Access this Article online
Quick Response Code:

Website:
jecajournal.com
Doi:
doi.org/10.4314/jeca.v21i1.16

Original Article

Relationship between External Ear Morphometry and Stature among Hausa Population from Selected Tertiary Institutions in Kano Metropolis, Nigeria

[1]Dauda, I.M., [1]Mohammad, I.A., [1]Husein, H.I., [6]Kumurya, H.S., [1]Sharif, M.I., [4]Ibrahim, I., [5]Abubakar, L.J., [2]Umar, K.B., [1]Abubakar, M., [2]Adamu, L.H., [1]Asuku, A.Y., [3]Taura, M.G.

Submitted: 17th April, 2024
Revised: 17th June, 2024
Accepted: 19th June, 2024
Published: 30th June, 2024

[1]*Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University Kano, Kano, Nigeria;* [2]*Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medicine and Allied Medical Sciences, Federal University Duste, Duste, Nigeria;* [3]*Department of Anatomy, College of Medicine, University of Bisha, Bisha, Saudi Arabia;* [4]*Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Yusuf Maitama Sule University, Nigeria;* [5]*Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria, Nigeria;* [6]*Human Anatomy Unit, Faculty of Basic Health Sciences, Al-istiqama University, Sumaila, Kano, Nigeria*

Address for Correspondence:
Dauda, I.M.
Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University Kano, Kano, Nigeria
ibrahimmdauda8@gmail.com
+2349035171125

Abstract

BACKGROUND AND AIM: Body anthropometry has been proved to be useful tool for height determination of individual. The aim of this study was to determine relationship of external ear morphometry with stature among Hausa population from selected tertiary institutions in Kano metropolis, Nigeria.
METHODOLOGY: Using simple random sampling, a total number of 390 students aged between 18 to 30 years participated in the study. Eight paired external ear parameters were measured using direct anthropometric techniques. The height was measured using standard protocols. Pearson correlation analysis was employed to determine the relationship of external ear morphometry with height and logistic regression was used for the height prediction from the ear morphometry.
RESULTS: The results of the present study showed that the mean values of ear dimensions was significantly higher in males compared to the female ($P > 0.01$) with the exception of left and right tragus to antihelix, ear lobe length, auricular projection which are significantly higher in female ($P < 0.01$). Irrespective of sex, significant positive correlation (moderate/strong) was observed in most of the variables with negative correlation in some like right tragus-antihelix ($r = -0.109$, $p = 0.05$) and left tragus-antihelix ($r = -0.171$, $p = 0.01$). Ear length present higher correlation ($r = 0.514$). A correlation of external ear dimensions with height based on sex shows that right and left EL, EW, ELL and TIN as well as left ELL were positively correlate with height with higher correlation in right ear length ($r = 0.259$). Similarly, for the female, right and left EL as well as right TH and right ELL were also positively correlate with height with higher correlation in right EL ($r = 0.207$).
CONCLUSION: A linear equation model for prediction of height from given ear dimension was generated. Therefore, ear morphometric parameters may be used as an additional tool in determination height among Hausa population.

Keywords:
Stature, External ear, Morphometry, Hausa.

INTRODUCTION

The only visible part of the ear is auricle, which is made up of cartilage and soft tissue that helps in keeping a particular shape with flexibility (Standring, 2008). The lateral surface of the auricle displays a unique contour in terms of prominences and depressions. These are formed through a complex developmental process which later gives the pinna a unique morphology in every individual (Moore *et al.,* 2011). Ears increase in both length and width with increase in age from birth to 99 years of age (Meijerman *et al.,* 2007).

The outer ear is a defining feature of the face (Alexander *et al.,* 2010) and knowledge of the morphometry of auricle is important in the

How to cite this article: Dauda, I.M., Mohammad, I.A., Husein, H.I., Kumurya, H.S., Sharif, M.I. *et al.* Relationship between External Ear Morphometry and Stature among Hausa Population from Selected Tertiary Institutions in Kano Metropolis, Nigeria. J Exp Clin Anat 2024; 21(1):101-109.
https://dx.doi.org/10.4314/jeca.v21i1.16

diagnosis of congenital malformations and syndromes, in planning the plastic surgeries of the external ear and designing the instruments for hearing (Farkas *et al.,* 1992; Brucker *et al.,* 2003; Kalcioglu *et al.,* 2003; Bozkir *et al.,* 2006). It is also important in personal identification in forensic sciences (Van der Lugt *et al.,* 2005; Asirdizer *et al.,* 2012). It is also used as one of the eleven anthropometric measurements for manual system of identifying individuals (Dhanda *et al.,* 2011).

