Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2024;41:39-46

Ear Biometrics and Positional Relationships to Facial Midline Landmarks, Eyes, Nose and Mouth of Fulanis and Yorubas of Nigeria

Akinlolu A.A.[1], Anigilaje Y.[2], Ebito G.[3]

[1]Department of Anatomy, Federal University of Health Sciences Otukpo, Benue State, Nigeria
[2]Department of Anatomy, University of Ilorin, Ilorin, Kwara State, Nigeria
[3]Department of Anatomy, Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria

Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: ear and facial cephalometry are of great importance in forensic civil and criminal investigations. Nigeria is composed of over 250 ethnic groups with Yorubas and Fulanis as arguably the second and fourth largest ethnic groups. Therefore, in-order to provide missing normative reference biometrics data of Nigerian ethnic groups, this study examined three-dimensional biometrics of the ear and positions of the ear to face in Fulanis and Yorubas who are co-residents of Ilorin in the North Central region of Nigeria.

Materials and Methods: age, Height, Bodyweight, three-dimensional photographs of the ear (right and left) and face of non-related 25 Fulani males and 25 Yoruba males whose ethnic groups were confirmed by three generations (paternal and maternal) were collected with informed consent. Ear Length, Ear Width, Concha Length, Concha Width, Lobule Length, Lobule Width and Ear Indices were computed. Distances of each of Otobasion superius, Otobasion inferius and Tragus of the ear to the eyes (exocanthion), nose (nasion and subnasale), mouth (cheilion) and facial midline landmarks (nasion, subnasale and gnathion) were also computed. Data were statistically analyzed with $p \leq 0.05$.

Results: the right Ear Index of Fulanis was lower than those of Yorubas, while the left Ear Index of Fulanis was higher than those of Yorubas.

Conclusion: overall, the findings of this study showed that Fulanis have shorter ear dimensions and shorter dimensions of positional relationships of ear to the eyes, nose, mouth and facial midline landmarks compared with Yorubas.

Keywords: Ear cephalometry; facial cephalometry; three-dimensional biometrics; Fulanis; Yorubas; Nigeria.

Introduction

The ear is directly related to the face and is of relevance in biometric studies and craniofacial surgical reconstructions. The ear is the organ of hearing, and is involved in the maintenance of equilibrium and balance[1,2]. It is divisible into three parts, the external, middle and internal ear. External and middle parts transfer sound to the internal ear, while the internal ear contains the organ of hearing and equilibrium. The external ear consists of the auricle and the external acoustic meatus. The auricle contains several elevations and depressions, and is made up mainly of irregularly shaped plate of elastic cartilage lined on both sides by thin skin[1,2]. Its lowest part (lobule) contains only connective tissue (fibrous tissue, fat and blood vessels) covered by skin[1,2]. The featuristic appearance of the human outer ear or pinna is formed by the outer helix, antihelix, lobe, tragus, antitragus and concha[1].

Biometric dimensions of the external ear such as ear height, ear width, lobular height, and lobular width are dependent on sex, age and ethnicity, and have been employed to demonstrate variations amongst human populations[3]. Ear sizes significantly increase with age, and larger values were observed in older individuals[4]. Some authors noted that the shape and appearance of the human ear is unique to each individual while others noted that the uniqueness of the ear to each individual is yet to be clearly established[4,5]. In addition, the use of the ear as a forensic biometric feature may be limited by confounding factors such as hair occlusion and ear symmetry[5-7]. However, the ear becomes a useful biometric feature when the face may become not completely recognized due to illumination changes, facial expression changes, eye glasses and facial make-up[5-7] in addition to obtainable facial measurements.

Nigeria is located in West Africa and it is one-sixth of Africa's total population. Nigeria is divisible into six distinct North-Central, North-East, North-West South-East, South-South and South-West geo-political regions. It is composed of over 250 ethnic groups with a population of over 140 million in the last national census conducted in 2006[8]. The Yorubas and

DOI: 10.51929/jms.41.39.2024
ISSN 2177-0298

Fulanis are arguably the second and fourth largest ethnic groups of Nigeria[8]. Ilorin is a Yoruba town but cosmopolitan and comprising of residents belonging to different ethnic groups such as Yorubas, Fulanis, Hausas, Nupes and others. Ilorin is the capital city of Kwara State in the North Central region of Nigeria[8].

Ear dimensions in some Nigerian ethnic groups such as Benins[9], Igbos[9] and Hausas[10] have been reported. However, the authors are not aware of any study which reported ear dimensions in Fulanis resident in Nigeria. In addition, Akinlolu *et al*.[8] reported one-dimensional cephalometry on the positional relationships of the ear to facial midline landmarks in Yorubas of Nigeria. However, data on ear biometrics and positional relationships to the eyes, nose and mouth of Fulanis and Yorubas of Nigeria are not yet available in literature. Therefore, in-order to further provide missing normative reference cephalometrics data in literature, this study examined three-dimensional digital cephalometry biometrics of the ear and the positions of the ear in relations to facial midline landmarks, eyes, nose and mouth of Fulanis and Yorubas who are co-residents in Ilorin, Kwara State in the North Central region of Nigeria.

