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Anthropometric Analysis of Craniofacial Indices in Students of Yoruba Lineage: Implications for Clinical Medicine, Forensic Anthropology, and Ethnic Diversity

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ABSTRACT

Population-specific facial anthropometry is essential for cultural esteem, preservation of ethnicity, and advances in reconstructive medicine. This study focuses on craniofacial indices in students of Yoruba lineage. Using a questionnaire, biodata were collected from 2109 participants, aged 18 to 29 years, who were of Yoruba lineage and were without facial abnormalities. Amkov 3.0 Super AMOLED 24 Mega Pixel Digital Camera facilitated photography, and Digitalize image analysis software streamlined measurement and index analyses. Generated Data, including facial index (FI), nasal index (NI), canthal index (CI), and ear index (EI), were statistically analyzed using SPSS software version 21.0. FI findings revealed a prevalence of hyperleptoproscopic faces among males (98.0%) and females (97.9%). Males showed a higher mean FI than females, indicating sexual dimorphism and the influence of gender on facial morphology. According to the NI data, males (50.5%) and females (52.2%) had hyperplatin as the most common nose type. In NI, there was an evident sexual dimorphism, with males displaying higher mean values than females. Close eyes were shown to be the dominant form for both genders based on the CI values, with higher mean values in men also indicating sexual dimorphism. The EI results showed large ears were the most common, with sexual and age-specificity in mean values. The data presented here sheds considerable light on the craniofacial features of the Yoruba people, demonstrating how age and gender significantly influence facial dimensions. This research finds relevance in reconstructive medicine, forensic anthropology, and ethnic diversity studies.

Keywords: craniofacial indices, Yoruba population, sexual dimorphism, ethnic variations, normative data

INTRODUCTION

Anthropometry has been used as a valuable scientific instrument to help comprehend the biological diversity of humans, diagnose and treat medical disorders, aid in forensic identification, and, provide information on population genetics [1]. At the center of these anthropometric studies were craniofacial indices, which were derived from measurements of the face. Therefore, the latter offers a window into the complex differences that distinguish various groups[2].

Craniofacial indices are quantitative measurements from specific linear facial measurements that reflect the proportions and relationships among facial features [2,3]. The ratio of the face's width-to-height or facial index (FI) offers information about the general shape of the face [4]. Alternatively, plastic surgeons and other physicians involved in facial reconstruction might benefit significantly from the nasal index (NI), which provides information on nasal morphology [5,6]. In contrast, the canthal index (CI), representing the distance between the inner and outer canthi of the eyes, offers a measure of eye shape and positioning. Lastly, the ear index, derived from ear length and width measurements, contributes to understanding ear morphology. Numerous studies have shown that the forms and sizes of each component of the human facial cranium, like the external ear, are distinct[7,8]. It has been demonstrated by Krishan *et al*. that we can utilize morphological differences in the human ear for individual identification[9]. Murgod *et al*. evaluated the degree of sexual dimorphism in 300 young adult Indians by measuring linear measurements of the ear as well as sex-related characteristics of the ear shape and earlobe attachments[10]. They concluded their discovery could accurately identify a person's sex in up to 69.3% of male and 72% of female subjects[10]. These indices form a comprehensive set of metrics that encapsulate the complex variations in craniofacial features[11].

Various ethnic groups have different anthropometric parameters, which environmental variables, sex, and age12,13 can influence. The Yoruba population, one of the largest ethnic groups in Nigeria and West Africa, boasts a rich cultural heritage and a diverse genetic makeup[14]. Understanding the craniofacial indices within this population is essential for developing population-specific norms that scientists can apply in various medical and forensic contexts. Furthermore, identifying sexual dimorphism within these indices is critical for tailoring medical interventions, such as cosmetic surgery procedures, to the specific anatomical characteristics of individuals.