The studies of the ear evolved initially from the development of surgical techniques for the treatment of congenital deformities and the reconstruction of traumatically injured ears (Tolleth, 1978; Avelar, 1986). Lobule parameters are important for plastic surgeons who aim to achieve a proper balance between right and left earlobes in reconstruction surgeries (Sharma *et al.,* 2007). Ear dimensions can also be used by plastic surgeons in pre-operative planning of otoplasty procedures involving correction of lobular ptosis and ear projection. Features of the pinna which serve these important functions include the heights and widths of the ear, earlobe, and the concha as well as ear projection dimensions. These features have been reported to vary with sex (Murgod *et al.,* 2013) and between populations (Jung and Jung, 2003).

It is usually difficult to measure the height of especially those with cerebral palsy, neuromuscular disorders, spinal deformity, and lower limb amputation or deformity (Miller and Koreska, 1983; Hogan, 1999), for this, there is need for height prediction using other anthropometric variables. The variables commonly reported for estimation of height includes arm span (Jalzem and Gledhill, 1993), segmental bone length (Cheng et al., 1998), ulna length (Gauld et al., 2004), knee height (Johnson and Ferrara, 1991) hand and foot dimension (Modibbo et al., 2012).

There were documented studies on the correlation of ear length and ear width with height (Taura *et al.,* 2016; Kumari *et al*., 2022). However, study investigating the relation of other external ear dimensions with stature and utilization of external ear anthropometry for estimation of the height of individuals received less attention especially among Hausa population. Therefore, the study aimed to determine the relationship of external ear morphometry with stature among Hausa population from selected tertiary institutions in Kano metropolis, Nigeria.

MATERIALS AND METHODS

Study Location and Sample Size Determination

The study was conducted at College of Health Sciences (CHS), Bayero University Kano (BUK), which has four faculties; Allied Health Sciences, Basic Medical Sciences (BMS), Clinical Sciences and Dentistry and Faculty of Basic Medical Sciences, Yusuf Maitama Sule University Kano (YUMSUK), at the anatomy and physiology departments.

Sample Size Determination

The sample size was determined using a standard formula (Lwanga and Lemeshow, 1991): $n = \frac{Z^2 Pq}{d^2}$ Where; n= minimum sample size, Z= standard normal deviation with confidence interval of 95% (±1.96), P= proportion in the target population (50%) 0.5

Q= 1-p, 1-0.5= 0.5, d = sampling error which is 5% (0.05)

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384$$

Therefore, the minimum number of subjects needed was 384.

Study Population and Sampling Technique

A total of three hundred and ninety (390) subjects made up of male (198) and female (192) subjects within the age range of 18-30 years were selected from the two universities using random sampling method. Participants with congenital deformities, tumor, trauma or previous surgery to the pinna and also non-Hausa ethnic group (participants whose parents and grandparents were from other ethnic group as declared by the participants) were excluded from the study. Before the commencement of the research, informed consents were sought from the participants. The study was also carried out according to Helsinki declaration. The approval to conduct the study was granted by the departmental committee of research and ethic (Department of Anatomy, Bayero University, Kano) (ANTBUK/UGPROJECT/18/0008).

Methodology

The study design was cross sectional type, which involves the collection of the bio-data and anthropometric parameters using profoma.

Biodata and Anthropometric Parameters Collection

Information collected were age, sex, ethnicity, height, and ear dimensions.

Determination of Height

Height was measured in a standing position without shoes as a vertical distance from the standing surface to the vertex of the head using a Stadiometer with weighing scale (Model RGZ 160, Health Medical Equipment, England) with a minimum measurement of 1 cm.

