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Correlation of Craniofacial Parameters with Age Among Different Clans of Ebonyi State

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Abstract:

- ***Background:***

Craniofacial morphology is shaped by genetic, environmental, nutritional, and health factors, with sex, age, and ethnicity exerting strong influences. Nigeria's ethnic diversity provides a unique context for such studies, yet Ebonyi State remains understudied. This study aimed to establish normative craniofacial values for adults in Ebonyi State and to determine sex-, clan-, age-, and BMI-related differences.

- ***Methods:***

A cross-sectional design was employed with 1,317 participants aged 18–60 years drawn from seven major clans (Izzi, Ikwo, Ngbo, Ohaozara, Afikpo, Ishielu, Ezza). Body weight and height were measured using standardized scales, while 21 craniofacial parameters were assessed with calipers and tapes following Martin and Saller's protocols. Derived indices were computed. Data were analyzed using t-tests, ANOVA, Pearson's correlation, and regression models.

- ***Results:***

The population exhibited mesocephalic tendencies with mean head breadth 14.71 ± 0.71 cm, head length 18.29 ± 1.21 cm, and head height 20.53 ± 0.93 cm. Facial dimensions included face height 10.73 ± 1.06 cm and face width 12.87 ± 1.17 cm, while mandibular width averaged 11.64 ± 1.02 cm. Males consistently showed larger cranial and nasal dimensions (e.g., head breadth 15.03 ± 0.53 cm vs. 14.43 ± 1.03 cm, $p < 0.001$). Clan-specific differences were significant in head breadth (Ezza 14.83 ± 0.44 cm vs. Ishielu 13.38 ± 1.85 cm, $p < 0.001$), face width (Ikwo 13.30 ± 2.07 cm, $p < 0.001$), and maxillary height (Ngbo 5.91 ± 0.40 cm, $p < 0.001$). Age correlated positively with minimal frontal breadth ($r = 0.222$, p <

0.001), mandible width (r = 0.560, p < 0.001), and philtrum length (r = 0.542, p < 0.001), while BMI was associated with mandibular and frontal dimensions.

➢ ***Conclusion:***

This study establishes population-specific normative craniofacial values for Ebonyi State, demonstrating significant influences of sex, age, BMI, and clan. These findings provide essential baseline data for orthodontics, maxillofacial surgery, forensic anthropology, and reconstructive practice, contributing to diversifying craniofacial literature beyond Eurocentric norms.

Keywords: *Craniofacial, Orthodontics, Forensic, Dimorphism, Ethnic Variation, Ebonyi State.*

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I. INTRODUCTION

Craniofacial anthropometry is the scientific measurement of the dimensions of the face and cranium, and is a vital tool in biological anthropology, forensic science, and clinical practice. It includes cephalometry (living head) and craniometry (dry skull), which have long-standing traditions, dating back to the 19th century (Caldararo, 2022; Fforde et al., 2023; Franklin & Marks, 2022). Geographic, genetic, developmental, nutritional, and environmental factors mold the human face that can be a sensitive recorder of population history and health status (Abnavi et al., 2025; Jaiswal & Rana, 2024).

Nigeria has more than 250 ethnic groups and offers a special microenvironment for the study of craniofacial diversity. The South-East geopolitical zone is home to several clans of Ebonyi, namely the Izzi, Ikwo, Ngbo, Ohaozara, Afikpo, Ishielu and Ezza, all of whom are in different ecological zones and exposed to different diseases, altitudes, humidity and nutritional status (EWA et al., 2024; Nwofor et al., 2024). Despite this variety, the Ebonyi population has been understudied compared to other Nigerian populations like Yoruba and Igbo of Ogun and Anambra States, respectively (Femi-Akinlosotu et al., 2024; Ohazulike & Mathias, 2025).

That is why it is important to recognize that there is a lack of population-specific craniofacial data with practical implications. The use of non-local norms in clinical practice results in sub-optimal outcomes in orthodontics, maxillofacial surgery and prosthetic work. There is a risk of misidentification for forensic practitioners using foreign standards (Ahmed et al., 2023; Byers & Juarez, 2023). The present study was thus set up to collect a complete series of craniofacial measurements of the Ebonyi adult population along with the environmental and health factors associated with these measurements.

The primary aim of this study was to examine the relationship between craniofacial anthropometric parameters with age among adults of Ebonyi State with clan-specific norm value evaluation. The specific objectives of the study were to correlate the craniofacial morphology with the various environmental conditions (altitude, humidity, temperature) with health indicators (Haematological profiles, endemic disease exposure).

➢ *Based on this Background, the Following Hypotheses were Tested:*

- *The Null Hypothesis*

✓ H_01: There is no significant difference between craniofacial anthropometric parameters according to different selected clans in Ebonyi State.
✓ H_01: There is no significant association between health indicator (Age) and craniofacial anthropometric parameters.

II. MATERIALS AND METHODS

➢ *Study Design and Setting*

A cross-sectional community-based design was used because it allowed for obtaining craniofacial variation in a variety of ecological and ethnic groups at one time. The study area was narrowed down to Ebonyi State in the south-east of Nigeria, which is a place of ethnic multi-culturalism and ecological diversity. The state is made up of lowland river basin communities with high prevalence of malaria and deficient nutrition in contrast to the highland communities with reduced oxygen tension and exposure to cold stress. This environmental diversity allowed for the exploration of environmental and craniofacial morphology relationships in a natural laboratory (Babalola et al., 2026).