Materials and Methods

Ethics statement

This research work was approved by the University of Ilorin Ethical Review Committee (UERC) with approval number; UERC/ASN/2018/1261. Experimental procedures were carried out in accordance with the National Ethics and Operational Guidelines for Research on Human Subjects, the Number code (1947); the World Medical Association Declaration of Helsinki (1964) and its amendments, the Helsinki Declaration of 1975, as revised in 2000 and the Council of International Organization of Medical Sciences (CIOMS) guidelines of 1993 as stated on the research policy of the UERC. In addition, every effort was made to follow all local and international ethical guidelines and laws that pertain to the use of humans in anatomical research[11].

Determination of sample size and samples collection

Fifty healthy and unrelated males (25 Fulanis and 25 Yorubas) were selected from volunteers amongst individuals of Fulani and Yoruba ethnic groups resident in Ilorin, Kwara State using purposive random sampling technique[12-16]. The purposive random sampling technique is applied when the sample size is completely dependent on volunteers for the study in experimental procedures considered invasive such as taking ear and facial photographs[12-16]. This is because individuals do not easily want to have their ear and facial identities captured and recorded by others. Hence, only the few individuals who consented to volunteer for this study were used as subjects for the study. Individuals with congenital anomalies, trauma, tumour, or any history of previous surgery to the pinna/ear were excluded from the study.

The aims and objectives of the study were verbally explained to all subjects. Consent forms were distributed to the volunteers to seek their informed consent, and each subject signed the Consent Form to indicate given approval. Data on age in years, height in meters, bodyweight in kilograms and ear and facial photographs were obtained from each subject only when confirmed as Fulanis and Yorubas by three generations (parents and grandparents).

Procedures for taking facial photographs

I. At the photometry point, a 300 mm square box was marked on a white cardboard behind the head of each subject with which the subject's ear and facial photographs were taken.

II. Two reference points of a linear distance of 300 mm were manually marked on the square box.

III. The subjects were asked to remove any visible ear and facial accessories that can obscene the faces.

IV. The head of each subject was adjusted to anatomical position.

V. The subjects were asked to look straight and forward as the pictures were taken.

VI. A 900 mm distance was ensured from the camera standing point to the photometry point.

VII. The pictures were taken with the aid of a 3D digital camera held on a camera tripod stand with adjustable height, while the camera was fixed to the height of each subject.

Definitions of cephalometric landmarks of the ear and face as presented in Figure 1

Superaurale (sa): The most superior projection of the helix[17-20].

Subaurale (sba): The most inferior projection of the ear lobule[17-21].

Otobasion superius (obs): It is the point of attachment of the helix in the temporal region. It determines the upper border of the ear insertion[17,19,20,22].

Otobasion inferius (obi): It is the point of attachment of the ear lobe to the cheek. It determines the lower border of the ear insertion[17,19-22].

Ear Width: The maximum breadth or width of the ear determined on an imaginary line drawn perpendicular to the long axis of the external ear joining the most posterior point to the most anterior point of the ear[20].

Tragus (t): It was derived from the Greek word tragos (goat). It is the small pointed eminence of the external ear located anterior to the concha and which projects backward over the meatus[1,20].

Exocanthion (ex): It is the soft tissue point situated at the outer commissure of each eye fissure[20,23.]

Nasion (n): It is the point in the midline of both the nasal root and the naso-frontal suture. The slight ridge

on which it is situated can be felt by the observer's fingernail. This point is above the line that connects the two inner canthi[15,17,18,21,24].

Subnasale (sn): The point on the living body where the nasal septum between the nostrils merges with the upper cutaneous lip in the midsagittal plane[15,17,18,21,24].

Cheilion (ch): It is the point located at each labial commissure[17,18,21,25].

Gnathion (gn): It is the lowest median landmark on the lower border of the mandible and is the lowest point used in measuring facial height. It is identified by palpation and is identical to the bony gnathion. It is also referred to as the Menton[17,18,20,21,25].

Figure 1. Cephalometric features and landmarks of the Ear.
1. Helix, 1a. Crus Helicis
2. Lobule
3. Scaphoid Fossa
4. Antihelix, 4a and 4b. Crura Antihelicis
5. Triangular Fossa
6. Antitragus
7. Concha
8. Incisure Intertragica
9. Tragus
10. Opening of External acoustic meatus.
sa - superaurale, sba - subaurale, obs - otobasion superius and obi - otobasion inferius.

Cephalometric evaluations of dimensions of the ear

Distances of the Ear Length (superaurale to subaurale), Ear Width (maximum width of the ear), Concha Length, Concha Width, Lobule Length and Lobule Width were computed in this study (Figure 1.1.). Ear Index (EI) was calculated as the percentage proportion of Ear Length to Ear Width.

