Human Biology Review (ISSN 22774424) ***www.HumanBiologyJournal.com***
International Peer Reviewed Journal of Biological Anthropology
Volume 14, Number 1, January-March 2025 Issue
Original scientific paper

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Human Biology Review, Volume 14 (1), pp. 1-14

Revised and accepted on December 17, 2024

Citation: Johnbull TO, Oladipo GS and Ehijiagbon CI. 2025. Anthropometry of the external ear and stature estimation. Human Biology Review, 14 (1), 1-14.

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ABSTRACT

This study investigates the morphological variations of the external ear and its potential for the evaluation of stature among the Ijaw population in Bayelsa State, Nigeria. Utilizing a cross-sectional design, data were collected from 200 participants aged 18-50 years using digital Vernier calipers for ear evaluations and steel tape rules for height measurements. The results indicated significant differences in ear values between genders, with males displaying larger auricular dimensions than females. Notably, the average right auricular height was 54.79 ± 3.56mmandthe left auricular height was 55.41± 3.29mm.Correlation analysis revealed that left auricular height and width were significantly positively associated with stature, suggesting that ear dimensions can be predictive of an individual's height. These reveals are in sync with previous studies but highlight unique morphological traits within the Ijaw population,influenced by genetic and environmental factors. This research contributes valuable data to forensic canthropology, particularly in the context of human identification and the estimation of physical characteristics based on ear morphology.

Keywords: Ear, Morphology, Stature Estimation, Ijaws, Nigeria, Anthropology, Forensic Science

INTRODUCTION

Several studies done had pointed out that there are varied related concerns in one's mind when it comes to humans which include identity, morphological features, distinctive features, genetic makeup, differences and biometric parameters. However, a number of the morphological attributes used for this purpose comprise facial traits, foot & finger prints, gait patterns, cranial, teeth, geometry of the hand and external ear are usually employed as forensic investigation tool used in distinguishing one person from other individual (Gibelli *et al*., 2012; Kumar and Singla, 2013; Krishan and Kanchan, 2015).

In order to understand physical variations that exist in humans, an anthropometry measurement of the external ear is essential. Although, measurements of the human body varied according to their sex, age and race. Therefore, studying of these physical differences is of great use when it comes to the production of prosthetics, clothing designs and plastic surgery (Deopa *et al*., 2013; Sharma, 2016). It is on record that all the human body parts are vital, but in recent times one major part of the body that have attracted the attention of forensic investigators is the human ear for the identification and discrimination of humans (Verma*et al*., 2016; Rubio *et al*., 2017).

It had been reported that the ear is distinctive in each person. The ear prints, like the fingerprints, are sufficiently distinct in telling apart persons and even undistinguishable set of twins as reported in the work of Daramola and Oluwaninyo (2011). Similar study had shown the exclusive nature of the external ear in the identification of alive and translated individuals (Krishan *et al*., 2019). In addition, studies on the application of the human ear as a means for human identification divided the human ear into three major parts: the internal, middle and external ear. These studies further demonstrated that the external ear is used in forensics (Murgod*et al*., 2013; Ahmed and Omer, 2015; Purkait, 2016; Krishan *et al*., 2019).

In human, the external ear being a vital organ contributes to the beauty of the human face and also potentially alters the appearance of an individual by its location, shape, dimension and projection (Ekanem *et al*., 2010). It had also been documented that the human ear is consisted of the external, middle and internal parts. Meanwhile, the external ear is reportedly made up of a shell-like auricle known as pinna, which is saddled with task of collecting sound. Additionally, sound when received by the pinna is then conveyed by the external acoustic meatus to the tympanic membrane whereas the auricle, that is helical in shape, is formed by an elastic cartilage enclosed in skin and possesses contours. The lobule or earlobe of the auricle is a tag of skin containing fibrofatty tissue and blood vessels. It is a common site for earrings and can also be pierced for taking blood sample. It is also known to be the last part of the auricle to develop (Edibamod *et al*., 2019).

The attachments to the earlobe were primarily grouped into "attached" and "free" or "unattached"earlobes (Ahmed & Yaas, 2013; Ordu *et al*., 2014; Verma*et al*., 2016). However, there are indications by researchers of another nomenclature of earlobes referred to as "intermediate or tapering earlobes" observed in many people (Mumin *et al*., 2018). These individuals having earlobes that drape freely are referred to having "free or unattached earlobes" whereas those possessing earlobes merged with the sides of proximal head are "attached or adherent earlobes" (Munir*et al*., 2015; McDonald, 2011).