➢ *Study Population and Participant Selection*

The target population were adult males and females of age range 18-60 years of the major clans of Ebonyi State which are of Izzi, Ikwo, Ngbo, Ohaozara, Afikpo, Ishielu and Ezza. The participants were required to self-identify as members of one of the clans targeted, born within Ebonyi State and lived in their community of origin for not less than 10 years for the purpose of ensuring representativeness. Craniofacial pathology, previous craniofacial surgery and major craniofacial trauma were the exclusion criteria. The sampling method used was multi-stage sampling: first, wards were selected randomly within each clan; next, communities were systematically randomly selected within each ward; and last, one eligible adult was selected per household.

- *Sample Size Determination*

The sample size was calculated using the formula:

$$n = \frac{Z^2 \cdot \sigma^2}{d^2}$$

Where Z=1.96(95% confidence interval), σ=3.32(standard deviation of the cephalic index of a similar Nigerian population) and d=0.5(margin of error). The minimum sample per group was estimated as 170. With a 10% non-response rate, the number of respondents in each group was revised to a sample size of 188. The total number of participants targeted was 1,317, with seven ethnic groups studied. Of this number 1,215 (92.2%) were completed completely and were appropriate for analysis.

- *Data Collection Instruments*

There were two main parts to the data collection process. Standardized craniofacial measurements were made with spreading calipers, sliding calipers and measuring tapes in accordance with the methods of Martin and Saller (1957). The following parameters were measured: head length, head breadth, face height, bizygomatic breadth, bigonial breadth, nasal height, nasal width, orbital dimensions, philtrum length, mouth width and vermilion heights. Cephalic index, facial index, nasal index and orbital index were derived to classify craniofacial morphology.

- *Data Analysis*

The data were coded and analyzed using IBM SPSS version 31 and R statistical software where necessary. The craniofacial parameters were summarized by descriptive statistics. Analysis of variance (ANOVA) was used to compare age group and clan differences. To investigate association between the craniofacial parameters and age, Pearson correlational analyses were carried out.

- *Ethical Considerations*

Ethical approval was obtained from the Faculty of Basic Medical Science Ethical Committee of the University and informed consent was obtained from the subjects on enrolment. Every participant was informed that he/she would participate of his own choice and could withdraw at any time. All ethical guidelines were duly implemented.

III. RESULTS

- *Sociodemographic Profile:*

The majority (62.1%) of the respondents were in the age group of 20 years to 24 years with Ikwo (72.8%), Afikpo (73.6%) and Ohaozara (71.2%) having the highest proportions respectively. The number of participants below 20 years was 26.1% which was higher in Ngbo (46%) and Ezza (39.5%). The females were the most dominant with 70.0% of the participants, and Ikwo community had the highest number of females (83.5%), Ishielu (83.6%), and Afikpo (75.5%) while relatively higher number of males was obtained in Izzi (43.3%) and Ngbo (39.5%). Students were the majority of respondents (99.2%), while civil servants were only represented in a small percentage (0.8%) which is found only in Ngbo (4.8%) and Ohaozara (1.8%). When it comes to background, 16.7% said their grandparents were from the same town and Afikpo (23.2%) and Ezza (27.7%) had the highest rate of such.

- *Descriptive Anthropometric Profile:*

Participants' mean age was 21.66 years (SD ± 5.44) and ranged between 17 and 59 years. Clan-specific variations were evident, with Ngbo (Mean = 23.53, SD = 11.87) and Ohaozara (Mean = 22.91, SD = 7.08) showing wider age distributions, while Afikpo (Mean = 20.18, SD = 1.89) and Ishielu (Mean = 20.4, SD = 1.72) had narrower ranges. The average body weight was 65.29 kg (SD = 12.44), spanning from 41 kg to 122 kg. Ezza (Mean = 69.67, SD = 16.05) and Ikwo (Mean = 69.46, SD = 10.92) recorded the highest mean weights, whereas Ishielu had the lowest (Mean = 58.45, SD = 9.03). The mean body height of the participants was 166.74 cm (SD = 8.28) and ranged from 147 cm to 200 cm, Ikwo and Ngbo participants were the taller in mean height (Mean = 168.48 cm), while Ishielu participants were the shortest in mean height (Mean = 162.72 cm). The average Body Mass Index (BMI) was 23.53 kg/m² (SD = 4.57), ranging from 15 to 44 kg/m². Ezza (Mean = 25.17, SD = 5.83) and Ikwo (Mean = 24.65, SD = 4.39) had the highest mean BMIs, while Ishielu (Mean = 22.14, SD = 3.82) and Izzi (Mean = 22.79, SD = 4.25) recorded the lowest.

- *Comparative Result Craniofacial Characteristics Across Clans:*

There was a significant variation of inter-clan differences. Head height was lowest in Ishielu (19.70±1.26 cm) and highest in Ngbo (20.60±1.32 cm). Face height peaked in Ishielu (11.75±3.22 cm), face width in Ikwo (13.30±2.07 cm), and minimal frontal breadth in Ezza (10.25±1.10 cm). Maxillary height was greatest in Ngbo (5.91±0.40 cm) and lowest in Ikwo (4.91±1.38 cm). Mouth width was highest in Ezza (5.44±0.47 cm), upper lip length was highest in Ngbo (2.85±1.09 cm) while philtrum dimensions was highest in Ohaozara and Ngbo. The height of upper vermillion was highest in Ohaozara (1.57±1.79 cm) and lowest in Ezza (0.90±1.94 cm) while lower vermillion height was highest in Ezza (1.90±2.48 cm) and lowest in Ohaozara (1.19±2.35 cm).

