Original article

Stature Estimation from the Right External Ear of Undergraduate Students in South-East Nigeria

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Abstract

Background: Ethnicity, stature and gender influence the anthropometric characteristics of the right ear, thus creating variations which are helpful for sex identification and medico-legal purposes in forensic examinations. This study has produced anthropometric data on the right external ear among the Ikwo people in southeastern Nigeria.

Materials and Methods: Ear and lobular indices were obtained from the dimensions of the right external ear of 240 Ikwo adults aged 18-35. Also, three predictive models (equations) were produced in the study.

Results: Descriptions of the right external ear for the study population were obtained. Aside from ear indices, which were higher in females than in males, males were taller in stature than females ($P<0.001$). Regarding correlation, right ear parameters in both sexes appeared positive and strongly correlated with stature. Regression models strongly predicted stature based on external ear measurements.

Conclusion: Medical applications (monitoring diseases, forensics, industrial design and apparel design) of this study cannot be overemphasized in this world of medical sciences, in particular when it comes to understand the human external ear in terms of hearing and communication.

(Obaje SG, Nwankwo SC, Egwu AO. Stature Estimation from the Right External Ear of Undergraduate Students in South-East Nigeria. SEEMEDJ 2020; 4(2); 12-19)

Received: May 13, 2020; revised version accepted: Oct 27, 2020; published: Nov 12, 2020

KEYWORDS: correlation analysis, external ear, regression models, sexual dimorphism

Introduction

Hearing, balance and communication are an integral part of human life (1). Medical sciences, especially communication medicine, are raising medical standards to understand not only how the external ear works (hearing, balance and communication), but also to explain clinical disorders (2). By applying biochemical methods, forensic investigators collect information at a crime scene, such as fingerprints, hair strands, blood, even from notebooks, and trace the details of the person (3). In fact, the application of anthropometry to body structures has proved to be useful in forensics, genetics, agriculture, industry and neurosciences (4). Anthropometry has been dealing with the measurement of physical features and functions of the human body, including linear dimensions, weight, volume and range of movement (5, 6). So, measuring the human ear is not an exception in this contemporary science. In another setting, scientists and anthropologists apply anthropometry to study human body measurements using parameters such as height, weight, triceps skinfold, subscapular skinfold, arm circumference, abdominal and calf circumference, knee height and elbow breadth (7-9).

In terms of the anatomy, the ear is an advanced and very sensitive organ of the human body (10, 11). The ear's function is to transmit and transduce sound to the brain through the parts of the ear: the outer ear, the middle ear and the inner ear (11, 12). Diseases and abnormalities of the ear are enormous. There are a number of different infections, diseases and even cancers that can affect the ear and ultimately lead to hearing loss (otosclerosis, otitis media and Ménière's disease) (13-15). Stature estimations also include body height, usually estimated by applying anatomical and mathematical techniques using long bones (foot dimensions, hand and head measurements). It has been observed that in males, total height is sometimes greater and correlates more with stature than in females (11,16-18). The study using ear indices, lobular indices and stature of the Ikwo people in southeastern Nigeria will be useful in forensic science, ear health and clinical sciences.

Material and Methods

Study location

Ebonyi State is located in southeastern Nigeria and inhabited primarily by the Igbo people, with the city of Abakaliki as its capital. There are other major townships, including Afikpo, Onueke, Ezzamgbo, Edda, Effium, Aba Omege, Amasiri, Unwana, Echara Ikwo, Egu-Ubia, Ụbụrụ, Onicha. The state covers a large area of 5,533 km^2. Its latitude is 6˚10'40.7"N and its longitude is 7˚57'33.43"E. Ebonyi has a tropical climate, with the summers much rainier than the winters. When it comes to agriculture, it is one of the most important states in Nigeria, known for its popular brand of rice Abakaliki and other food crops grown in large quantities, such as yam, cassava, maize, cocoyam, cowpea and groundnut.