Ear Morphometry

Participants were asked to sit in an upright relaxed position "natural and normal" with erect posture of head and shoulders, with both arms hanging free beside the trunk for the linear measurements of the ear (Farkas *et al.,* 2005).

Eight external ear dimensions were measured (Table 1) using stainless steel digital vernier caliper (Neiko 01407A, New York, USA) according to previous methods (Packiriswamy *et al.,* 2012; Tatlisumak *et al.,* 2015).

Statistical Analyses

The data was analyzed using the Statistical Package for Social Sciences (SPSS) software version 20. The data were expressed as mean ± standard deviation (SD). Independent sample t test was used to test for sexual dimorphism, Pearson's correlation was used to determine the relationship between the study variables and linear logistic regression was used for the height prediction form the ear morphometry. The level of significance was set at $p < 0.05$.

Tables 1: Description of ear measurement from one landmark to another

Variables	Abbreviation	Measurements
Auricle projection	AP	From helix to mastoid process at the tragus level
Ear length	EL	From the most superior point of the auricle to the most inferior point of the earlobe on lines parallel to the base of the auricle
Superior point of the auricle to intertragic notch	TIN	From the superior point of the auricle to the bottom of intertragic notch
Ear width	EW	Distance between the most anterior and the most posterior points of the auricle
Tragus to helix	TH	Distance from the tragus to helix
Tragus to antihelix	TA	Distance from the tragus to antihelix
Earlobe width	ELW	Between the most anterior point to the most posterior points of the earlobe
Earlobe length	ELL	Between the most inferior point of the earlobe and the deepest point of the intertragic notch