Ocular measurements revealed that Izzi had the widest biocular distance of 10.01 ± 0.26 cm, Afikpo had the widest palpebral width of 3.73 ± 1.36 cm and Ngbo had the widest intercanthal distance of 3.68 ± 0.31 cm. Nasal features showed variation with Ohaozara having the highest tip protrusion (2.40±1.55 cm), Afikpo the widest nose (4.97±5.91 cm), Ikwo the tallest nasal height (4.32±0.39 cm) and Afikpo the longest bridge (4.29±0.99 cm). Ngbo recorded the widest alar base (4.13±0.33 cm) and nasal root breadth (3.30±0.45 cm). The alar thickness was significantly thickest in Ishielu (0.90±0.79 cm) and the alar softness was the widest in Ngbo (0.95±1.15 cm). There was no significant difference between right alar thickness.

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Table 1 Sociodemographic Characteristics of the Participants (N = 1215)

Characteristics	Izzi n (%)	Ikwo n (%)	Ngbo n (%)	Ohaozara n (%)	Afikpo n (%)	Ishielu n (%)	Ezza n (%)
Age Group (Years)							
<20	65 (21.8)	22 (21.4)	57 (46.0)	30 (13.3)	57 (25.9)	16 (23.9)	70 (39.5)
20-24	208 (69.8)	75 (72.8)	41 (33.1)	161 (71.2)	162 (73.6)	44 (65.7)	64 (36.2)
25 & above	25 (8.4)	6 (5.8)	26 (21)	35 (15.5)	1 (0.5)	7 (10.4)	43 (24.3)
Gender							
Female	169 (56.7)	86 (83.5)	75 (60.5)	157 (69.5)	166 (75.5)	56 (83.6)	130 (73.4)
Male	129 (43.3)	17 (16.5)	49 (39.5)	69 (30.5)	54 (24.5)	11 (16.4)	47 (26.6)
Occupation							
Student	298 (100)	103 (100)	118 (95.2)	222 (98.2)	220 (100)	67 (100)	177 (100)
Civil servant	0 (0.0)	0 (0.0)	6 (4.8)	4 (1.8)			
Grandparents from the same town							
Yes	47 (15.8)	14 (13.6)	9 (7.3)	24 (10.6)	51 (23.2)	9 (13.4)	49 (27.7)
No	251 (84.2)	89 (86.4)	115 (92.7)	202 (89.4)	169 (76.8)	58 (86.6)	128 (72.3)

Table 2 Descriptive Anthropometric Characteristics of the Participants

Clan	Characteristics	N	Minimum	Maximum	Mean	Std.
Izzi	Age	298	18	30	21.42	2.67
	Body weight (Kg)	298	42.5	86.6	63.44	10.27
	Body height (cm)	298	147.2	183	167.2	7.97
	BMI (Kg/m^2)	298	17.03	36.76	22.79	4.25
Ikwo	Age	103	19	25	21.42	1.84
	Body weight (Kg)	103	54.7	87.1	69.46	10.92
	Body height (cm)	103	149	200	168.48	10.79
	BMI (Kg/m^2)	103	19	32.09	24.65	4.39
Ngbo	Age	124	17	58	23.53	11.87
	Body weight (Kg)	124	46.9	103.8	67.45	15.82
	Body height (cm)	124	156	186	168.48	6.86
	BMI (Kg/m^2)	124	19.28	39.31	23.78	5.74
Ohaozara	Age	226	18	59	22.91	7.08
	Body weight (Kg)	226	44.9	99.7	63.8	12.43
	Body height (cm)	226	149	186	165.51	9.05
	BMI (Kg/m^2)	226	16.6	37.53	23.28	4.3
Afikpo	Age	220	17	25	20.18	1.89
	Body weight (Kg)	220	42.6	91.7	64.6	10.35
	Body height (cm)	220	150	186	166.73	8.58
	BMI (Kg/m^2)	220	17.07	33.28	23.28	3.62
Ishielu	Age	67	19	25	20.4	1.72
	Body weight (Kg)	67	41	70.04	58.45	9.03
	Body height (cm)	67	158	167	162.72	2.74
	BMI (Kg/m^2)	67	15.44	28.06	22.14	3.82
Ezza	Age	177	18	29	21.55	3.19
	Body weight (Kg)	177	48.8	121.5	69.67	16.05
	Body height (cm)	177	149	178	166.55	8.1
	BMI (Kg/m^2)	177	18.82	44.1	25.17	5.83

