

DISCUSION

Participants' Characteristics

The general characteristics of participants revealed that males were significantly taller than females, while females exhibited a slightly higher body mass index (BMI). Although weight differences were not statistically significant, this pattern indicates typical sexual variation in body composition—males showing greater stature and females tending toward higher adiposity. The anthropological implication of this finding is that sexual dimorphism in body stature among the Okrika tribe is consistent with other Nigerian populations, where males generally have greater skeletal dimensions. Clinically, such differences are important

because general body size can influence anatomical proportions, including auricular features. For forensic identification, establishing baseline somatic characteristics like height and BMI differences enhances the interpretation of population-specific biometric data.

External Ear Dimensions

The analysis of external ear parameters showed that most measurements, including right and left ear lengths and lobular lengths, did not differ significantly between sexes. However, the right lobule width (RLW) and left ear width (LEW) were significantly larger in males. This indicates that ear width exhibits sexual dimorphism among the Okrika. This finding corresponds with previous study done by Erekosima *et al*. (2022), who observed higher mean auricular values in males compared to females among the same ethnic group. Similar trends were documented by Oladipo *et al*. (2017) in the Kalabari population, reinforcing the regional pattern that males generally possess broader auricles. Also, Anyanwu *et al*. (2023) reported larger auricular dimensions in males compared to females in a study done among three ethnic groups in Nigeria.

Their findings confirmed sexual dimorphism and further established correlations between auricular dimensions and stature.

The findings of this study hold significant clinical and forensic implications. Clinically, the observed sex-based differences in ear parameters (ear width) underscore the importance of considering sex-specific anatomical norms in reconstructive and aesthetic surgery, enabling surgeons to design prosthetic ears and execute surgical corrections that are anatomically proportionate and sex-appropriate. From a forensic perspective, ear width may serve as a valuable secondary trait for sex estimation in anthropological analyses, particularly in instances where primary identifiers are unavailable or compromised. Furthermore, the consistency of these findings across Okrika and Kalabari populations within the Niger Delta region suggests a shared genetic and environmental influence on auricular morphology, warranting further exploration of the interplay between genetic and environmental factors in shaping ear anatomy. These results contribute to the growing body of knowledge on human variation and have important implications for fields reliant on anatomical accuracy.

Correlation Between External Ear Measurements and Stature

The study found no significant correlation between external ear parameters and stature in either sex. Ear length, width, and lobular dimensions showed weak or negligible correlation coefficients. This indicates that ear size does not proportionally increase with overall body height in the Okrika population.

This outcome aligns with the observations of Ahmed and Omer (2015) in Sudan, who found limited association between auricular measurements and height, suggesting that ear dimensions function as independent anthropometric variables. However, this is in contrasts with Anyanwu *et al*. (2023), who reported a moderate correlation between auricular dimensions and stature among Nigeria's major ethnic groups. The discrepancy underscores the need for population-specific evaluation rather than applying generalized anthropometric models across diverse

Since ear dimensions are independent of stature, surgeons can rely on direct auricular measurements for reconstructive procedures without adjusting for body height. Also Ear parameters may not serve as reliable predictors of height, but they remain useful for sex differentiation.

CONCLUSION

This study provided valuable insights into the external ear morphology of the Okrika tribe, highlighting significant sexual dimorphism in auricular width dimensions. The findings underscore the importance of population-specific research and provide a valuable reference for clinicians and forensic experts. The established normative values can guide reconstructive and aesthetic surgeons in achieving optimal outcomes, while the identified sex-specific differences in ear width can serve as a supplementary tool in forensic investigations. This study contributes to the growing body of knowledge on external ear morphometry and its applications in anthropology, anatomy, and forensic science, emphasizing the need for continued research in diverse populations.

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