It is no longer acceptable to treat people of diverse races, cultures, or geographic areas in a "cookie-cutter" manner. The data about the facial features of the Yoruba population in Nigeria have not yet been thoroughly examined or in sufficient quantities to produce conclusions that can be statistically significant. Therefore, the clinical relevance of this study extends to the diagnosis and treatment of craniofacial abnormalities, where a nuanced understanding of population-specific norms is crucial. Plastic surgeons can benefit from tailored approaches that consider the inherent variations in facial features, enhancing the precision and efficacy of reconstructive procedures. In forensics, establishing normative data and recognizing sexual dimorphism within craniofacial indices offer valuable tools for biological profiling, facilitating accurate identification in medico-legal investigations.

This study aimed to add to the body of knowledge by providing in-depth anthropometric assessments of a representative sample of the Yoruba population, with a specific focus on the facial index (FI), nasal index (NI), canthal index (CI), and ear index (EI). Within the Yoruba ethnic group, we attempted to establish normative data for these craniofacial indices using facial pictures and exact linear measurements. Studying sexual dimorphism within these indices also illuminates the subtle differences between men and women, which is essential information for clinical medicine, plastic surgery, forensic medicine, genetics, biological profiling, and ethnic identification.

Figure 1: Map of Nigeria showing study area of Yoruba-speaking states: A) Lagos, B) Ogun, C) Ondo, D) Osun, E) Oyo, F) Kwara, G) Ekiti, and H) Kogi[14,15].

MATERIALS AND METHODS

Ethics

Ethical approval was sought and obtained from the University of Ilorin Ethical Review Committee (reference number UERC/ASN/2019/1694). Each participant consented after a careful explanation of the research and what the community and society stand to gain. We adopted qualitative and quantitative research approaches for this study by administering a questionnaire. The following ethical issues were considered in this study: beneficence, non-maleficence, autonomy, and justice.

Research equipment

2D photo-image analysis, Amkov 3.0 Super AMOLED 24 Mega Pixel Digital Camera (X4 Zoom), Digimizer software program (version 5.3.5, MedCalc, Belgium), vernier calipers, rulers, etc., Other materials include a tripod stand (DSLR camera holder), stadiometer rule (2-meter stature meter), and weighing scale (toughened glass electronic digital scale-LWG-2018A).

Study population

The study was conducted among University of Ilorin students of Yoruba sub-ethnic groups (Lagos, Ogun, Ondo, Osun, Oyo, Kwara, Ekiti, and Kogi) in Nigeria. The study population included males and females within the age range of 18 to 29 years. The biodata of 2,109 healthy and consented volunteers with no apparent facial abnormalities were collected using semi-structured, self-administered questionnaires.

Inclusion criteria

The volunteers were 18-29 years of age and were of pure Yoruba sub-ethnic groups, traced to their grandparents (by association to the third generation) recruited from the University of Ilorin with no obvious abnormality of the face, and consented to participate in the study.

Exclusion criteria

Participants with apparent facial abnormalities, such as cleft lips and palate; congenital conditions known to affect the head or face (e.g., hydrocephalus, holoprosencephaly); pronounced asymmetry of the face; a family history of craniofacial syndromes or facial anomalies; and participants with severe facial injuries in the past or family members from the same nuclear family were excluded from the study.

Landmarks *m*easured

We chose various landmarks following the method adopted by Farkas[28] and annotated by the Digitizer software (Figure 2). Twelve (12) linear craniofacial distances were digitally located and measured on each facial photograph image.