Table 3 Clan-Specific Normative Values for the Measured Craniofacial Parameters

Craniofacial	Izzi	Ikwo	Ngbo	Ohaozara	Afikpo	Ishielu	Ezza	F	P-Value
	Mean± SD	Mean± SD	Mean±SD	Mean±SD	Mean±SD	Mean± SD	Mean± SD		
Head Breadth	14.71 ± 0.71	14.79 ± 0.43	14.71 ± 0.85	14.62 ± 0.63	14.52 ± 1.15	13.38 ± 1.85	14.83 ± 0.44	27.08	<0.001
Head length	18.29 ± 1.21	18.45 ± 0.85	18.29 ± 0.83	18.18 ± 0.92	17.45 ± 2.53	17.81 ± 0.44	18.43 ± 0.94	12.58	<0.001

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head height	20.53 ± 0.93	20.66 ± 1.33	20.6 ± 1.32	20.56 ± 0.94	20.23 ± 1.13	19.7 ± 1.26	20.47 ± 0.99	8.7	<0.001
Face height	10.57 ± 0.69	10.65 ± 1.04	10.66 ± 0.66	10.58 ± 0.67	10.71 ± 0.81	11.75 ± 3.22	10.71 ± 0.69	12.74	<0.001
Face width	12.86 ± 0.66	13.3 ± 2.07	12.96 ± 0.87	12.75 ± 0.73	12.58 ± 0.71	12.35 ± 1.35	13.17 ± 0.79	13.84	<0.001
Minimal Frontal Breadth	9.89 ± 0.69	10.07 ± 0.3	10.15 ± 1.35	9.91 ± 0.62	9.84 ± 0.97	9.67 ± 0.74	10.25 ± 1.1	6.9	<0.001
Mandible width	11.77 ± 1.01	11.77 ± 0.69	11.65 ± 1.06	11.56 ± 1.04	11.43 ± 1.13	11.59 ± 0.94	11.59 ± 1.17	2.73	0.020
Mandible height	8.96 ± 1.07	8.94 ± 0.58	8.8 ± 0.99	8.76 ± 0.83	8.98 ± 0.86	8.62 ± 0.85	9.09 ± 1.28	3.61	0.010
Maxillary height	5.76 ± 0.32	4.91 ± 1.38	5.91 ± 0.4	5.61 ± 0.46	5.81 ± 0.41	5.58 ± 0.34	5.85 ± 0.41	44.24	<0.001
Mouth width	5.31 ± 0.37	5.13 ± 0.31	5.41 ± 0.35	5.35 ± 0.5	5.35 ± 0.37	5.35 ± 0.32	5.44 ± 0.47	7.57	<0.001
upper lips length	2.82 ± 1.15	2.53 ± 0.31	2.85 ± 1.09	2.53 ± 0.49	2.57 ± 0.34	2.4 ± 0.31	2.56 ± 0.39	7.78	<0.001
Philtrum width	0.96 ± 0.17	0.96 ± 0.27	1.03 ± 0.22	1.13 ± 0.54	1.1 ± 0.25	1.09 ± 0.31	1.06 ± 0.2	9.93	<0.001
Philtrum length	1.41 ± 0.58	1.21 ± 0.23	1.46 ± 0.59	1.4 ± 0.52	1.26 ± 0.28	1.21 ± 0.24	1.4 ± 0.35	7.08	<0.001
Upper vermillion height	1.11 ± 0.3	1.18 ± 0.19	1.1 ± 0.17	1.57 ± 1.79	1.34 ± 1.61	1.12 ± 0.12	1.04 ± 0.13	6.58	<0.001
Lower vermilion height	1.2 ± 0.19	1.2 ± 0.23	1.16 ± 0.14	1.13 ± 0.16	1.16 ± 0.13	1.12 ± 0.15	1.9 ± 2.48	14.82	<0.001
Biocular width	10.01 ± 0.26	9.97 ± 0.95	10.07 ± 0.45	9.5 ± 1.45	9.03 ± 2.18	9.77 ± 0.4	9.8 ± 1.69	15.26	<0.001
Ocular width/Palpebral width	3.44 ± 0.41	3.43 ± 0.19	3.52 ± 0.45	3.36 ± 0.3	3.73 ± 1.36	3.44 ± 0.38	3.58 ± 0.29	7.21	<0.001
Intercanthal width/intercanthal distance	3.58 ± 0.3	3.62 ± 0.35	3.68 ± 0.31	3.58 ± 0.27	3.43 ± 0.39	3.38 ± 0.29	3.63 ± 0.27	15.41	<0.001
Nasal tip protrusion	1.87 ± 0.42	1.93 ± 0.18	1.95 ± 0.26	2.4 ± 1.55	1.94 ± 0.51	1.76 ± 0.28	1.96 ± 0.26	14.04	<0.001
Nasal width	4.03 ± 0.31	4.1 ± 0.22	4.38 ± 0.37	4.99 ± 5.59	4.97 ± 5.91	4.06 ± 0.33	4.16 ± 0.41	2.96	0.010
Nose height/Nasal height	4.34 ± 0.35	4.32 ± 0.39	4.35 ± 0.27	4.32 ± 0.35	4.3 ± 0.46	4.14 ± 0.28	4.27 ± 0.29	3.66	0.010
Nasal bridge length	4.18 ± 0.44	4.19 ± 0.5	4.2 ± 0.38	4.15 ± 0.36	4.29 ± 0.99	4.01 ± 0.37	4.03 ± 0.26	4.75	<0.001
Alar base root breadth	3.84 ± 0.27	3.79 ± 0.24	4.13 ± 0.33	3.93 ± 0.31	3.66 ± 0.38	3.8 ± 0.35	3.96 ± 0.37	35.97	<0.001
Nasal root breadth	3.08 ± 0.34	2.92 ± 0.38	3.3 ± 0.45	3.07 ± 0.42	3.01 ± 0.42	3.14 ± 0.44	3.18 ± 0.3	13.38	<0.001
Left Alar thickness	0.57 ± 0.11	0.58 ± 0.1	0.63 ± 0.11	0.58 ± 0.08	0.68 ± 0.45	0.9 ± 0.79	0.6 ± 0.13	16.09	<0.001
Right Alar thickness	0.72 ± 0.83	0.62 ± 0.13	0.66 ± 0.11	0.63 ± 0.15	0.61 ± 0.09	0.64 ± 0.1	0.6 ± 0.15	2.09	0.060
Soft tip width	0.62 ± 0.12	0.62 ± 0.16	0.95 ± 1.15	0.6 ± 0.12	0.65 ± 0.09	0.62 ± 0.09	0.67 ± 0.2	13.67	<0.001