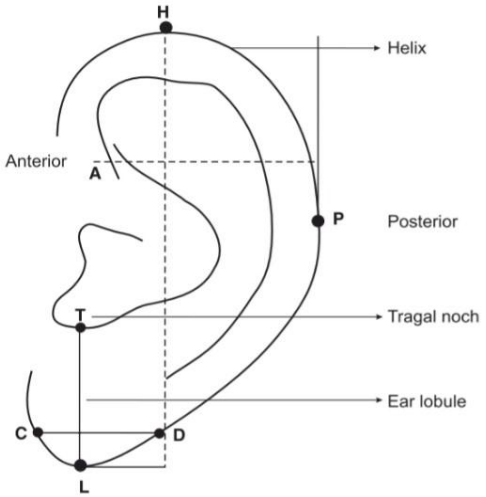
Study design

In the study, about 240 students (male = 120 and female = 120) from Alex Ekwueme Federal University Ndufu-Alike in the 2018/2019 academic session of aged 18-35 years were recruited. The informed consent was obtained and signed. Also, ethical approval (FUNAI/RE/120) was obtained prior to the study. A digital anthropometric method was applied to measure ear length and breadth, base of auricle, lobe length and breadth while stature measured using a stadiometer (Figure 1 and Figure 2). Also, the ear and lobular indices, lobe attachments, and ear shape were calculated and from this, differentiating sex based on external ear variables was achieved. Ear length was measured as the perpendicular distance between the tangents to the highest point on the helix and the lowest point on the lobule. Ear index was measured as distance from the ear width/Ear length ×100. Lobular index was measured as the lobular width/Lobular length ×100.

Figure 1. The stadiometer used for measuring the stature of the participants from Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria

Stature was measured from the foot to the vertex of the head. All measurements were made by two research assistants using a scale to the nearest millimetre.

Figure 2. Points used for anthropometric measurements of the right external ear among the subjects from Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria



*****Total ear height= L-H, ear width= A-P, lobular height= L-T, lobular width (C-D).*

Inclusion criteria

All participants recruited for the study must belong to the same ethnic group (Igbo). Must be enrolled as students in Alex Ekwueme Federal University Ndufu-Alike Ikwo, Ebonyi State, southern part of Nigeria in the 2018/2019 academic session. Also, subjects must belong to the age bracket of 18-35 years.

Exclusion criteria

Subjects that are non-Igbo in the university were excluded from the study.

Statistical analysis

The data was collected using Excel spreadsheets (MS Office, 2013). The statistical analysis of the data was performed using SPSS Version 20 (IBM Corp., Armonk, NY). Student's t-test was performed after determining the normality of data ($P<0.001$). A Pearson's product moment correlation coefficient was applied on the right ear for both sexes. Also, the linear regression analysis was used to generate regression models to ascertain the level and strength of association between stature and right ear morphometry.

Results

Right ear indices (see Table 1) were higher in females than in males (54.8±2.53 mm and 51.52±2.51 mm respectively), while males were taller in stature than females (161.42±7.81 mm and 160.21±7.01 mm respectively). Lobular indices (99.45±8.62 mm and 99.43±8.61 mm) appeared to be the same in both males and females ($P<0.001$). All parameters appeared to be significant ($P<0.001$).

Table 1. Anthropometric measurements using the t-test to measure the right ear and stature among male and female adults of the Ikwo people (mm)

Parameters (mm)	Males N = 120	Females N = 120	P-values
EI	51.52±2.51	54.81±2.53	0.001
LI	99.45±8.62	99.43±8.61	0.001
S	161.42±7.81	160.21±7.53	0.001

*** EI: Ear indices, LI: Lobular indices, S: Stature

The analysis (see Table 2) showed a positive and stronger correlation in males than in females regarding the three parameters (P<0.001). In terms of correlation, ear indices were positive and stronger in males than in females (r = 0.92 and r = 0.82 respectively), while the value of lobular indices was r = 0.90 and 0.86 respectively. Furthermore, correlation between the ear variables with stature were positive and strong in both males and females (r = 0.89 and r = 0.80 respectively). In the regression analysis (see Table 3 and 4), R2 adjusted values were 0.94, 0.91 and 0.85 for ear indices, lobular indices and stature for males, and 0.90, 0.89, and 0.65 for females respectively. In this case, the study appeared strongly predictive regarding the three ear measurements with stature for both sexes and statically significant (P<0.001).

Table 2. Correlational analysis of the right ear and stature among male and female adults of the Ikwo people

Parameters	Male Stature		Female stature	
	r	P-value	r	P-value
EI	0.92	0.001	0.82	0.001
LI	0.90	0.001	0.86	0.001
S	0.89	0.001	0.80	0.001

***EL: Ear length, EW; Ear width, LL: Lobular length, LW: Lobular width, EI: Ear indices, LI: Lobular indices, S: Stature

Predictive equations for ear indices, lobular indices and stature were S = 89.14+(1.61×EI), 88.71+(1.71×LI) and 74.45+(1.68×S) for males, and S = 88.12+(1.60×EI), 86.27+(1.68×LI) and 74.45+(1.66×S) for females respectively.