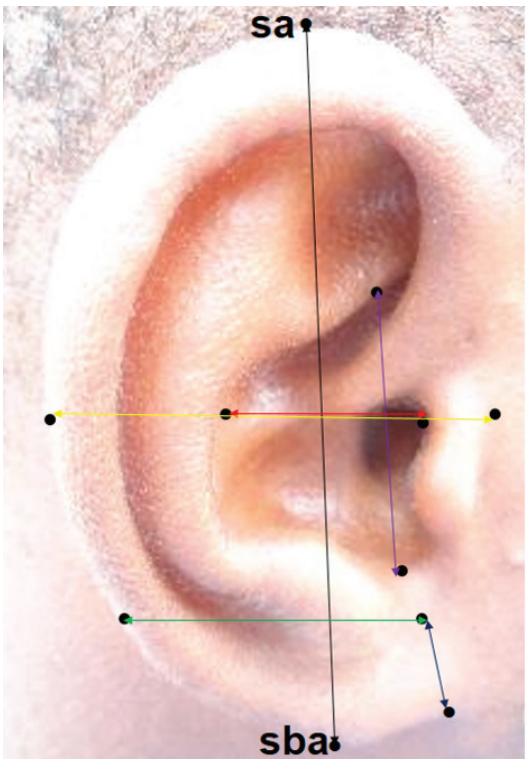

Figure 1.1. Biometric measurements of Ear dimensions.
Dark solid line – Ear Length or Height, Yellow solid line – Ear Width or Breadth, Purple solid line – Concha Length, Red solid line – Concha Width, Blue solid line – Lobule Length or Height and Green solid line – Lobule Width or Breadth.

Biometric evaluations of position of the ear to the eyes

Distances of the Otobasion superius (obs) to Exocanthion (ex), Otobasion inferius (obi) to Exocanthion (ex) and Tragus (t) to Exocanthion (ex) were computed in this study (Figure 2).

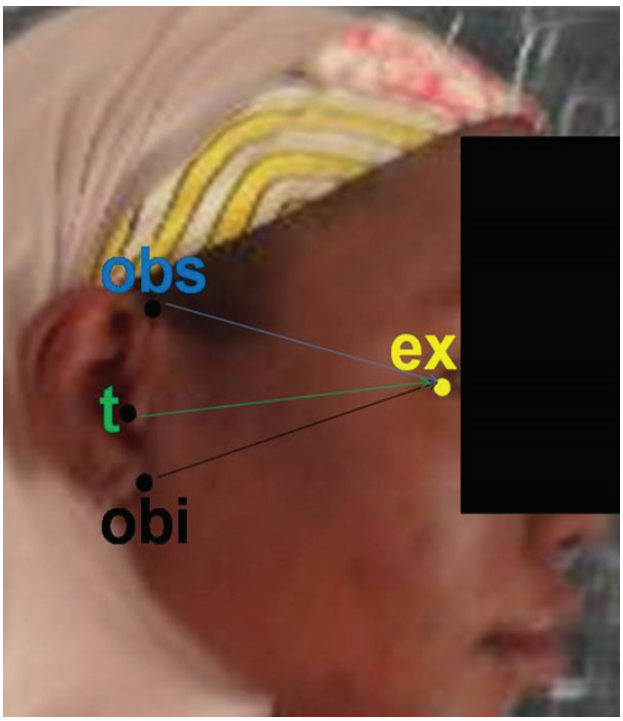

Figure 2. Biometric measurements of the position of the Ear in relation to the Eyes.
obs – otobasion superius, obi – otobasion inferius, t – tragus and ex – exocanthion.

Biometric evaluations of position of the ear to the mouth

Distances of the Otobasion superius (obs) to Cheilion (ch), Otobasion inferius (obi) to Cheilion (ch) and Tragus (t) to Cheilion (ch) were computed in this study (Figure 3).

Biometric evaluations of position of the ear to the nose and facial midline landmarks

Distances of the Otobasion superius (obs) to Nasion (n), Otobasion superius (obs) to Subnasale (sn) and Otobasion superius (obs) to Gnathion (gn) were computed in this study (Figure 4). In addition, distances of the Otobasion inferius (obi) to Nasion (n), Otobasion inferius (obi) to Subnasale (sn) and Otobasion inferius (obi) to Gnathion (gn) were computed in this study (Figure 4). Furthermore, distances of the Tragus (t) to Nasion (n), Tragus (t) to Subnasale (sn) and Tragus (t) to Gnathion (gn) were computed in this study (Figure 4).

Procedures for calculating cephalometric measurements

On the ear and facial images, the selected cephalometric landmarks were identified based on definitions of such landmarks from existing literatures (Akinlolu, 2016a-d), and marked using Adobe photoshop (CS6) brushes. The two referenced points which represent the distance of 300 mm were equally marked using Adobe photoshop (CS6) brushes. The number of pixels across the two reference points represented the given distance and was then used to determine the actual life size or distance between any other two points of ear and facial parameters detected on the image using trigonometric and geometric theories. Since some of the points were not at the same horizontal or vertical levels, the actual distance was converted using the pixels of the two reference points and their computed distance as read by the Adobe Photoshop (CS6). The size of each image was divided by 2 to reduce the image size on the Adobe Photoshop (CS6) before conversion.