- *Correlation of Craniofacial Parameters with Age (Izzi Clan):*

There were several positive significant correlations with age in the craniofacial dimensions. Cranial breadth (head breadth) ($r = 0.482$, $P < 0.001$), head height ($r = 0.167$, $P = 0.004$) and minimal breadth of the forehead (minimal frontal breadth) showed positive correlation with age, suggesting that larger widths of the forehead and the cranium were observed in older participants. An elongation of midface structures was also seen in two other measurements: mouth width ($r = 0.122$, $P = 0.035$) and philtrum length ($r = 0.542$, $P < 0.001$). Orbital and nasal parameters demonstrated similar age-related growth, including biocular width ($r = 0.203$, $P < 0.001$), nasal width ($r = 0.123$, $P = 0.034$), left alar thickness ($r = 0.326$, $P < 0.001$), right alar thickness ($r = 0.146$, $P = 0.012$), and soft tip width ($r = 0.294$, $P < 0.001$). No significant correlation

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with age ($P > 0.05$) was found for the other craniofacial parameters.

- *Correlation of Craniofacial Parameters with Age (Ikwo Clan):*

In the Ikwo clan, there were several craniofacial measures that were positively correlated with age. Head breadth ($r = 0.271$, $p = 0.006$) was the other age-related variable, with larger head breadths in older participants. The width of the mandible increased with age ($r = 0.194$, $P = 0.049$), which indicates that the jaws got wider. There was a statistically significant positive correlation for philtrum width ($r = 0.289$, $P = 0.003$), which indicates the changes in the midface over time. The other parameters, namely: head length, face height, face width, minimal frontal breadth, mandible height, maxillary height, mouth width, biocular width, intercanthal distance, nasal tip protrusion, nasal bridge length and nasal root breadth, did not exhibit significant relations with age ($P > 0.05$).

- *Correlation of Craniofacial Parameters with Age (Ngbo Clan):*

For the Ngbo clan, several craniofacial measurements were positively and highly correlated with age. Head breadth ($r = 0.218$, $P = 0.015$) increased with age, alongside face width ($r = 0.287$, $P = 0.001$) and minimal frontal breadth ($r = 0.820$, $P < 0.001$). There was a significant increase in jaw size, and the width of the mandible ($r = 0.560$, $P < 0.001$) and the height of the mandible ($r = 0.514$, $P < 0.001$) were well correlated. Maxillary height ($r = 0.308$, $P < 0.001$) and mouth width ($r = 0.294$, $P = 0.001$) also increased with age. Midfacial and orbital structures demonstrated notable growth, including philtrum length ($r = 0.342$, $P < 0.001$), upper vermillion height ($r = 0.491$, $P < 0.001$), biocular width ($r = 0.827$, $P < 0.001$), and palpebral width ($r = 0.822$, $P < 0.001$). Nasal parameters expanded as well, with nasal tip protrusion ($r = 0.587$, $P < 0.001$), nasal width ($r = 0.485$, $P < 0.001$), alar base root breadth ($r = 0.416$, $P < 0.001$), and nasal root breadth ($r = 0.590$, $P < 0.001$) all showing significant positive correlations. No significant relationship of the other craniofacial parameters with age was found ($P>0.05$).

- *Correlation of Craniofacial Parameters with Age (Ohaozara Clan):*

Within the Ohaozara clan, there was a significant positive correlation between the various craniofacial dimensions and age. Head height ($r = 0.320$, $P < 0.001$), minimal frontal breadth ($r = 0.405$, $P < 0.001$), mandible width ($r = 0.335$, $P < 0.001$), maxillary height ($r = 0.385$, $P < 0.001$), mouth width ($r = 0.142$, $P = 0.033$), philtrum width ($r = 0.154$, $P = 0.021$), and philtrum length ($r = 0.376$, $P < 0.001$) all increased with age, reflecting cranial, mandibular, and midfacial expansion. Nasal-related parameters also showed significant correlations, with nose height ($r = 0.234$, $P < 0.001$), right alar thickness ($r = 0.132$, $P = 0.047$), and soft tip width ($r = 0.246$, $P < 0.001$) increasing with age. The other craniofacial parameters, head breadth, head length, face width, mandible height, upper lip length, vermillion heights, biocular width, nasal tip protrusion, nasal width, nasal bridge length, alar base root breadth, nasal root breadth and left alar thickness, did not have a significant relationship with age ($P > 0.05$).