Table 1: Linear craniofacial measurements

1.	Nasal width	the maximum horizontal distance between the alae (al)
2.	Nasal height	straight distance between nasion (n) and sub nasale (sn)
3.	Vermillion height	vertical distance between labral-superiors-stomium (ls-sto) – labral-inferiors-stomium (li-sto)
4.	Mouth width	horizontal distance between cheillion (ch) – cheillion (ch)
5.	Mandible height	stomium(li-sto) – gnathion (gn)
6.	Mandible width	gonion (go) – gonion (go)
7.	Morphological facial height	nasion (n) – gnathion (gn)
8.	Bizygomatic distance	zygium (zy) –zygium (zy)
9.	Inter-endocanthal width	endocanthion (en) – endocanthion (en)
10.	Inter-exocanthal width	exocanthion (ex) – exocanthion (ex)
11.	Ear height	superaurale (sa) – subaurale (sba)
12.	Ear width	tragus (t) – postaurale (pa)

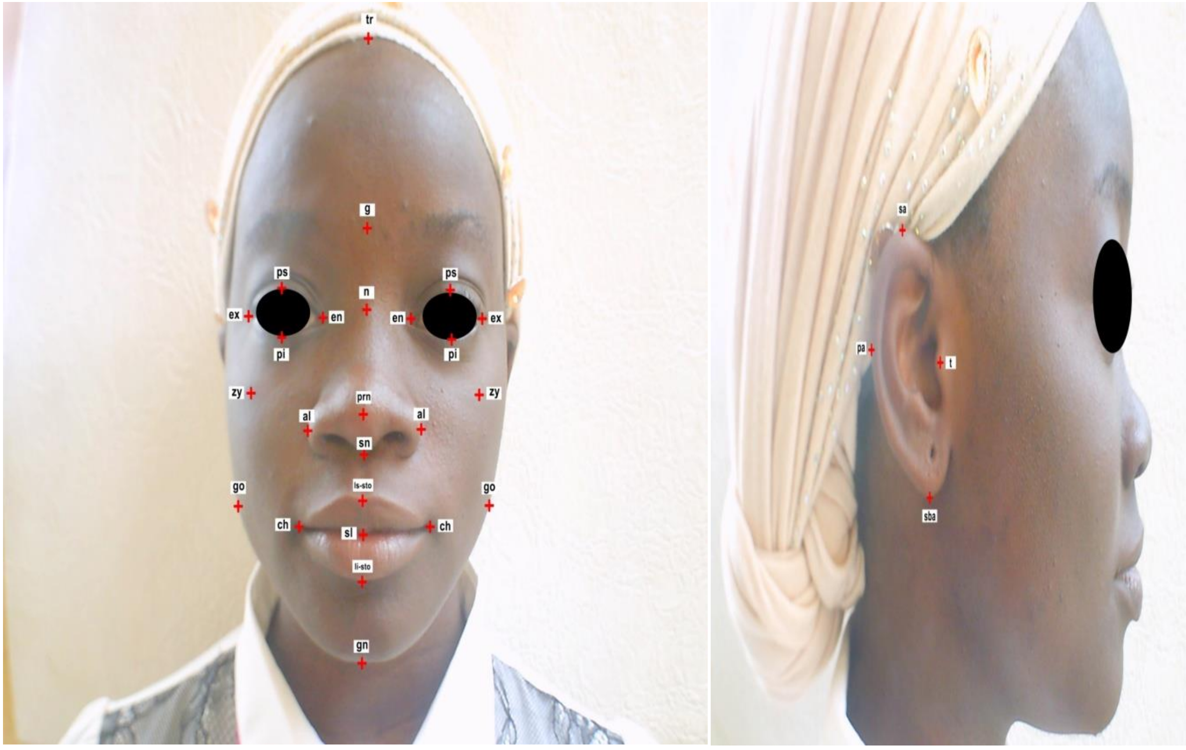

Figure 2: **Craniofacial annotations by the Digitizer software.** Glabella (g); Nasion (n); Endocanthion (en) L/R; Exocanthion (ex) L/R; Palpebraic superius (ps) L/R; Palpebraicinferius (pi) L/R; Pronasale (prn); Subnasale (sn); Alare (al); Labrale superius (ls); Labraleinferius (li); Cheillion (ch) L/R; Trichion (tr); Gonion (go); Superaurale (sa-); Subaurale (sba); Postaurale (pa); Palpebral superioris (ps); Palpebral inferioris (pi); Tragus (t), Gnathion (gn)