For example, the Ear Length is defined as the linear distance between the Trichion and Gnathion. The TFH computed by the Adobe Photoshop (CS6) was converted to actual life size or distance as follows:

Manually computed distance between the two reference points (X): = 300 mm.

Computed distance X using Adobe Photoshop (CS6): = 649.8 mm.

Computed Ear Length distance between selected two anthropometric reference points using Adobe Photoshop (CS6): = 222.3 mm.

Conversion of computed Ear Length distance to life size: = 300 X 222.3/649.8 mm = 102.63 mm.

Finally, the result was divided by two to reduce the large image size = 102.63/2 = 51.3 mm.

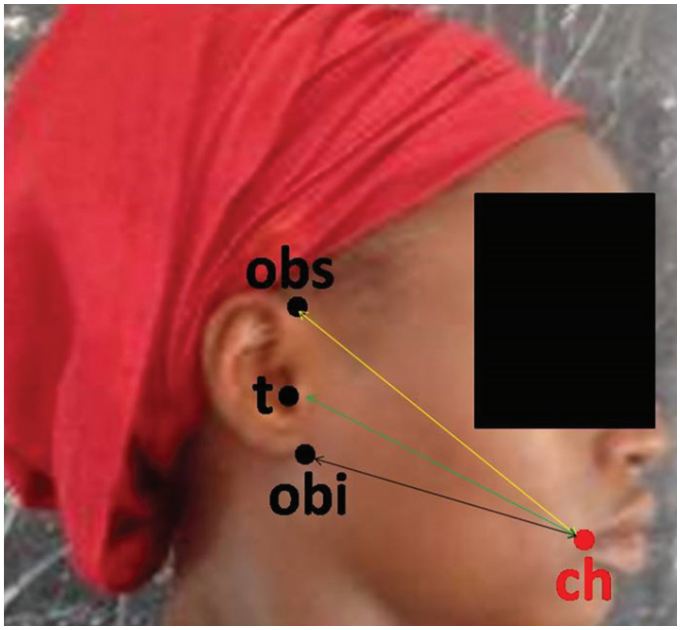

Figure 3. Biometric measurements of the position of the Ear in relation to the Mouth.
obs – otobasion superius, obi – otobasion inferius, t – tragus and ch – cheilion.

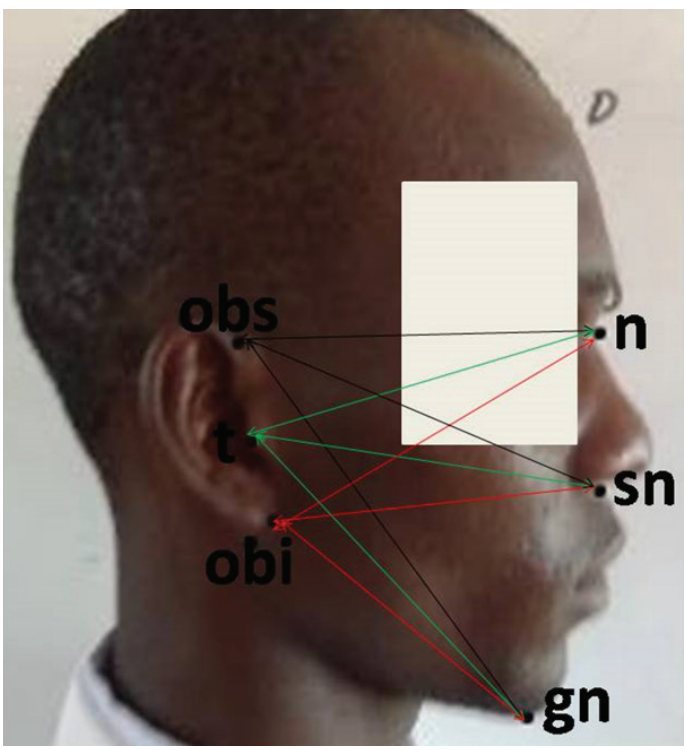

Figure 4. Biometric measurements of the position of the Ear in relation to facial landmarks.
obs – otobasion superius, obi – otobasion inferius, t – tragus, n – nasion, sn – subnasale and gn – gnathion.

Statistical analysis

Computed data were statistically analyzed using the statistical package for the social science software (SPSS Statistics version 23.0) developed by the International Business Machines Corporation (IBM). Data were presented as Mean ± Standard Deviation (SD) with determination of level of significance at p-values ≤ 0.05.