In an anthropometric study on the ear, measurements have been carried out on diverse Populations. Several studies had been carried out in different regions in the world. Studies in India ,Urhobo, Southern Nigeria showed that females were discovered to have statistically higher lobular length and width comparedfor to their male counterparts (Sharma, 2016; Eboh, 2013), whereas the ones done among the American, Italian, Indian, Israeli and Turkish populations demonstrated that boys and men tend to have larger ears than the girls and women (Alexander *et al*., 2011). Related works have shown higher auricular proportions in males when compared to the females in northern Nigeria are higher. Those by Sharma, (2016) further revealed that ear dimensions were higher in males than females (Sharma, 2016; Eboh, 2013). While among the Chinese population, the lobular dimensions were observed not significantly different in both genders (Wang *et al*., 2011).

Accordingly, Alexander *et al*. (2011) described the external part of the human ear (pinna or auricle) as one most classic features in the human face. Additionally, widespread studies by forensic anthropologists showed the auricle plays certain aspect in human as identification marker based on the morphological variance that is seen either on gender, age and the ethnicity of the individual (Murgod *et al*., 2013). Whereas the form, proportion and location of the auricle, in an individual are peculiar to that individual just as the fingerprint, and so aiding its usage in forensics (Alexander *et al*., 2011).

It has been reportedly known that ear mark samples have been retrieved on door and window panels where a burglar has been listening for likely invasion. However, when forensic investigations are made, such marks are collected and assessed with archived information establishing a match with suspects.

Therefore, ear prints provide usefulness in forensic evidences. Furthermore, the ear morphology and biometrics are frequently employed when fingerprints prove difficult which might result from wearing protective hand gloves. Thus, conventional biometrics involving facial recognition has minor value compared to the ear owing to the fact that the ear cannot be disguised with spectacle or moustache and also its ageing process is slow (Fakorede *et al*., 2021). It is worthy of note that the ear is not affected by changes in facial expression. More so, and contrary to other traits like the retina and iris in human, minimal to no apprehension originating from the human ear although, this can be captured from a distance (Amirthalingam and Radhamani, 2013). Likewise, regarding personal identification the human ear with its striking attribute of stability and inimitability in individuals ranging from birth to later life have made it a grand forensic tool (Muntasa*et al*., 2011).

Series of researchers had revealed in human that all aspects of the ear is exclusive in form (Alexander *et al*., 2011; Muteweye and Muguti, 2015). Interestingly a similar study conducted by Oladipo *et al.* (2023) provided that baseline data credible for designing ergonomically suitable hearing aids and as well as forensic identification. Also, Murgod*et al*. (2013) and Ahmed and Omer, (2015) in their separate studies assessed the sex-related scope of the ear shape, attachments of the lobe and linear measurements of the ear in regards to evaluating the degree of sexual dimorphism in 300 young adult Indians and showed an impressive 69.3% accuracy in male individuals and 72% in females when it comes to sex identification.

A pool of data about the parameters of the human ear exists in Nigerian populations. Ekanem *et al*. (2010) did an anthropometric work on the external ear in Maiduguri, North-Eastern Nigeria.

In 2013 Eboh, examined the morphological changes in the pinna in relation to age and gender among the Urhobo people in South-South Nigeria. Taura*et al*. (2013) documented the information of the external ear anthropometrical variations among the Hausas in Northern Nigeria for reference purposes.

Despite an impressive publication on anthropometric measurement of the external ear, there is rarity of the morphological indices of the external ear and stature estimation among the people of Ijaw in Bayelsa state, Nigeria. This leads to the aim of this present study to ascertain the anthropometry of the external ear among the Ijaws in Bayelsa state, Nigeria and provide accurate information of the ear landmarks for forensic identification of this population.

METHODS

The study utilized cross-sectional descriptive research designed to determine the morphology of the external ear and stature among the Ijaws in Bayelsa State of Nigeria.

200 adults (100 males, 100 females) aged 18-60 years were involved in this study. A Digital Vernier calliper for ear measurements and steeltape rule for height measurements.

Participants having obvious deformity of the ear either congenital oracquired were excluded from the study**.** Also, subjects who are not from Ijaw extraction wereexcluded.

All participants were made to sit on a chair and the head held in Frankfurt horizontal plane.

Female participants were requested to remove their earrings before their ear measurements were taken. All measurements were taken in duplicates and the arithmetic mean of the two calculated and recorded in millimeters to avoid inter-observer error. All measurements were taken using a digital calipers (Shanghai, China).

Four main linear indices of both right and left external ears of all participants were measured using a sliding digital caliper (Murgod et al. 2013; Ahmed and Omer 2015).

Stature: Stature was measured as a vertical distance from the vertex to the floor using a standard anthropometric Frankfurt plane.

Auricular height was measured from the highest point of the auricle to the most inferior point on the earlobe (supra-aurale to sub-aurale).