Furthermore, four (4) Craniofacial Indices were extracted from the measured linear distances (adopted from Barash *et al.*[16]):

1. **Morphological facial index (FI)** = $\frac{\text{Morphological facial height (n-gn)} \times 100}{\text{Bizygomatic width (zy-zy)}}$

2. **Nasal index (NI)** = $\frac{\text{Nasal width (al-al) x 100}}{\text{Nasal height (n-sn)}}$

3. **Ear index (EI)** = $\frac{\text{Ear width (t-pa)} \times 100}{\text{Ear height (sa-sb)}}$

4. **Canthal index (CI)** = $\frac{\text{Inter-endocanthal width (en-en) x 100}}{\text{Inter-exocanthal width(ex-ex)}}$

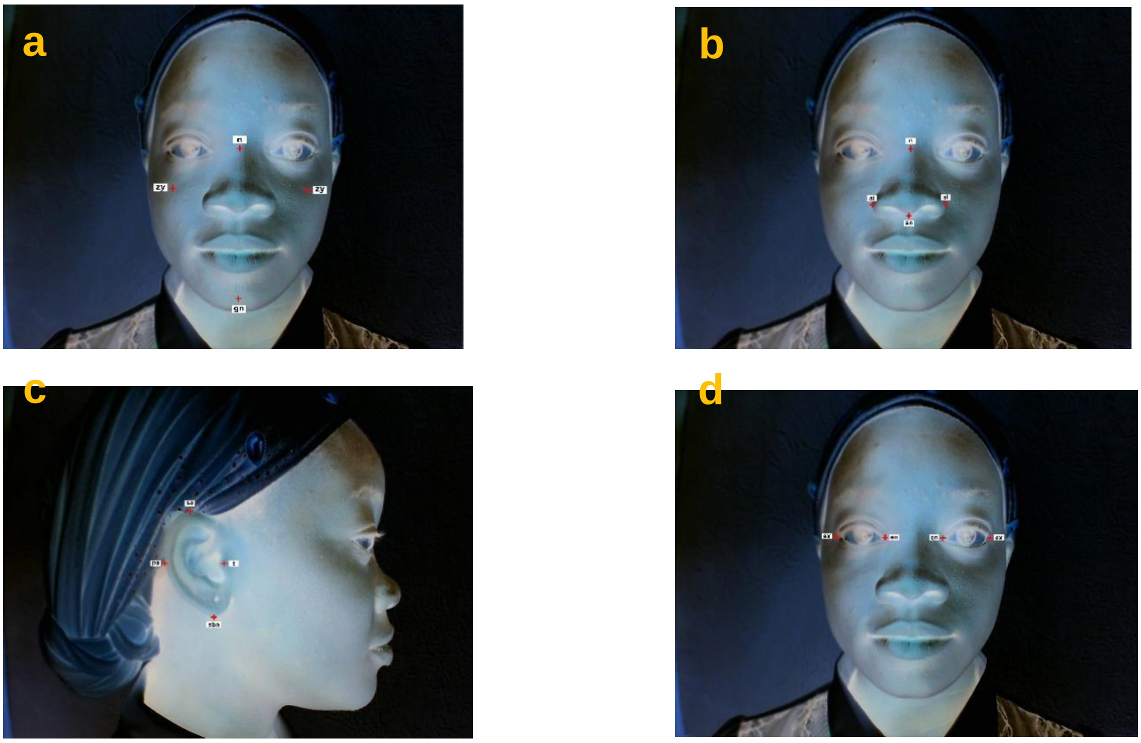

Figure 3: **Measured craniofacial indices.** (a) Facial index, (b) Nasal index, (c) Ear index, and (d) Canthal index.

Statistical Analysis

We utilized SPSS version 21 for data analysis. The distribution of patterns and demographic frequency were categorized precisely with descriptive statistics. At the same time, Pearson's Chi-square analysis test (confidence level of 95%) was used for the pattern's distribution difference, trends, and associations.