Results

Age, Height, Bodyweight and Body Mass Indices of Fulanis and Yorubas

The Age, Bodyweight and Height for Fulani subjects range from 20 - 80 years, 51 – 66 Kg and 1.57 - 1.81 m respectively. The mean values for Age and Body Mass Index for Fulanis were 35.20 years and 20.41 Kg/m^2 respectively. The Age, Bodyweight and Height for Yoruba subjects ranged from 20 – 25 years, 51 - 81 Kg and 1.60 - 1.84 m respectively. The mean values for Age and Body Mass Index for Yorubas were 21.87 years and 21.62 Kg/m^2 respectively.

Comparative analyses of ear dimensions between Fulanis and Yorubas

Statistical analyses of right Ear dimensions showed significant lower mean values ($p \leq 0.05$) in all 6 parameters (Ear Length, Ear Width, Concha Length, Concha Width, Lobule Length and Lobule Width) in Fulanis compared with Yorubas (Tables 1 and 2). In addition, statistical analyses of left Ear dimensions showed significant lower mean values ($p \leq 0.05$) in 5 out of 6 parameters (Ear Length, Ear Width, Concha Length, Lobule Length and Lobule Width), but non-significant higher mean value ($p > 0.05$) of Concha Width in Fulanis compared with Yorubas (Tables 1 and 2). Furthermore, the right Ear Index of Fulanis was lower than those of Yorubas (Tables 1 and 2). In contrast, the left Ear Index of Fulanis was higher than those of Yorubas (Tables 1 and 2).

Comparative biometric evaluations of position of the ear to the eyes between Fulanis and Yorubas

Statistical analyses of right and left Ear dimensions showed significant lower mean values ($p \leq 0.05$) in all 3 parameters (Otobasion superius to Exocanthion, Otobasion inferius to Exocanthion and Tragus to Exocanthion in Fulanis compared with Yorubas (Table 3).

Table 1. Three-dimensional biometrics of ear dimensions in Fulanis and Yorubas.

Cephalometric Parameters	Fulani Subjects (Right Ear) Mean ± SD	Yoruba Subjects (Right Ear) Mean ± SD	Fulani Subjects (Left Ear) Mean ± SD	Yoruba Subjects (Left Ear) Mean ± SD
Ear Length	57.5 ± 5.3	64.2 ± 3.9	54.9 ± 6.7	66.0 ± 3.7
Ear Width	27.7 ± 3.7	34.3 ± 3.1	28.9 ± 2.8	33.5 ± 2.7
Ear Index = Ear Width/Ear Length X 100	48.3 ± 5.8	53.5 ± 5.4	53.5 ± 8.6	50.9 ± 4.9
Concha Length	24.5 ± 2.8	28.0 ± 6.7	23.7 ± 3.6	28.0 ± 3.2
Concha Width	13.9 ± 2.2	17.8 ± 4.6	15.0 ± 2.3	17.3 ± 2.5
Lobule Length	11.6 ± 2.0	14.2 ± 2.8	12.1 ± 2.2	14.9 ± 2.5
Lobule Width	11.9 ± 2.1	17.1 ± 4.6	11.2 ± 16	15.4 ± 2.3

Table 2. Three-dimensional biometrics of ear dimensions in Fulanis and Yorubas in comparison with other ethnic groups.

Cephalometric Parameters	Fulani Subjects	Yoruba Subjects	Benin Males[9]	Igbo Males[9]	Ghana Males[3]	Indians[26]	Caucasians[26]	Afro-Carribeans[26]
Right Ear Length	57.5 ± 5.3	64.2 ± 3.9	58.5 ± 4.9	56.0	58.97 ± 3.50			
Left Ear Length	54.7 ± 6.7	66.0 ± 3.7	58.6 ± 5.2	55.7	58.27 ± 3.77	68.9	65.2	62.7
Right Ear Width	27.7 ± 3.74	34.3 ± 3.1	34.0 ± 4.9		32.47 ± 3.10			
Left Ear Width	28.95 ± 2.8	33.5 ± 2.7	33.3 ± 4.8		32.80 ± 2.23	36.0	34.4	33.8
Right Ear Index	48.3 ± 5.8	53.5 ± 5.4						
Left Ear Index	53.5 ± 8.6	50.9 ± 4.9						
Right Concha Length	24.5 ± 2.8	28.0 ± 6.7						
Left Concha Length	23.7 ± 3.6	28.0 ± 3.2						
Right Concha Width	13.9 ± 2.2	17.8 ± 4.6						
Left Concha Width	15.0 ± 2.3	17.3 ± 2.5						
Right Lobule Length	11.6 ± 2.0	14.2 ± 2.8	15.9 ± 3.6	14.0	14.18 ± 2.07			
Left Lobule Length	12.1 ± 2.2	14.9 ± 2.5	15.8 ± 3.3	14.0	14.35 ± 2.80			
Right lobule Width	11.9 ± 2.1	17.1 ± 4.6	17.2 ± 4.2		15.47 ± 2.29			
Left Lobule Width	11.2 ± 1.6	15.4 ± 2.3	17.2 ± 4.0		15.63 ± 2.49			

Table 3. Three-dimensional biometrics of distances of the ear to the eyes, nose, mouth and facial midline landmarks in Fulanis and Yorubas.