Discussion

Scientists studying human ears are adding new dimensions to future discussions about the external ear in humans (1, 2). Our study showed that males were taller in stature than females. This also corroborated the sexual dimorphic features studied in anthropology. Moreover, ear indices appeared to be higher in males than in females, while the lobular indices were the same in both sexes. The human ear gives a clue to estimating stature at the time of criminal investigations and legal discussions (2, 5). In northern Nigeria, a study of the Hausa ethnic group aged 16-35 used the digital and face-arth software and observed sexual dimorphism in ear

analyses (12, 17). Also, a comparative study of the external ear involving medical students showed that all ear and lobular indices were higher in males than in females (13, 18, 19). The morphometric variables of the right female ear were somewhat inconsistent with our study, as they were higher compared to the right ear in males, although the difference was not significant (20, 21). The reason for the differences observed in the study can be attributed to the influence of ethnicity, genetics, climate and nutrition (22-24).

Our study follows the application of Krogman's principle to determine regression formulae used to estimate stature from bones, fragments of bones or measurements of body parts (2), and it was reported that regression formulae presents a better estimation and association between ear indices and stature. Our study (Table 3, 4) produced three prediction models (ear indices, lobular indices and stature).

Table 3. Regression equations for predictions of stature from the right ear among male adults of the Ikwo people

Model			Male
	R^2	P-value	R-equation
EI	0.94	0.001	S = 89.14+(1.61×EI)
LI	0.91	0.001	S = 88.71+(1.71×LI)
S	0.85	0.001	S = 74.45+(1.68×S)

*** EI: Ear indices, LI: Lobular indices, S: Stature

Table 4. Regression equations for predictions of stature from the right ear among female adults of the Ikwo people

Model			Female
	R^2	P-value	R-equation
EI	0.90	0.001	S = 88.12+(1.60×EI)
LI	0.89	0.001	S = 86.27+(1.68×LI)
S	0.65	0.001	S = 74.45+(1.66×S)

*** EI: Ear indices, LI: Lobular indices, S: Stature

All the regression-adjusted values (R2) for ear indices, lobular indices and stature were positive and higher in males than in females. All the anthropometric parameters were significant (P<0.001). Some studies (25-28) were consistent with our study that predicted stature from both ears in a simple linear regression analysis. Furthermore, some studies implicated the evolutionary changes to have influenced ear measurements (29-30). Again, interracial marriages have become the norm in many cultures and have been producing genetically similar population (31). Apart from ear dimensions, some studies deal with other human body parts to estimate stature using regression models (32). The similarity in lobular indices in our subjects (Table 1-2) may result from the fact that they all belong to the same generation, with great grandparents who carried the same genetic interpretation.

Regarding sexual dimorphism, there reference to the correlation and estimation of stature from other body parts, for instance in a study of estimation of stature from length of fingers, estimation of stature from index and ring finger

length and estimation of stature from hand and phalange length (32-33). Also, studies on the estimation of stature from craniofacial measurements, sex differences in morphometry of North Indian acetabula (34-35). In particular, in some cases, it has been pointed out that the reason behind the association between stature and anatomical parts could be traceable to protein intake in early childhood with body composition, insulin-like growth factor in mid-childhood and early adolescence, environmental and genetic factors (21, 26). Importantly, human beings are considered to be bilaterally symmetrical in both thumb and fingers of both hands, irrespective of sex or handedness, allowing for an estimation of stature of an individual, which plays an important role for individuality (33, 35). To further support our study, one research discussed the right and left ears as mostly asymmetrical with respect to ear length, ear breadth and base of auricle, which were larger in males than in females, while the lobe length and breadth were larger in females as compared with males (chi square test, $p \leqslant 0.001$), concluding that the ear parameters gave a moderate to good sex identification accuracy (36). This study could be useful for human embryology and monitoring gestational age, for industrial designs and forensic education.

Conclusion

Ear and lobular indices appear to be correlated with stature. Using the three regression models, a correlation between stature and ear measurement can be predicted, meaning that ear length can be used to identify individual stature. This study is helpful for communication medicine, forensic study and basic medical science.

Acknowledgement. Our study team wish to thank Prof Uche Nwachi Edward, former Provost of the College of Medicine, for his administrative support and scientific advice.

Disclosure

Funding. No specific funding was received for this study.

Competing interests. None to declare.

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