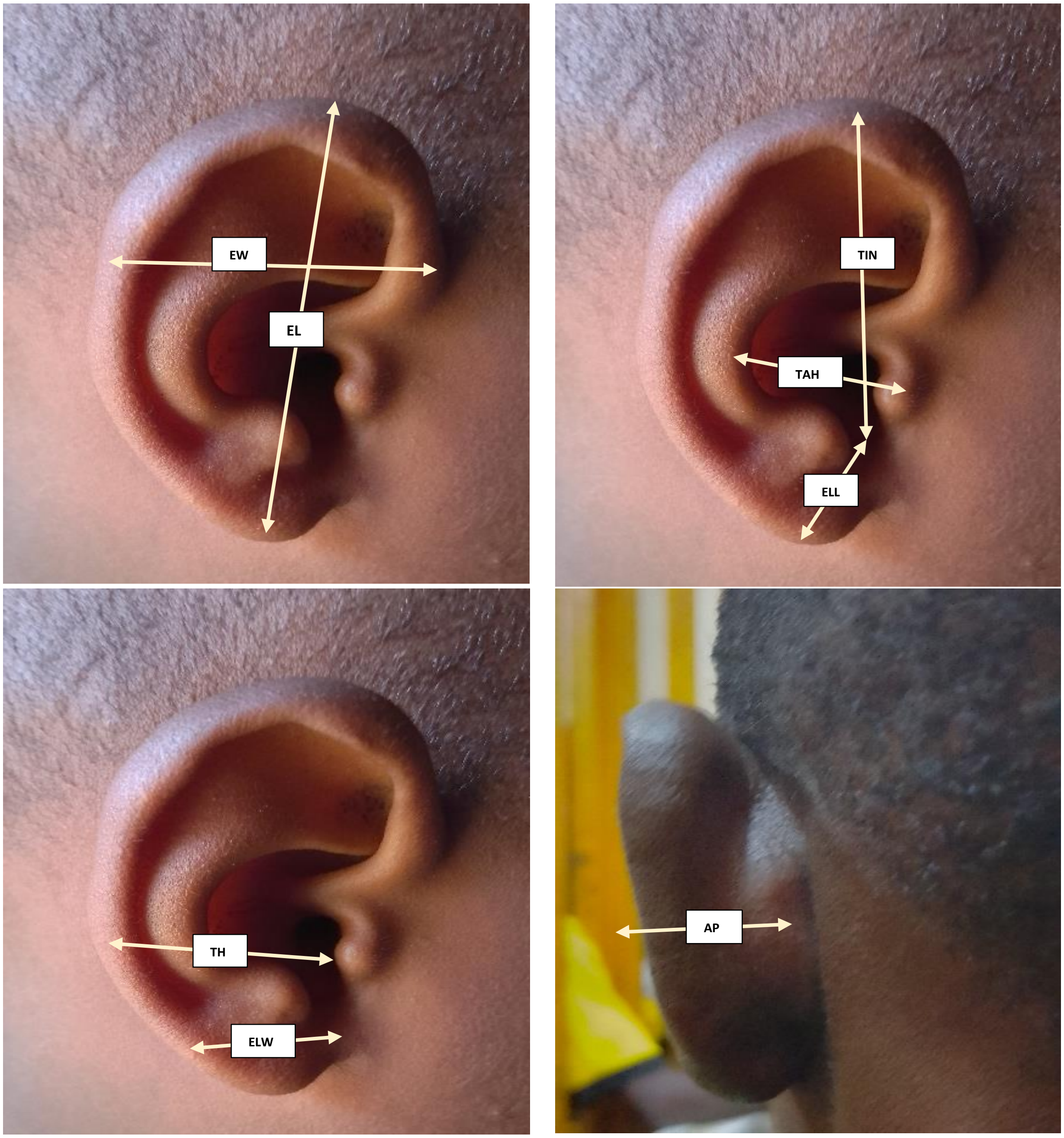

Plate I: Landmark of the external ear measurement

RESULTS

Table 2 shows the descriptive statistics and sexual dimorphism of the external ear morphometry and height of the participants. The mean age of the participants was 21.66 ± 2.56. Mean values of ear dimensions was significantly higher in males compared to the female subjects ($P > 0.01$) with the exception of left and right tragus to antihelix, ear lobe length, auricular projection which are significantly higher in female ($P < 0.01$).

Table 3; shows relationship of the external ear morphometry with height among Hausa population of Kano State, Nigeria. Irrespective of sex, significant positive correlation (moderate/strong) was observed in most of the variables with negative correlation in some like right tragus-antihelix (*p* = 0.05) and left tragus-antihelix (*p* = 0.01). Ear length present higher correlation (r =0.514).

A correlation of external ear dimensions with height based on sex shows that right and left EL, EW, ELL and TIN as well as left ELL were positively correlate with height with higher correlation in right ear length. Similarly, for the female, right and left EL as well as right TH and right ELL were also positively correlate with height with higher correlation in right EL

Table 4 and 5 showed the regression analysis for height prediction from external ear dimensions for the general population and for the separate gender (male and female).

Table 2: Descriptive statistics and sexual dimorphism of height and external ear morphometry of Hausa population from CHS-BUK and FBMS-YUMSK

				Male (198)	Females (192)	
Variables	Min	Max	Mean± SD	Mean± SD	Mean± SD	*P* - value
Age (years)	18.00	30.00	21.66± 2.56	22.59±2.48	20.70±2.28	<0.001
Height (m)	1.26	1.83	1.66 ± 0.08	1.70 ± 0.07	1.61 ± 0.06	<0.001
Right ear length (mm)	44.00	70.00	55.05±4.63	58.20±3.85	51.80± 2.71	<0.001
Right ear width (mm)	22.00	39.00	32.05±2.81	33.35±2.26	30.71±2.69	0.11
Right tragus-helix (mm)	19.00	33.00	27.30±2.32	27.87±2.25	26.71± 2.24	<0.001
Right tragus-antihelix (mm)	13.00	28.00	20.83±2.67	19.95±2.34	21.73±2.69	<0.001
Right earlobe length (mm)	8.00	27.00	14.23±2.47	13.80±2.30	14.68± 2.56	<0.001
Right earlobe width (mm)	7.00	31.00	17.18±5.20	21.53±2.59	12.70±2.89	<0.001
Right TIN (mm)	11.00	54.00	42.62±5.59	46.49±3.12	38.61± 4.69	<0.001
Right auricular projection (mm)	6.00	38.00	14.33±3.02	13.76±2.91	14.91± 3.02	<0.001
Left ear length (mm)	44.00	70.00	54.64±4.54	57.58±3.93	51.62±2.83	<0.001
Left ear width (mm)	24.00	40.00	31.80±2.90	33.23±2.34	30.33±2.69	<0.001
Left tragus-helix (mm)	20.00	37.00	26.69±2.39	26.83±2.30	26.55±2.48	<0.001
Left tragus- antihelix (mm)	14.00	28.00	20.51±2.72	19.40±2.18	21.65±2.76	<0.001
Left earlobe length (mm)	9.00	21.00	14.17±2.39	13.55±2.05	14.81±2.55	0.25
Left earlobe width (mm)	7.00	28.00	17.05±4.87	20.99±2.33	12.98±3.16	<0.001
Left TIN (mm)	12.00	54.00	42.27±5.30	45.67±3.29	38.78±4.66	<0.001
Left auricular projection (mm)	6.00	42.00	14.05±3.21	13.03±2.69	15.10±3.35	<0.001