Cephalometric paramaters	Fulanis (right ear)	Yorubas (right ear)	T-test	Fulanis (left ear)	Yorubas (left ear)	T-test
obs - ex	62.82±5.93	77.05±6.10	0.00	62.81±6.2	74.11±5.48	0.00
t - ex	73.54±6.19	82.40±5.45	0.00	73.68±5.4	81.69±4.33	0.00
obi - ex	84.16±7.1	90.87±6.0	0.001	85.60±6.0	91.05±5.8	0.003
obs - ch	96.76±10.4	126.37±9.1	0.00	95.63±10.09	117.62±7.91	0.00
t - ch	91.81±9.46	116.57±8.8	0.00	91.67±8.1	110.21±7.4	0.00
obi - ch	87.48±8.6	108.23±7.2	0.00	88.10±7.15	103.25±7.2	0.00
obs - n	103.94±11.86	125.47±11.23	0.00	107.98±10.7	118.73±9.71	0.001
obs - sn	117.60±9.6	142.93±12.6	0.00	117.84±10.2	135.83±9.4	0.00
obs - gn	127.56±10.38	155.20±11.23	0.00	131.58±11.5	146.26±10.12	0.00
t - n	119.89±11.63	134.14±8.37	0.00	124.53±11.35	131.82±10.02	0.023
t - sn	116.19±12.11	139.29±10.56	0.00	119.15±12.9	133.08±8.8	0.00
t - gn	117.94±11.0	139.33±10.82	0.00	120.77±12.81	133.33±7.45	0.00
obi - n	120.78±11.78	133.85±9.9	0.00	126.19±10.54	131.24±8.02	0.069
obi - sn	103.19±12.5	122.42±8.5	0.00	108.31±11.46	121.93±11.4	0.00
obi - gn	110.91±13.24	135.88±10.84	0.00	114.48±11.45	127.86±11.35	0.00

Comparative biometric evaluations of position of the ear to the mouth between Fulanis and Yorubas

Statistical analyses of right and left Ear dimensions showed significant lower mean values ($p \leq 0.05$) in all 3 parameters (Otobasion superius to Cheilion, Otobasion inferius to Cheilion and Tragus to Cheilion in Fulanis compared with Yorubas (Table 3).

Comparative biometric evaluations of position of the ear to the nose and facial midline landmarks between Fulanis and Yorubas

Statistical analyses of right and left Ear dimensions showed significant lower mean values ($p \leq 0.05$) in 8 out of 9 parameters (Otobasion superius to Nasion, Otobasion superius to Subnasale, Otobasion superius to Gnathion, Tragus to Nasion, Tragus to Subnasale, Tragus to Gnathion, Otobasion inferius to Nasion and Otobasion inferius to Gnathion in Fulanis compared with Yorubas (Table 3). However, there was non-significant lower mean values ($p > 0.05$) in Otobasion inferius to Subnasale in Fulanis compared with Yorubas (Table 3).

Discussion

The computed bodyweight, height and BMI in this study implied that the Fulanis subjects were of lower bodyweight and height compared with those of Yoruba subjects. In addition, both Fulanis and Yorubas had normal BMI classification with values between 18.5 and 25.0.

In Fulani males, the right ear dimensions of Ear Length, Concha Length and Lobule Width were slightly longer than their counterpart left ear dimensions. In contrast, the right ear dimensions of Ear Width, Concha Width and Lobule Length were slightly shorter than their counterpart left ear dimensions. However, in Yoruba males, the left ear dimensions of Ear Length and Lobule Length were slightly longer than their counterpart right ear dimensions with few points. The Concha Length were the same for the right and left ears of Yoruba males. In contrast, the left ear dimensions of Ear Width, Concha Width and Lobule Width were slightly shorter than their counterpart right ear dimensions (Tables 1 – 3). The non-significant bilateral assymmetry in ear dimensions between right and left ears in the present study is similar to those of one-dimensional studies in males of Benins and Igbos of Nigeria as reported by Oludiran and Omotoso[9], and those of Ghanaians reported by Fakuu *et al.*[3]. Furthermore, the computed ear dimensions in this study implied that the Fulani males have shorter right and left ear dimensions compared with Yoruba males in the present study (Tables 1 - 3).

In comparison with other African ethnic groups within and outside Nigeria, computed right and left ear dimensions of Ear Length, Ear Width, Lobule Length and Lobule Width of Fulani males in the present study were shorter than those of one-dimensional studies in males of Benins[9] and Ghanaians[3] as presented in Table 2. In contrast, the right and left ear dimensions of Ear Length and Ear Width of Yoruba males in the present study were longer than those of males of Benins[9], while the right and left ear dimensions of Lobule Length and Lobule Width in Yoruba males were shorter than those of males of Benins[9] (Table 2). Furthermore, computed right and left ear dimensions of Ear Length, Ear Width

and Lobule Length of Yoruba males in the present study were longer than those of Ghanaian males[3] as presented in Table 2. However, for computed right Lobule Width was longer in Yoruba males than those of Ghanaian males[3] while the Left Lobule Width was shorter in Yoruba males than in Ghanaian males[3] as presented in Table 2.