RESULTS

Morphological Categorization of Craniofacial Indices based on Gender in the Yoruba Population

The morphological categorization of the facial indices recorded in this study showed that a relatively higher percentage of the Yoruba males and females had hyperleptoproscopic (very long) faces compared to the other face types (Table 2), revealing no gender differences. In contrast to the monopolized facial type, nasal indices categorization showed that Yoruba males are mostly hyperplatyrrhine (50.5%) while females are primarily platyrrhine (52.2%) (Table 3). Like the face type, Eye type categorization in this study revealed no gender differences; nonetheless, the close-eye and intermediate-eye types were the dominant eye types for Yoruba males and females used for this study (Table 4). Lastly, male and female Yoruba populations had large ears, with a tiny percentage having medium or small ears (Table 5).

Table 2: Crosstab Gender (M/F) Facial Index Categorization.

		Hypereuryproscopic	Euryproscopic	Mesoproscopic	Leptoproscopic	Hyperleptoproscopic	Total
Gender (M/F)	Male	0_a 0.0%	0_a 0.0%	2_a 0.2%	15_a 1.7%	**848_a** **98.0%**	865 100.0%
	Female	1_a 0.1%	1_a 0.1%	4_a 0.3%	20_a 1.6%	**1217_a** **97.9%**	1243 100.0%
Total		1 0.0%	1 0.0%	6 0.3%	35 1.7%	**2065** **98.0%**	2108 100.0%

Each subscript letter denotes a subset of Facial Index categories whose column proportions do not differ significantly from each other at p≤0 .05

Table 3: Gender (M/F) Nasal Index Categorization

		Leptorrhine	Mesorrhine	Platyrrhine	Hyperplatyrrhine	Total
Gender (M/F)	Male	$0_{a,b}$	33_{b}	395_{b}	437_{a}	865
		0.0%	3.8%	45.7%	50.5%	100.0%
	Female	$1_{a,b}$	82_{b}	649_{b}	511_{a}	1243
		0.1%	6.6%	52.2%	41.1%	100.0%
Total		1	115	1044	948	2108
		0.0%	5.5%	49.5%	45.0%	100.0%

Each subscript letter denotes a subset of Nasal Index categories whose column proportions do not differ significantly from each other at p≤0 .05.

Table 4: Gender Canthal Index (CI)

		Close eye	Intermediate eye	Far apart eye
Gender (M/F)	Male	456_{a}	402_{a}	7_{a}
		52.7%	46.5%	0.8%
	Female	635_{a}	593_{a}	16_{a}
		51.0%	47.7%	1.3%
Total		1091	995	23
		51.7%	47.2%	1.1%

Each subscript letter denotes a subset of CI categories whose column proportions do not differ significantly from each other at p≤0.05.

Table 5: Gender Ear Index Classification

		Large ear	Medium ear	Small ear	No of participants
Gender (M/F)	Male	732_{a}	89_{b}	$23_{a,b}$	844
		86.7%	10.5%	2.7%	100.0%
	Female	1134_{a}	73_{b}	$20_{a,b}$	1227
		92.4%	5.9%	1.6%	100.0%
Total		1866	162	43	2071
		90.1%	7.8%	2.1%	100.0%

Each subscript letter denotes a subset of Ear Index categories whose column proportions do not differ significantly from each other at p≤0.05.

Morphological categorization of craniofacial indices based on age in the Yoruba population

The results showed that the hyperleptoproscopic (very long face) was the dominant face type, and the close and intermediate eye types were the prevalent eye types across all ages, revealing no age differences in both face and eye types (Tables 6 and 7). However, the categorization of nasal indices showed that participants across the age groups had platyrrhine and hyperplatyrrhine nose types as the dominant nose types (Table 3) and large ears as the dominant ear type. In contrast, medium or small ear types were seen in a few individuals.

Table 6: Crosstab Age Categorization of Facial Index.