** P < 0.01; * P < 0.05 Min; Minimum, Max; Maximum, SD; Standard deviation, TIN; Superior point of the auricle to intertragic notch.

Table 3: Relationship of the external ear morphometry with height among Hausa population of Kano State, Nigeria

	All (n = 390)	Male (n = 198)	Female (n = 192)
Variables (mm)	Height (m)	Height (m)	Height (m)
Right ear length	0.514**	0.259**	0.207**
Right ear width	0.372**	0.211**	0.120
Right tragus-helix	0.248**	0.125	0.159*
Right tragus-antihelix	-0.109*	0.037	0.136
Right earlobe length	0.031	0.159*	0.146*
Right earlobe width	0.473**	0.113	-0.019
Right TIN	0.455**	0.244**	0.056
Right auricular projection	-0.031	0.036	0.141
Left ear length	0.497**	0.236**	0.228**
Left ear width	0.383**	0.212**	0.111
Left tragus-helix	0.130*	0.121	0.114
Left tragus-antihelix	-0.171**	0.019	0.106
Left earlobe length	-0.032	0.172*	0.098
Left earlobe width	0.480**	0.149*	0.043
Left TIN	0.441**	0.231**	0.089
Left auricular projection	-0.117*	0.022	0.117

**. Correlation at the 0.01 level; *. Correlation at the 0.05 level, TIN; Superior point of the auricle to intertragic notch.

Table 4: Regression model of height prediction from external ear dimensions for the general population

	Combined (Male and Female) (N=390)				
	Height (m)				
Variables (mm)	R^2	SEE	Constant	β	P - Value
Right ear length	0.264	0.069	1.169	0.009	< 0.001
Right ear width	0.138	0.074	1.318	0.011	< 0.001
Right tragus-helix	0.062	0.078	1.423	0.009	< 0.001
Right tragus-antihelix	0.012	0.070	1.725	-0.003	0.031
Right earlobe length	0.001	0.070	1.643	0.001	0.543
Right earlobe width	0.223	0.071	1.532	0.007	< 0.001
Right TIN (mm)	0.207	0.071	1.380	0.007	< 0.001
Right auricular projection	0.001	0.070	1.669	-0.001	0.540
Left ear length	0.247	0.069	1.180	0.009	< 0.001
Left ear width	0.147	0.074	1.321	0.011	< 0.001
Left tragus-helix	0.017	0.079	1.541	0.004	0.010
Left tragus-antihelix	0.029	0.079	1.760	-0.005	0.001
Left earlobe length	0.001	0.070	1.672	-.0001	0.525
Left earlobe width	0.230	0.070	1.523	0.008	< 0.001
Left TIN	0.195	0.072	1.376	0.007	< 0.001
Left auricular projection	0.014	0.079	1.698	-0.003	0.021

SEE; Standard. Error of the Estimate, TIN; Superior point of the auricle to intertragic notch, Height (m) = β (Ear Morphometry) + Constant

Table 5: Regression model of height prediction from external ear dimensions for the separate gender.