In comparison with ethnic groups outside Africa, the Left Ear Length and Left Ear Width of Fulani males computed in this study were shorter than those of males of Indians, Caucasians and Afro-Carribeans reported by Alexander *et al*,[26] as presented in Table 2. In contrast, the Left Ear Length and Left Ear Width of Yoruba males computed in this study were shorter than those of males of Indians but longer than those of males of Caucasians and Afro-Carribeans reported by Alexander *et al*,[26] as presented in Table 2.

There is paucity of studies which examined the positions of the ear to the eyes, nose, mouth and antero-median aspects of the face in ethnic groups within and outside Nigeria. This is probably due to the expected long time consumption required to conduct such studies physically via one-dimensional cephalometry. Subjects are not likely to be patient enough for such studies to be conducted. Hence, the reported data in this study on the positions of the ear to the eyes, nose, mouth and antero-median aspects of the face in of Fulani males and Yoruba males in the present study were possible because the biometric measurements were computed on three-dimensional digital images.

The only data on one-dimensional study of the position of the ear to antero-median aspects of the face was in Yorubas of Nigeria reported by Akinlolu *et al*.[21]. Comparatively, the position of the upper border of right ear insertion to nasion (otobasion superius to nasion) in Yoruba males of the present study (125.47±11.23) was longer than those of Yoruba males (122.70±0.39) reported by Akinlolu *et al*.[22]. Similarly, the position of the lower border of right ear insertion to nasion (otobasion inferius to nasion) in Yoruba males of the present study (133.85±9.9) was longer than those of Yoruba males (126.70±0.37) reported by Akinlolu *et al*.[22]. In addition, the position of the upper border of right ear insertion to subnasale (otobasion superius to subnasale) in Yoruba males of the present study (142.93±12.6) was longer than those of Yoruba males (128.60±0.24) reported by Akinlolu *et al*.[21]. Similarly, the position of the lower border of right ear insertion to subnasale (otobasion inferius to subnasale) in Yoruba males of the present study (122.42±8.5) was longer than those of Yoruba males (116.40±0.64) reported by Akinlolu *et al*.[22].

For the position of the upper border of right ear insertion to the lowest median landmark on the lower border of the mandible (otobasion superius to gnathion) in Yoruba males of the present study (155.20±11.23) was longer than those of Yoruba males (144.60±0.35) reported by Akinlolu *et al*.[22]. Similarly, the position of the lower border of right ear insertion to the lowest median landmark on the lower border of the mandible (otobasion inferius to gnathion) in Yoruba males of the present study (135.88±10.84) was longer than those of Yoruba males (124.70±0.40) reported by Akinlolu *et al*.[22].

Conclusions

Overall, the findings of the present study provide novel three-dimensional biometric cephalometry of the positions of the ear to the eyes, nose, mouth and antero-median aspect of the face of Fulanis and Yorubas of Nigeria which are not available in literature. Generally, the Fulanis have shorter ear dimensions compared with the Yorubas, who are their co-residents in Ilorin in the North Central region of Nigeria.

Acknowledgements

The kind supports of Fulani and Yoruba subjects and those of laboratory staff members of the Department of Anatomy of University of Ilorin, Nigeria, are well acknowledged.

References

1. Moore KL, Agur AMR, Dalley AF. Clinically Oriented Anatomy. 5th ed. USA: Williams and Wilkins, Lippincott; 2006:887-912.
2. Garg K. BD Chaurasia's Human Anatomy. Regional and Applied (Dissection and Clinical). Head, Neck and Brain. 4th ed. India: CBS Publishers and Distributors, New Delhi; 2006:44-62.
3. Faakuu E, Abaidoo CS, Appiah AK, Tetteh J. Morphological study of the external ear among the Dagaabas in the upper west region of Ghana. Scient Afr 2020;8:e00408. https://doi.org/10.1016/j.sciaf.2020.e00408.
4. Sforza C, Menezes Mde. Three-dimensional face morphometry. Dental Press J Orthodont 2010;15(1):13-15.
5. Yan P. Ear biometrics in human identification [Ph.D. Dissertation]. Indiana: Department of Computer Science and Engineering, University of Notre Dame; 2006. http://www3.nd.edu/~kwb/PingYanPhD.pdf.
6. Yuan L, Mu ZM, Xu Z. Using ear biometrics for personal recognition. Advances in biometric person authentication. Computer Sci 2005;3781:221-228.
7. Abaza A, Ross A, Herbert C, Harrison MAF, Nixon MS. A survey on ear biometrics. ACM Comp Surv 2013;45(2):1-35.
8. Akinlolu AA, Sule N, Muhammed M, *et al*. Preliminary phylogenetics: Hausas, Igbos and Yorubas of Nigeria are closely related, and are externally related to Guinea, but are not closely related to Egypt, Israeli-Jews or Saudi-Arabia. Int J Anthropol 2021;36(3-4):223-263.
9. Oludiran OO, Omotoso DR. A morphometric study of the external ears at Benin City. Nigerian J Plastic Surg 2012;1-5. https://www.researchgate.net/publication/234023627.
10. Mustapha M, Firdausi Y, Aliyu IA, Ibrahim T, Ahmed I, Miko AM. Right and left ear asymmetry among Hausa adolescents in Zaria, Northwestern Nigeria. Bayero J Biomed Sci 2018;3(1):289-293.
11. Iwanaga J, Singh V, Takeda S, *et al*. Standardized statement for