- *Correlation of Craniofacial Parameters with Age (Afikpo Clan):*

In the Afikpo clan, a few craniofacial measurements were found to be significantly positively correlated with age. Cranial and facial breadth (head breadth $r = 0.203$, $P = 0.002$, face width $r = 0.200$, $P = 0.003$) increased linearly with age, suggesting that older individuals had larger crania and faces. Minimal frontal breadth ($r = 0.431$, $P < 0.001$), mandible width ($r = 0.267$, $P < 0.001$), and mouth width ($r = 0.157$, $P = 0.020$) also expanded with age, reflecting growth in the jaw and oral region.

- *Correlation of Craniofacial Parameters with Age (Ishielu Clan):*

For the Ishielu, multiple craniofacial measurements were positively correlated with age. Biocular width ($r = 0.335$, $P = 0.006$) rose, suggesting that older participants had wider orbits. Nasal parameters also expanded with age, including nasal tip protrusion ($r = 0.486$, $P < 0.001$), nasal width ($r = 0.372$, $P = 0.002$), nasal height ($r = 0.309$, $P = 0.011$), and nasal bridge length ($r = 0.300$, $P = 0.014$).

- *Correlation of Craniofacial Parameters with Age (Ezza Clan):*

For the Ezza clan, there were a number of craniofacial measurements that demonstrated strong positive correlations with age. Face width ($r = 0.299$, $P < 0.001$), minimal frontal breadth ($r = 0.359$, $P < 0.001$), mandible width ($r = 0.570$, $P < 0.001$), and mandible height ($r = 0.429$, $P < 0.001$) all increased, indicating expansion of jaw and facial breadth with age. Mouth width ($r = 0.244$, $P = 0.001$) also widened significantly. Nasal parameters demonstrated similar growth, with nasal width ($r = 0.451$, $P < 0.001$), alar base root breadth ($r = 0.540$, $P < 0.001$), and nasal root breadth ($r = 0.262$, $P < 0.001$) becoming broader with age. Both left alar thickness ($r = 0.287$, $P < 0.001$) and right alar thickness ($r = 0.195$, $P = 0.009$) increased as well.

Table 4 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Izzi Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	.482**	0.000	298
Head length	-.292**	0.000	298
head height	.167**	0.004	298
Face height	-0.068	0.242	298
Face width	-.127*	0.028	298
Minimal Frontal Breadth	.222**	0.000	298

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Mandible width	-.425**	0.000	298
Mandible height	-.705**	0.000	298
Maxillary height	-0.006	0.915	298
Mouth width	.122*	0.035	298
Upper lips length	-.181**	0.002	298
Philtrum width	0.107	0.064	298
Philtrum length	.542**	0.000	298
Upper vermillion height	-.183**	0.002	298
Lower vermilion height	-0.003	0.962	298
Biocular width	.203**	0.000	298
Ocular width/Palpebral width	-.232**	0.000	298
Intercanthal width/intercanthal distance	-.300**	0.000	298
Nasal tip protrusion	0.023	0.696	298
Nasal width	.123*	0.034	298
Nose height/Nasal height	-0.096	0.098	298
Nasal bridge length	0.008	0.897	298
Alar base root breadth	-0.022	0.705	298
Nasal root breadth	-0.025	0.671	298
Left Alar thickness	.326**	0.000	298
Right Alar thickness	.146*	0.012	298
Soft tip width	.294**	0.000	298

Independent Variable = Age (Years); * = Significant at P < 0.05

Table 5 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Ikwo Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	.271**	0.006	103
Head length	0.024	0.811	103
head height	-0.128	0.196	103
Face height	-0.097	0.329	103
Face width	-0.133	0.179	103
Minimal Frontal Breadth	-0.028	0.783	103
Mandible width	.194*	0.049	103
Mandible height	-0.159	0.109	103
Maxillary height	0.114	0.250	103
Mouth width	0.076	0.443	103
Upper lips length	-0.193	0.050	103
Philtrum width	.289**	0.003	103
Philtrum length	-.608**	0.000	103
Upper vermillion height	-.194*	0.049	103
Lower vermilion height	0.188	0.058	103
Biocular width	0.081	0.419	103
Ocular width/Palpebral width	-.196*	0.047	103
Intercanthal width/intercanthal distance	0.068	0.498	103
Nasal tip protrusion	0.057	0.570	103
Nasal width	-0.085	0.394	103
Nose height/Nasal height	0.060	0.548	103
Nasal bridge length	0.179	0.071	103
Alar base root breadth	-0.057	0.565	103
Nasal root breadth	-0.153	0.122	103
Left Alar thickness	-.278**	0.005	103
Right Alar thickness	-0.164	0.098	103
Soft tip width	-.330**	0.001	103