	Male (N=198) Height (m)					Female (N=192) Height (m)				
Variables (mm)	R^2	SEE	Constant	B	P – Value	R^2	SEE	Constant	B	P – Value
Right ear length	0.067	0.071	1.413	0.005	< 0.001	0.043	0.061	1.368	0.005	0.004
Right ear width	0.044	0.071	1.472	0.007	0.003	0.014	0.062	1.529	0.003	0.098
Right tragus-helix	0.016	0.073	1.586	0.004	0.080	0.025	0.062	1.496	0.004	0.027
Right tragus-antihelix	0.001	0.073	1.676	0.001	0.602	0.018	0.062	1.546	0.003	0.060
Right earlobe length	0.025	0.072	1.629	0.005	0.025	0.021	0.062	1.562	0.004	0.044
Right earlobe width	0.013	0.073	1.630	0.003	0.114	0.000	0.062	1.619	0.000	0.794
Right TIN (mm)	0.060	0.071	1.433	0.006	0.001	0.003	0.062	1.585	0.001	0.440
Right auricular projection	0.001	0.073	.1.686	0.001	0.612	0.020	0.062	1.571	0.003	0.052
Left ear length	0.056	0.071	1.446	0.004	0.001	0.052	0.061	1.355	0.005	0.001
Left ear width	0.045	0.071	1.479	0.007	0.003	0.012	0.062	1.536	0.003	0.126
Left tragus-helix	0.015	0.073	1.596	0.004	0.090	0.013	0.062	1.538	0.003	0.115
Left tragus-antihelix	0.000	0.073	1.686	0.001	0.786	0.011	0.062	.1.562	0.002	0.142
Left earlobe length	0.030	0.072	1.616	0.006	0.015	0.010	0.062	1.579	0.002	0.178
Left earlobe width	0.022	0.072	1.601	0.005	0.036	0.002	0.062	1.603	0.001	0.556
Left TIN	0.053	0.071	1.465	0.005	0.001	0.008	0.062	1.568	0.001	0.221
Left auricular projection	0.000	0.073	1.691	0.001	0.758	0.014	0.062	1.581	0.002	0.107

SEE; Standard. Error of the Estimate, TIN; Superior point of the auricle to intertragic notch, Height (m) = β (Ear Morphometry) + Constant

DISCUSSION

Detailed knowledge of the morphologic dimensions of normal ear is essential for the diagnosis of congenital abnormalities and syndromes, forensic investigations and for the ergonomic design of hearing aids (Coward *et al.,* 2000; Purkait and Singh, 2007; Tatlisumak *et al.,* 2015), plastic surgery (Brent 1992; Cagatay and Erol 2006) and determination of racial variation. This can also be useful in assessment of body composition parameters that can be utilized as screening tool for the determination of the well-being of an individual or possible risk of diseases. The present study explored the relationship of external ear morphometry and stature among Hausa population from two selected tertiary institution in Kano metropolis, Nigeria.

The present study established the basal data for various parameters of the external ear and its correlation with height as well as sexual dimorphism. From the result, the mean values of ear dimensions was significantly higher in males compared to the female subjects ($P > 0.01$) with the exception of left and right tragus to antihelix, ear lobe length, auricular projection which are significantly higher in female ($P < 0.01$). This finding is similar to the findings in the South Indian population, as well as in North Indian population (Sidera and Vrushali, 2015).

It is well documented that in ear morphometric studies ethnic background, in addition to age and sex, is one of the key factor need to be put into consideration while examining differences and relationship between variables (Bozkir *et al.,* 2006; Meijerman *et al.,* 2007; Sharma *et al.,* 2007; Sforza *et al.,* 2009). Another reason for the discrepancy of ear lobe length may be the inclusion criteria employed by the previous study where females have pierced earlobes. It is obvious that the uses of ring as evidence by pierce ear increases the vertical dimensions of the ear and subsequently alter the morphology and morphometry of the ear.

Irrespective of sex, significant positive correlation was observed in most of the variables with negative correlation in some like right tragus-antihelix ($p = 0.05$) and left tragus-antihelix ($p = 0.01$). Ear length present higher correlation (r =0.514). A correlation of external ear dimensions with height based on sex shows that right and left EL, EW, ELL and TIN as well as left ELL were positively correlate with height with higher correlation in right ear length. Similarly, for the female, right and left EL as well as right TH and right ELL were also positively correlate with height with higher correlation in right EL. Our finding is in keeping with the previous studies that established relationship of external ear dimension with height and weight. It was revealed that ear length and ear width of both ears correlate significantly with height among Hausa population (Taura *et al.,* 2016). Also, Durgawale and

Jadhav (2018) documented a significant positive correlation between ear length and height from western Maharashtra population. Ear dimensions exhibit significant correlation with height and weight in both males and females (Azaria *et al.,* 2003).