the ethical use of human cadaveric tissues in anatomy research papers: Recommendations from Anatomical Journal Editors-in-Chief. Clinical Anat 2022;1-3. https://doi.org/10.1002/ca.23849.
12. Bacchetti P, Deeks SG, McCune JM. Breaking free of sample size dogma to perform innovative translational research. Sci Translat Medicine 2011;3(87):1-4.
13. Memon S, Fida M, Shaikh A. Comparison of different craniofacial patterns with pharyngeal widths. J Coll Physicians Surgeons Pak 2012;22(5):302-306.
14. Akinlolu AA. Facial biometrics of Yorubas of Nigeria using Akinlolu-Raji image-processing algorithm. J Med Sci 2016a;36:39-45.
15. Akinlolu AA. Nasal biometrics and nasofacial proportion in Hausas and Yorubas using Akinlolu-Raji image-processing algorithm. CHRISMED J Health Res 2016b;3:112-118.
16. Akinlolu AA. Facial biometrics using Akinlolu-Raji image-processing algorithm and anthropological facts which prove that Kebbi and Zamfara Hausas are Hausa Bakwai. Sub-Saharan Afr J Medicine 2016c;3:45-52.
17. Farkas LG. Anthropometry of the head and face. 2nd ed. Lippincott: Williams and Wilkins, Raven Press; 1994:3-56.
18. Farkas LG, Katic MJ, Forrest CR, *et al*. International anthropometric study of facial morphology in various ethnic groups/races. J Craniofacial Surg 2005;16(4):615-646.
19. Ekanem AU, Garba SH, Musa TS, Dare ND. Anthropometric study of the pinna (auricle) among adult Nigerians resident in Maiduguri metropolis. J Med Sci 2010;10:176-180.
20. Akinlolu AA. Ear and facial biometrics of Hausas and Yorubas using a novel image-processing algorithm for forensic face recognition [Ph.D. Thesis]. Ilorin: Department of Anatomy, University of Ilorin, Nigeria; 2016d.
21. Porter PJ, Olson KL. Anthropometric facial analysis of the African American woman. Arch Facial Plastic Surg 2004;3:191-197.
22. Akinlolu AA, Akinola BO, Hussein AK. Position of the ear in relation to facial midline landmarks in Nigerians. Internet J Human Anat 2010;1(1):1-7. http://print.ispub.com/api/0/ispub-article/10497.
23. Gwen RJ, Swennen FACS, Jarg-Erich H. Three-dimensional cephalometry: a Colour atlas and manual. Germany: Springer Berlin Heidelberg; 2010:152-193.
24. Akinlolu AA, Atoyebi M, Akinola OB, Fatunke I, Jimoh R, Ajao MS. Sex and tribal differences in facial measurements of Nigerians of Yoruba, Hausa and Igbo origin. Res J Forensic Sci 2016;4 (1):5-11.
25. Akinlolu AA, Akinola BO, Nurudeen RL, Kadiri RE, Ajao MS. Cephalometric study of mouth morphology among major Nigerian tribes. Anatomy J Africa 2015;4 (1):496-504.
26. Alexander KS, Stott DJ, Sivakumar B, Kang N. A morphometric study of the human ear. J Plastic Reconstr Aesth Surg 2011;64:e41-e47.

Mini Curriculum and Author's Contribution

1. Akinlolu A.A. Qualification: BSc; MSc.; PhD. Contribution: Main contributor in writing the manuscript. Conceptualized, designed and supervised the experimental procedures, performed the experimental procedures, analyzed and interpreted the data, read and approved the final manuscript. Rank: Professor - ORCID: 0000-0002-2374-8754.

2. Anigilaje Y. Qualification: BSc. Contribution: Performed experimental procedures, performed the experimental procedures, analyzed and interpreted the data, read and approved the final manuscript. Rank: Former Undergraduate project student - ORCID: 0000-0002-2374-8754.

3. Ebito G. Qualification: BSc; MBBS, MSc. Contribution: Performed experimental procedures, analyzed and interpreted the data, read and approved the final manuscript. Rank: Research contributor and former postgraduate student - ORCID: 0000-0002-2374-8754.

Received: November 27, 2023
Accepted:December 13, 2023

Corresponding author
Adelaja Akinlolu
E-mail: adelaja.akinlolu@fuhso.edu.ng