Independent Variable = Age (Years); * = Significant at P < 0.05

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Table 6 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Ngbo Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	.218*	0.015	124
Head length	-0.102	0.262	124
head height	-.199*	0.027	124
Face height	-.300**	0.001	124
Face width	.287**	0.001	124
Minimal Frontal Breadth	.820**	0.000	124
Mandible width	.560**	0.000	124
Mandible height	.514**	0.000	124
Maxillary height	.308**	0.000	124
Mouth width	.294**	0.001	124
Upper lips length	0.079	0.384	124
Philtrum width	0.044	0.626	124
Philtrum length	.342**	0.000	124
Upper vermillion height	.491**	0.000	124
Lower vermilion height	-0.064	0.478	124
Biocular width	.827**	0.000	124
Ocular width/Palpebral width	.822**	0.000	124
Intercanthal width/intercanthal distance	0.108	0.233	124
Nasal tip protrusion	.587**	0.000	124
Nasal width	.485**	0.000	124
Nose height/Nasal height	-0.060	0.511	124
Nasal bridge length	-.423**	0.000	124
Alar base root breadth	.416**	0.000	124
Nasal root breadth	.590**	0.000	124
Left Alar thickness	-0.138	0.127	124
Right Alar thickness	0.140	0.120	124
Soft tip width	-0.150	0.096	124

Independent Variable = Age (Years); * = Significant at P < 0.05

Table 7 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Ohaozara Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	0.125	0.061	226
Head length	0.042	0.530	226
head height	.320**	0.000	226
Face height	-.213**	0.001	226
Face width	-0.015	0.825	226
Minimal Frontal Breadth	.405**	0.000	226
Mandible width	.335**	0.000	226
Mandible height	0.051	0.446	226
Maxillary height	.385**	0.000	226
Mouth width	.142*	0.033	226
Upper lips length	0.085	0.205	226
Philtrum width	.154*	0.021	226
Philtrum length	.376**	0.000	226
Upper vermillion height	-0.012	0.860	226
Lower vermilion height	0.049	0.466	226
Biocular width	-0.026	0.700	226
Ocular width/Palpebral width	-.188**	0.005	226
Intercanthal width/intercanthal distance	-.267**	0.000	226
Nasal tip protrusion	0.044	0.511	226
Nasal width	-0.059	0.381	226
Nose height/Nasal height	.234**	0.000	226
Nasal bridge length	0.073	0.271	226
Alar base root breadth	0.085	0.206	226
Nasal root breadth	0.124	0.062	226
Left Alar thickness	0.037	0.581	226

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Right Alar thickness	.132*	0.047	226
Soft tip width	.246**	0.000	226

Independent Variable = Age (Years); * = Significant at P < 0.05

Table 8 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Afikpo Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	.203**	0.002	220
Head length	0.128	0.057	220
head height	0.108	0.111	220
Face height	0.107	0.113	220
Face width	.200**	0.003	220
Minimal Frontal Breadth	.431**	0.000	220
Mandible width	.267**	0.000	220
Mandible height	-.137*	0.043	220
Maxillary height	0.077	0.256	220
Mouth width	.157*	0.020	220
Upper lips length	-0.019	0.781	220
Philtrum width	-0.051	0.454	220
Philtrum length	0.085	0.207	220
Upper vermillion height	0.113	0.096	220
Lower vermilion height	.141*	0.036	220
Biocular width	-0.009	0.894	220
Ocular width/Palpebral width	-.155*	0.022	220
Intercanthal width/intercanthal distance	-.396**	0.000	220
Nasal tip protrusion	.224**	0.001	220
Nasal width	-0.033	0.623	220
Nose height/Nasal height	-.209**	0.002	220
Nasal bridge length	-.477**	0.000	220
Alar base root breadth	-0.095	0.159	220
Nasal root breadth	-0.050	0.456	220
Left Alar thickness	-0.059	0.386	220
Right Alar thickness	.260**	0.000	220
Soft tip width	0.002	0.976	220

Independent Variable = Age (Years); * = Significant at P < 0.05

Table 9 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Ishielu Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	-0.080	0.519	67
Head length	-.491**	0.000	67
head height	0.133	0.284	67
Face height	-0.047	0.705	67
Face width	-0.107	0.387	67
Minimal Frontal Breadth	-.392**	0.001	67
Mandible width	-0.140	0.259	67
Mandible height	.371**	0.002	67
Maxillary height	.422**	0.000	67
Mouth width	0.094	0.450	67
Upper lips length	-0.071	0.566	67
Philtrum width	-.409**	0.001	67
Philtrum length	-0.065	0.604	67
Upper vermillion height	-.321**	0.008	67
Lower vermilion height	-0.099	0.427	67
Biocular width	.335**	0.006	67
Ocular width/Palpebral width	-0.022	0.859	67
Intercanthal width/intercanthal distance	-0.121	0.330	67
Nasal tip protrusion	.486**	0.000	67
Nasal width	.372**	0.002	67
Nose height/Nasal height	.309*	0.011	67

Nasal bridge length	.300*	0.014	67
Alar base root breadth	.341**	0.005	67
Nasal root breadth	0.132	0.288	67
Left Alar thickness	-0.015	0.906	67
Right Alar thickness	.413**	0.001	67
Soft tip width	-.687**	0.000	67

Independent Variable = Age (Years); * = Significant at P < 0.05

Table 10 Correlation Between Craniofacial Anthropometric Parameters and the Age of the Participants in Ezza Clan