		Hypereuryproscopic	Euryproscopic	Mesoproscopic	Leptoproscopic	Hyperleptoproscopic
Age Cat	15 - 19 years	1_a 0.1%	1_a 0.1%	3_a 0.3%	16_a 1.4%	1158_a 98.2%
	20 - 24 years	0_a 0.0%	0_a 0.0%	3_a 0.4%	18_a 2.1%	836_a 97.5%
	25 - 29 years	0_a 0.0%	0_a 0.0%	0_a 0.0%	1_a 1.4%	71_a 98.6%
Total		1 0.0%	1 0.0%	6 0.3%	35 1.7%	2065 98.0%

Table 7: Ear Index

		Large ear/ narrow & long	Medium ear	Small ear	No of participant
AgeCat	15 - 19 years	1043_a 90.3%	94_a 8.1%	18_a 1.6%	1155 100.0%
	20 - 24 years	759_a 89.9%	63_a 7.5%	22_a 2.6%	844 100.0%
	25 - 29 years	64_a 88.9%	5_a 6.9%	3_a 4.2%	72 100.0%
Total		1866 90.1%	162 7.8%	43 2.1%	2071 100.0%

Each subscript letter denotes a subset of Ear Index Cat categories whose column proportions do not differ significantly from each other at $p<0.05$

Potential Associations between Changes in Craniofacial Indices and Biological Phenotypes in the Yoruba Population

The result (Table 8) showed that morphological facial index (MFI) had a weak and significant positive correlation with weight, age, and height but a weak and significant negative correlation with BMI, while the nasal index (NI) showed a weak and significant positive correlation with weight and BMI, but there was no association with age and height; the intercanthal index (CI) had no correlation with age, height, weight, or BMI; and the ear index (EI) showed a weak and significant positive correlation with height and age, but there was no association with weight and BMI.

Table 8: Correlation between Biological data and Craniofacial indices

Biological data		**Morphological facial index**	**Nasal index**	**Canthal index**	**Ear index**	**Mean of biological data**
Age (years)	Pearson Correlation (r)	0.057*	0.030	0.005	0.051*	19.50
	p-value	0.009	0.170	0.814	0.021	
Height (M)	Pearson Correlation (r)	0.234**	0.039	0.007	0.070**	1.59
	p-value	0.000	0.070	0.739	0.001	
weight (Kg)	Pearson Correlation (r)	0.089**	0.070**	-0.022	0.039	58.43
	p-value	0.000	0.001	0.307	0.076	
BMI	Pearson Correlation (r)	-0.067*	0.045*	-0.029	-0.009	23.02
	p-value	0.002	0.040	0.187	0.684	

*=p<0.05; **=p<0.01; M=meters; Kg= kilograms; BMI= body mass index

DISCUSSION

In this study, a total of 2109 participants were involved, with a notable gender disparity - 1244 females compared to 865 males, establishing a ratio of 1.4:1. This discrepancy might be attributed to the higher turnout of females for the study or could be reflective of an uneven gender distribution during the recruitment session. Additionally, it's plausible that more females were admitted than males during the recruitment phase.

When the participants were categorized by age, adhering to the World Health Organization (WHO) standards, adolescents (15–19 years) constituted the largest group (1179), followed by young adults (20–24 years) with 858 participants, and adults (25–29 years) totaling 72 individuals, averaging an age of 19.5 years across all groups. This age classification aligns with Barash *et al*.[16], who posited that younger age minimally impacts facial morphology. In contrast, significant changes occur later in life, corroborating the observations by Bishara *et al*.[17] regarding facial morphological changes after the mid-twenties. The choice of these age groups is essential, particularly as earlier research has highlighted the rise of criminal behaviors during adolescence and early adulthood, coinciding with the predominant age groups in post-secondary institutions[18].