In conclusion, the present study provides reference data with regards to the external ear morphometry of Hausa population from Bayero University Kano and Yusuf Maitama Sule University Kano. The relationships of external ear morphometry with height have been established. Therefore, ear parameters may be used as an additional tool in height determination.

Acknowledgements

We thank all the participants in the study. Technical support provided by others is well appreciated.

CONFLICT OF INTEREST

None Declared.

REFERENCES

Alexander, K. S., Stott, D. J., Sivakumar, B. & Kang, N. (2010). Morphometric study of the human ear. *Journal of Plastic Reconstruction Aesthetic Surgery*, 20:1 – 7.

Asirdizer, M., Tatlisumak, E., Ozyurt, B. & Yavuz, M. S. (2012). Determination of the usability limits of auricle morphology for identification. *Journal of Forensic Medicine*, 26(2):104 – 14.

Avelar, J. (1986). Important of ear reconstruction for the aesthetic balance of the facial contour. *Aesthetic Plastic Surgery*, 10:147 – 56.

Azaria, R., Adler, N., Silfen, R., Regev, D. & Hauden, D. J. (2003). Morphometry of the adult human ear lobe: a study of 547 subjects and clinical application. *Plastic Reconstruction Surgery,* 3: 2398 – 402.

Bozkir, M. G., Karakas, P., Yavuz, M. & Dere, F. (2006). Morphometry of the external ear in our adult population. *Aesthetic Plastic Surgery*, 30: 81 – 85.

Brent, B. (1992). Auricular repair with Autogenous rib cartilage grafts: Two decades of experience with 600 cases. *Plastic Reconstruction Surgery*, 90 (3): 355 – 74.

Brucker, M. J., Patel, J. & Sullivan, P. K. (2003). A morphometric study of the external ear: Age and sex related differences. *Plastic Reconstruction Surgery*, 112: 647 – 652.

Cagatay, B. & Erol, A. (2006). Anthropometric measurements of the external ear in a group of Turkish primary school students. *Aesthetic Plastic Surg*ery, 30(2):255 – 259.

Cheng, J., C., Leung, S., S., Chiu, B., S., Tse, P., W., Lee, C., W., Chan, A., K. et al. (1998). Can we predict body height from segmental bone length measurements? A study of 3,647 children. *Journal of Pediatric Orthopaedics*; 18: 387–393.

Coward, T. J., Scott, B. J., Watson, R. M. & Richards, R. (2000). Laser Scanning of the ear identifying the shape and position in subjects with normal facial symmetry. *International Journal of Oral Maxillofacial Surgery*, 29 (1): 18 – 23

Dhanda, V., Badhan, J. S. & Garg, R. K. (2011). Studies on the development of latent ear prints and their significance in personal identification. *Problems of Forensic Science*, 138:285 – 95.

Durgawale, J. M., & Jadhav, S. S. (2018). Length of external ear: A tool for prediction of height-Study in western Maharashtra population. *Journal of Evidence Based Medicine Healthcare,* 5(16), 1381 – 1384.

Farkas, L. G., Katic, M. J., Forrest, C. R., Alt, K. W., Bagic, I., Baltadjiev, G., Cunha, E., Cvicelova, M., Davies, S., Erasmus, I., Gillett-Netting R. & Hajnis, K., *et al.,* (2005). International anthropometric study of facial morphology in various ethnic groups/races. *Journal of Craniofacial Surgery,* 126: 615 – 646.

Farkas, L. G., Posnick, J. C. & Hreczko, T. M. (1992). Anthropometric growth study of the ear. *Cleft Palate Craniofacial Journal*; 29(4):324 – 9.