Auricular width was taken from the distance between the most anterior and posterior part of the auricle (pre-aurale to post-aurale).

Lobular height was taken as the distance from the intertragicincisure to the caudal part of the lobe (Inter-tragic notch to sub-auricle).

Lobular width was taken as the distance between the most anterior and posterior part of the ear (A line perpendicular to the line defining the lobular height).

RESULTS

Table 1: Comparison of the Mean Values of the Various Auricular Dimensions in the Left and Right Ears of Study Participants.

Parameters	Right (n=200) Mean ± SD	Left (n=200) Mean ± SD	t-value	P-value	Rmk
Auricular height(mm)	54.79 ± 3.56	55.41± 3.29	-2.419	0.018*	S
Auricular width (mm)	28.42 ± 2.60	29.55± 2.55	-5.393	0.000*	S
Lobular height (mm)	18.35 ± 3.11	19.37± 3.27	-4.456	0.000*	S
Lobular width (mm)	16.45 ± 1.80	16.26± 1.85	1.237	0.220	NS

Key: SD= Standard Deviation, mm = millimeters.

Table 2: **Correlation Coefficient between various auricular dimensions and Heights of the Study Participants**

Parameters	Correlation with Height		Remark
	r	***p*-value**	
Right auricular height (mm)	0.195	0.107	NS
Left auricular height (mm)	0.327	0.006	S
Right auricular width (mm)	0.271	0.023	S
Left auricular width (mm)	0.397	0.001	S
Right lobular height (mm)	-0.384	0.001	S
Left lobular height (mm)	-0.309	0.009	S
Right lobular width (mm)	-0.021	0.865	NS
Left lobular width (mm)	-0.057	0.638	NS

Key: **mm**=millimeters, *r*=Pearson correlation; NS= Not statistically significant; S= statistically significant. P<0.05 is considered statistically significant.

Table 3: Linear Regression Analysis of Right and Left Ear Parameters for Prediction of Stature in the Study Participants

	Std error of estimation	**Correlation coefficient (*r*)**	***P*-value**	**Regression equation**
RAH	7.78	0.195	0.018	144.47+(0.43×RAH)
LAH	7.49	0.327		144.47+(0.78×LAH)
RAW	7.63	0.271	0.137	144.70+(0.82×RAW)
LAW	7.28	0.397		144.70+(1.22×LAW)
RLH	7.32	-0.384	0.001	185.85+(-0.97×RLH)
LLH	7.54	-0.309		185.85+(-0.74×LLH)
RLW	7.93	-0.021	0.092	169.53+(-0.09×RLW)
LLW	7.92	-0.057		169.53+(-0.24×LLW)

Key: *r*= Pearson correlation; RAH= Right auricular height; LAH= Left auricular height; RAW= Right auricular width; LAW= Left auricular width; RLH= Right lobular height; RLW= Left lobular height; RLW= Right lobular width; LLW= Left lobular width.

Table 4: Comparison of the Mean values of the Various Auricular Dimensions in male and Female Participants.

Parameters	**Male (n=100) Mean ± SD**	**Female (n=100) Mean ± SD**	**t-value**	**P value**
Right auricular height (mm)	54.60 ± 3.52	54.65± 3.84	-0.053	0.958
Left auricular height (mm)	55.49 ± 2.98	54.94± 3.90	0.629	0.534
Right auricular width (mm)	29.32 ± 2.51	27.52± 2.34	2.898	0.007*
Left auricular width (mm)	30.57 ± 2.65	28.74± 2.29	3.075	0.005*
Right lobular height (mm)	16.80 ± 2.55	19.71± 3.18	-3.518	0.001*
Left lobular height (mm)	17.99 ± 2.80	21.00± 3.20	-3.662	0.001*
Right lobular width (mm)	16.69 ± 1.70	16.22± 2.03	1.015	0.319
Left lobular width (mm)	16.58 ± 1.49	16.10± 2.23	1.034	0.310
Height (cm)	172.88 ± 6.22	162.28± 6.18	8.056	0.000*

Key: SD= Standard Deviation, mm = millimeters; cm= Centimeter

DISCUSSION

The ear constitutes facial aesthetics of humans as such evaluating and differentiating the size has become imperative. This study was carried out to provide an informative data on the morphology of the external ear and its correlation with stature estimation among the Ijaws in BayelsaState.

The result in this study demonstrated that the mean right auricular height is 54.79 ± 3.56 in mm while, the left auricular height is seen to be 55.41 ± 3.29 (mm). When it came to the right auricular width the value was 28.42 ± 2.60mm, that of the left ear width was 29.55 ± 2.55(mm), and the value of the right lobular height was 18.35 ± 3.11 in mm. The Left lobular height is shown to be 19.37 ± 3.27 mm, Right lobular width 16.45 ± 1.80 mm while Left lobular width was 16.26 ± 1.85 mm, and finally the lobular height was 168.64 ± 7.93 millimeters. Compared to the Indian men studied by Murgod and his colleagues (2013), Nigerian men from Bayelsa State (Ijaw ethnic group) have smaller auricles.