In this study, careful consideration was given to covariate factors such as weight, height, and body mass index (BMI) that could potentially yield false positive results. The calculated average BMI of 23.02 indicated that most participants fell within the normal weight range, minimizing the potential influence of BMI on the studied parameters. The results revealed that the canthal index (CI) and ear index (EI) exhibited no association with BMI. However, the facial index (FI) demonstrated a weak but significant negative correlation, while the nasal index (NI) displayed a weak but significant positive correlation with BMI. These findings diverge from Adhikari *et al*[19], who reported moderate to substantial relations between facial features and BMI, age, sex, and ancestry. The observed disparities might signify BMI, height, and fat distribution variations influenced by gender, age, and genetic factors[20].

Our investigation into the facial index (FI) disclosed that hyperleptoproscopic faces were the most prevalent among both Yoruba males (98.0%) and females (97.9%). A small fraction of participants exhibited other facial types. Strikingly, these results echoed findings by Okwesili *et al*.[21] among Igbo adolescents and adults[21], and Eliakim-Ikechukwu *et al*.[22] among Hausa males, indicating potential ethnic similarities in facial types. Nevertheless, discrepancies emerged with the findings of Omotoso *et al*.[23] and Eliakim-Ikechukwu *et al*.[22], highlighting the importance of methodological variations, including the use of photography versus calipers and differing landmarks for face length determination.

Comparing mean FI values between males (116.81±13.21) and females (113.64±14.55), our results suggested that males had a higher mean facial index than females. This observation concurred with Okwesili *et al*.[21], who reported similar sexual dimorphism among the Igbo population[21]. Notably, such differences underscore the impact of sexual and ethnic influences on facial morphology, emphasizing the significance of measurement methods.

Nasal index (NI) analysis unveiled hyperplatyrrhine as the predominant nose type in Yoruba males (50.5%) and females (52.2%). These findings align with previous studies among Yoruba and Igbo populations. Importantly, sexual dimorphism was evident, with males exhibiting higher mean NI values than females. Such normative data are crucial for rhinoplastic surgery, craniofacial anomalies, and ethnic identification.

Canthal index (CI) analysis indicated a prevalence of close eyes among Yoruba males (52.7%) and females (51.0%), with sexual dimorphism indicated by higher mean values in males. Our results corroborated previous findings from Adhikari *et al*.[19], Oladipo *et al*.[24], and Oziokoet *al*.[25], providing valuable normative data for evaluating craniofacial syndromes and aiding in the design of visual aids. Importantly, CI demonstrated no correlation with age, height, weight, or BMI, emphasizing its stability as a useful anthropometric measure. Nonetheless, higher outcomes in men may be because of differences in facial development brought on by genetics, ethnicity, environment, and climate.

Ear index (EI) analysis revealed large ears as the most common type among Yoruba males (86.7%) and females (92.4%), with sexual dimorphism evident in mean values. These findings were consistent with other global studies like Verma *et al*. in Northeast India[26], Sharma *et al*.[27] in Northern India, and Ozioko *et al*.[25] in Southeast Nigeria, emphasizing the impact of ethnic and racial differences on ear morphology. Notably, age consideration demonstrated that most participants across age groups exhibited large/narrow long ears, consistent with studies in other populations. The study's findings similarly aligned with the notion that the ear continues to grow throughout life, supporting the relevance of normative ear index data for craniofacial anomaly diagnosis and the design of hearing aids.

Comparative analysis of the study's findings with previous research underscored racial, ethnic, and sexual dimorphic variations across all anthropometric indices. These variations are essential considerations for clinicians, surgeons, and researchers in diverse fields, including forensic medicine, plastic surgery, and biological profiling.

Conclusively, this anthropometric study on the Yoruba population has yielded normative data on facial, nasal, canthal, and ear indices. The observed sexual dimorphism and ethnic variations in craniofacial features emphasize the importance of population-specific normative data for accurate clinical assessments. As these indices play a crucial role in individual identification, understanding their variations across populations is vital for practical and culturally sensitive applications in medical and anthropological contexts.

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