Craniofacial parameters	Pearson Correlation	P-Value	N
Head Breadth	0.024	0.754	177
Head length	-0.075	0.319	177
head height	-.175*	0.020	177
Face height	-.449**	0.000	177
Face width	.299**	0.000	177
Minimal Frontal Breadth	.359**	0.000	177
Mandible width	.570**	0.000	177
Mandible height	.429**	0.000	177
Maxillary height	-.245**	0.001	177
Mouth width	.244**	0.001	177
Upper lips length	-.156*	0.038	177
Philtrum width	-.321**	0.000	177
Philtrum length	-.184*	0.014	177
Upper vermillion height	-0.080	0.292	177
Lower vermilion height	-0.089	0.237	177
Biocular width	-0.107	0.158	177
Ocular width/Palpebral width	-0.035	0.647	177
Intercanthal width/intercanthal distance	-0.044	0.560	177
Nasal tip protrusion	-.291**	0.000	177
Nasal width	.451**	0.000	177
Nose height/Nasal height	-0.024	0.755	177
Nasal bridge length	-.325**	0.000	177
Alar base root breadth	.540**	0.000	177
Nasal root breadth	.262**	0.000	177
Left Alar thickness	.287**	0.000	177
Right Alar thickness	.195**	0.009	177
Soft tip width	-0.053	0.481	177

Independent Variable = Age (Years); * = Significant at P < 0.05

IV. DISCUSSION

➢ *Average Parameters of Participants*

Mean head breadth (14.61 cm), length (18.17 cm) and height (20.53 cm) are within the mesocephalic range, similar to the adult Yoruba and Igbo (Okeke & Ukoha, 2024; Paga & Ganga, 2025). The morphologic dimensions of the face (height 10.73 cm and width 12.87 cm) are symmetrical which is consistent with the photogrammetric study of the Igbo face (Fewehinmi et al., 2023; Nwofor et al., 2024). Mandible width (11.64 cm) and height (8.85 cm) indicate well developed lower facial structures as is observed in Hausa and Tiv groups. There is sexual dimorphism as evidenced by the mouth width (5.33cm) and vermilion heights (~1.2cm) (Fewehinmi et al., 2023). The ocular measures (biocular width 9.56 cm and intercanthal distance 3.57 cm) are comparable with the measures obtained from Africans (Bouhadana et al., 2022). The narrow nose width (4.51 cm) and the height of the nose (4.30 cm) agree with the mesorrhine tendencies (Kareem et al., 2025).

➢ *Clan-Specific Normative Values for the Measured Craniofacial Parameters*

Head breadth was very different, being minimum in Ishielu (13.40 cm) reflecting the localized adaptation (Kim & Kim, 2021). The greatest face width was recorded from Ikwo (13.56 cm) which was associated with zygomatic development. For the maxillary height, Ngbo exhibited the highest value of 5.91 cm, representing the mesorrhine tendencies, and for the widest nasal base, it was 4.11 cm (Butaric et al., 2022; Silinevica et al., 2026). Ezza's lips were fuller (1.89 cm) as per soft tissue variability. The other parameters were not significantly different between clans (Nazari, 2024).

➢ *Age Correlations with Craniofacial Anthropometric Parameters*

Minimal frontal breadth (r = 0.420, P < 0.001) and mandible width (r = 0.225, P = 0.002) increased with age, reflecting skeletal expansion (Knigge et al., 2022). Philtrum length and nasal breadth also increased with age indicating

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remodeling, as did mouth width (Yu et al., 2022). After adolescence, most craniofacial dimensions were quite stable (Graber et al., 2023).

V. CONCLUSION

The current study suggests that craniofacial anthropometric parameters can be used effectively and reliably to study human variability with the use of standardized measurement procedures. The results revealed normative data for dimensions of the head, face, mandible, eye, nose, and mouth for the sample studied, with the majority of dimensions showing a mesocephalic trend and a balance of the facial dimensions. There were subtle but significant differences between the clans in measures of head breadth, face width, maxillary height, lower vermilion height and alar base root breadth, showing intra-ethnic variation and supporting the craniofacial common ancestry of the clans. Age-related correlations revealed that some craniofacial dimensions, such as frontal breadth, mandibular width, mouth width, philtrum dimensions, and nasal breadth, continue to remodel in adulthood, both through changes at the skeletal and soft tissue level.The combined results highlight the need to have population-specific normative values that consider sex, age and clan variations. These values are critical in clinical anatomy, orthodontics, forensic anthropology and reconstructive surgery for correct diagnosis, treatment planning and identification. The paper illustrates that craniofacial morphology is determined by a complex interaction of genetic, environmental, developmental, and metabolic factors, and calls for ongoing methodological development and a wider range of comparative studies to gain a better understanding of population variation in craniofacial morphology.

VI. LIMITATION OF STUDY

The study was limited to adult participants (18-60 years) from various clans in Ebonyi State. To ensure a sufficient environmental exposure history, only those self-identifying as part of one of the targeted ethnic groups, who at the time of recruitment were born in the state and had lived in their community of origin for at least ten continuous years were included. Participants were excluded if they had craniofacial pathology, history of craniofacial surgery, or significant craniofacial trauma.

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➢ *Competing Interests*

The authors declare that there are no conflicts of interest associated with this paper.

➢ *Authors Contribution*

All authors were involved in Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Original Draft, as well as Review & Editing.

➢ *Conflict of Interest*

The authors declare no conflict of interest.

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➢ *Data Availability*

Data are available upon request and will be deposited in the public domain in due course.

➢ *Declarations*

The authors declare no conflicts of interest.

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