Gauld, L., M., Kappers, J., Carlin, J., B., Robertson, C., F. (2004). Height prediction from ulna length. *Developmental Medicine Child Neurology*, 46: 475–480

Hogan, S., E. (1999). Knee height as a predictor of recumbent length for individuals with mobility impaired cerebral palsy. *Journal of the American College of Nutrition* 18:

Jalzem, P., F., Gledhill, R., B. (1993). Predicting height from arm measurements. *Journal of Pediatric Orthopaedics*, 13(6):761– 65. 201–205

Johnson, R., K., Ferrara, M., S. (1991). Estimating stature from knee height for persons with cerebral palsy: an evaluation of estimation equations. *Journal of the American Dietetic Association,* 91: 1283–1284

Jung, H. S., & Jung, H. S. (2003). Surveying the dimensions and characteristics of Korean ears for the ergonomic design of ear-related products. *International Journal of Industrial Ergonomics*, 31(6): 361 – 373.

Kalcioglu, M. T., Miman, M. C., Toplu, Y., Yakinci, C., & Ozturan, O. (2003). Anthropometric growth study of normal human auricle. *International Journal of Pediatric and*

Lwanga, S. K. & Lemeshow, S. (1991). Sample size determination in health studies; a practical manual.*World Health Organization*, Geneva, p. 10.

Meijerman, L, van der Lugt, C. and Maat, G., J., R. (2007). Cross-sectional anthropometric study of external ear. *Journal of Forensic Science*, 52:286-293.

Miller F, Koreska J. (1983). Height measurement of patients with neuromuscular disease and contractures. *Developmental Medicine and Child Neurology*; 34: 55–60.

Modibbo, M., H., Taura, M., G., Agu, O., C., Bashir, U. (2012). Estimation of stature from hand and foot dimensions in Hausa neonates: a hospital-based study. *Bayero Journal of Pure and Applied Sci*ences, 5(2): 110 – 114

Moore, K., L., Persaud, T., V., N. andTorchia, M.,G. (2011). The Developing Human 10th Edition.*Elsevier Health Sciences*, p 433-436.

Murgod, V., Angadi, P., Hallikerimath, S. and Kale, A. (2013). Anthropometric study of the external ear and its applicability in sex identification: assessed in an Indian sample. *Australian Journal of Forensic Science*, 45: 431– 444.

Packiriswamy, V., Kumar, P. and Rao, K., G. (2012). Photogrammetric analysis of palpebral fissure dimensions and its position in Malaysian South Indian ethnic adults by gender. *North American Journal of Medical Science*, 4(10):458-462.

Purkait, R., and Singh, P. (2007). Anthropometry of the normal human auricle: A study of adult Indian men. *Aesthetic Plastic surgery*, 31(4): 372-9.

Sforza, C., Grandi, G., Binelli, M., Tommasi, D., G., Rosati, R. andFerrario, V., F. (2009). Age and sex related changes in the normal human ear. *Forensic Science International*, 187:110e1-110e7.

Sharma, A., Sidhu, N. K., Sharma, M. K., Kapoor, K. and Singh, B. (2007). Morphometric study of ear lobule in northwest Indian male subjects. *Anatomical Science International*, 82(2):98-104

Sidera, S., Vrushali, P. (2015). Anthropometric measurements of human external ear. *Journal of Evolution of Medical and Dental Sciences,* 59(4):10333-38.

Standring, S. (2008). The anatomical basic of clinical practice: Gray's Anatomy 40th Edition. *LondonElsevier*, 547.

Tatlisumak, E., yavuz, M., S., kutlu, N., asirdizer, N., yoleri, l. and Aslan, A. (2015). Asymmetry, handedness and auricle morphometry. *International Journal of Morphology*, 33(4):1542-1548.

Taura, M., G., Adamu, L., H., Gudaji, A. and Modibo, M. (2016). Height prediction from external ear morphometry; a pilot study. *International Journal of Research in Health Science*, 4(1):15-19.

Tolleth, H. (1978). Artistic anatomy, dimensions, and proportions of external ear. *Journal of Plastic Reconstructive Surgery*, 5:337.

Van der Lugt, C., Nagelkerke, N., J. and Maat, G., J. (2005). Study of the relationship between a person's stature and the height of an ear imprint from the floor. *Medical Science Law*, 45(2):135-41.