The mean Auricular Length obtained from the studied Indian men was 62.85 ± 3.35 mm, while results from this study indicates that Nigerian men from Bayelsa state have a mean Auricular Length of 54.79 ± 3.56 mm. Concerning proportions of Lobular Length, Nigerian men from the sample population have been observed to possess akin lobules with their Indian counterparts, with mean values of 18.99 ± 2.47mm and 18.35 ± 3.11mmin Indians andNigerians respectively. Concerning Lobular Width, Nigerian men in the studied population have smaller lobules (16.45 ±1.80 mm) compared to their Indian counterparts (18.54 ± 1.77mm).

In this present study, there were statistically significant differences ($p<0.05$) observed between right and left ear measurements as shown in (table 2).This finding is in agreement with the previous works of Eboh, (2013) who stated noteworthy asymmetry in left and right ear parameters. On the other hand, it was not in-line with the works by Kishan *et al.* (2019) whose result on males and females has no difference statistically.

The present study also revealed that the values of Auricular height, Auricular width and Lobular height measurement of the left ear is significantly ($p<0.05$) higher than the right ear as shown in (table1).This implies that the left ear dimensions were of higher value than that of right ear. This is consistent with the previous works of Ahmed and Omer, (2015), and Taura *et al.*, (2013) who reported a higher value for the left ear than the right ear. However, it contradicts that report by Acar *et al*. (2017) who indicated a superior value for the right ear width than the left as seen among the female population in Turkey. The explanation for the observed differences in the study can be ascribed to ethnic, genetics, climate and nutrition influences (Laxman, 2019; Spiller *et al*., 2018).

The results of the present study also revealed that right auricular height showed a positive correlation ($r=0.195$, $p=0.107$) with height, but was not statistically significant as shown in (table

2). Left auricular height showed a significant positive correlation with height (r=0.327, p=0.006). Right Auricular Width and Left Auricular Width showed a good significant correlation with height (r=0.271, p=0.023) and (r=0.397, p=0.001). Right Lobular Height (r=-0.384, p=0.001) and Left Lobular Height (r=0.309, p=0.009) showed a significant negative correlation with height. Right lobular width (r=-0.021, p= 0.865) and Left Lobular Width (r=-0.07, p=0.638) gave a negative relationship with height, but not statistically important. This is in consonant with an earlier work done by Ade et al., (2019), where auricular width portrays a good interplay with height (r=0.151, p=0.003).

Furthermore, using simple linear regression analysis to predict stature, the result revealed that auricular height (*r*=0.195, p=0.018) demonstrates a positive statistically significant relationship with stature. Lobular height (*r=-0.*384, *p*=0.001) showed statistically unfavourable relationship with stature. While Auricular Width (*r*=0.271, p=0.137) and Lobular Width (*r=0.*021,p= 0.092) were all not statistically significant for predictability of stature as shown in (table 3).

This finding is consistent with the previous works by Obaje *et al*., (2020), and Shotwell, (2019) which reported that regression models favorably forecast stature based on external ear morphometry. However, it is inconsistent with the previous works by Ade *et al*., (2019), which indicated no noteworthy connection involving the measurements of Auricular Length, Width; Lobular Length, Width and stature in males and females.

Results from table 4 revealed that the mean values of Right Auricular Height in males was slightly lower than female but not statistically significant (p>0.05). The mean value of Left Auricular Height in male subjects was slightly higher than female subjects (54.94 ± 3.90), but not statistically relevant (p>0.05). Right Auricular Width and Left Auricular Width measurement was significantly more (p<0.05) in the males as opposed to the females. The mean value of Right Lobular Height in male subjects was significantly lower (p<0.05) than the female subjects. Left Lobular Height values in male subjects were significantly lower than females. However, no noticeable change (p>0.05) in values of the Right & left Lobular Width between male and female in this study population. The mean value of height in males was relatively (p<0.05) higher than the female population.

Conclusion

This body of work has acknowledged bilateral asymmetry in the left and right auricular indices of both males and females. In the present study was observed mathematical relevance ($p<0.05$) between right and left ear measurements. It also revealed that Auricular height and width variedly differed between males and females. Right Auricular Width and Left Auricular Width showed a significant positive correlation with height. The result showed that Auricular parameters are a veritable means when establishing human variation and evaluating stature which are also of importance in biometric and forensic studies among Ijaws in Bayelsa State.

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