Comparative Analysis of Cephalofacial Dimorphism among Indigenous Ethnic Groups in Benue State, Nigeria

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Abstract

The face is an important physiognomic feature in humans, and facial anthropometric variables are valuable biometric physiognomies that vary with age, sex, and ethnicity. This study aimed to establish a standard for determining the extent of sexual dimorphism and study the distribution of basic face types by comparison with other ethnic groups in Benue State and Nigeria as a whole. A sample of 450 indigenous people from the Benue State volunteered to participate in this study. The cohort included 150 Tiv, 150 Idoma, and 150 Igede people, between the age group of 18 and 35 years. Participants were randomly recruited from the entire geographical locations of the state, using the inclusion criteria. Anthropometric variables were measured using a digital sliding caliper including facial length (FL) (measured from the trichion to the gnathion) and facial width (FW) (measured as the bizygomatic width, between the right and left zygion). Cephalofacial indices were calculated from these variables. The results revealed significant differences in some of the measured variables between males and females across the various ethnic groups in Benue State, including variation in FL and FW. The comparative results for various ethnicities in Benue State (Tiv, Idoma, and Igede people) also showed a positive correlation between FL and FW, which could be used to predict cephalofacial indices among Tiv, Idoma, and Igede ethnic groups in this area. These results indicate that the dominant facial index among Idoma and Igede people was leptoprosopic (long face) while that among Tiv people is mesoprosopic (round face). The current findings could be useful for elucidating the sex differences and ancestral relationships, as well as for forensic anthropology, reconstructive surgery, and anthropometric considerations for the three ethnic groups in Benue State, Nigeria.

Keywords: Anthropometry, Benue, dimorphism, indices, leptoprosopic, mesoprosopic

INTRODUCTION

Anthropometry refers to the scientific study of the measurement of body size and proportions of living humans, to assist in understanding human physical variation and aid in anthropological classification.¹ Anthropometry plays a significant role in orofacial surgery, clothing and industrial design, ergonomics, and architecture, whereby statistical data correlating the distribution of body dimensions in the population can be used to enhance the products.² Cephalometry is an important branch of anthropometry involving the measurement of the head and face of a living body or a cadaver.¹,³,⁴ Cephalometry is helpful in medicine, reconstructive surgery, orthodontics, and clinical diagnosis. Facial indices are among the most important cephalometric parameters for person recognition and have been used to describe racial and sexual differences.⁵⁻⁶ Face recognition is a widely used approach for person recognition, and the human cephalometric parameters in forensic medicine indicate the importance of anthropometry under a range of conditions, including natural, intentional, and accidental events (e.g., air crash, earthquake, road and train accidents, war-related deaths, flood, and fire).⁹ The viscerocranium, which houses most of the specialized sensory organs, as well as the dentition, oral, and nasal cavities, serves as a bony framework for the mimetic (imitative) musculature.¹⁰ Facial anthropometry is helpful in medicine, clinical diagnosis, and treatment planning.¹ The five categories of faces, based on prosopic index values,
These materials are typically sized and positioned to be comfortable and convenient for the average-sized person. In addition, anthropometry is commonly used to assess the nutritional status of a particular population, providing a technique for assessing child developmental patterns during the 1st year of life, monitoring growth rates and assisting in the design of materials, equipment and anything with a standard size, such as clothing, for a particular individual. The main reason for determining cephalofacial dimensions in forensic science is to help law enforcement agencies in discerning personal identity in medicolegal cases, because, in many cases, cephalofacial dimensions are the only means of evidence available for forensic investigation. Therefore, this type of information is vital for facial reconstruction, plastic and oral surgeries, as well as for clinical and research purposes. Thus, the present study aimed to establish a standard for determining the extent of sexual dimorphism and study the distribution of basic face types of three ethnic groups in Benue State, Nigeria, comparing the findings with those of other ethnic groups in Benue State and Nigeria as a whole.

Methodology

This research was carried out in Benue State, Nigeria. The state contains three major ethnic groups: Igede, Idoma, and Tiv people. Benue State is located in the middle-east region of Eastern-Central Nigeria and is bordered by Nassarawa State to the North, Taraba to the East, Ebonyi and Cross River State to the South, and Kogi State to the West, having an area of 34,059 km² and a population of 5,181,642 in 2005. Idoma, Tiv, and Igede languages are predominantly spoken by each group, and other ethnic groups include Etulo and Abakwa people. Makurdi is the capital city of Benue State, which is a rich agricultural region in Nigeria. Benue State contains many rivers and is considered the food basket of the nation. This study used sliding calipers Figure 1 to measure the total facial length (FL). A total of 450 volunteers were recruited for this study. Among these, 150 individuals from each ethnic group (80 males and 70 females) between the ages of 18 and 35 years, with no evidence of facial malformation, were randomly selected for comparison.

Anthropometric measurements

The length and width of the face were measured between relevant anatomical landmarks while the patient was seated, with their head placed in an anatomical position, raised to a comfortable degree, and recorded to the nearest millimeter (mm) using digital sliding calipers. The FL was measured from the trichion to the gnathion, Figure 2 and the width of the face was measured as the bizygomatic width between the right and left zygion Figure 3 to obtain the facial index (FI). The FI was calculated using the following equation:

$$\text{Facial index} = \frac{\text{Facial length}}{\text{Facial width}} \times 100$$

The data were statistically analyzed using the one-way analysis of variance (ANOVA), and the results are presented in tables as mean ± standard deviation along with significance probability values.

Research subjects

A sample of 450 indigenous people in Benue State took part in the study. This cohort included 150 Tiv people, 150 Idoma people, and 150 Igede people, with 80 males and 70 females in each ethnic group, between the age group of 18 and 35 years. Participants who met the inclusion criteria were randomly recruited from the entire geographical location of the state.

Inclusion criteria

All volunteers who were considered for this research belonged to either the Tiv, Idoma, or Igede ethnic groups and were born and brought up in Benue State, Nigeria. All participants were healthy and free from any kind of facial malformation.

Exclusion criteria

Volunteers who did not belong to the Tiv, Idoma, or Igede ethnic groups, those who were below or above the stipulated age range, those with any kind of facial malformation, and those not willing to participate were excluded from the study.

Ethical approval

Ethical approval was obtained from the Faculty of Basic Medical Sciences, Cross River University of Technology, in accordance with the Helsinki Declaration of 1975, as revised in 2000. The rationale of the research was explained to all volunteers, and only those who gave consent were examined.

Data analysis

The comparisons of means, standard deviations, and one-way ANOVA were calculated to derive the results for mean FL and mean facial width (FW). FI values were calculated, and the results are shown in tables and graphs.

Results

Study results are presented on Tables 1-5 and Figures 4-8 below.

Discussion

The face is an important feature of the skull, conveying the information about gender, age, and ethnic group. Although the importance of faces is clear, it is difficult to characterize. In the current study, cephalofacial indices for determining sex differences and ethnicity were examined using the anthropometric methods in three ethnic groups in Benue State, Nigeria. This study attempted to elucidate the basic proportions of the face width and face length, with a specific focus on ethnic variation and sex differences with advancing age.
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**Figure 1:** Digital Vernier caliper is used in measuring the distance between two opposite sides of a surface

**Figure 2:** Facial length measured from the trichion to the gnathion

**Figure 3:** Facial width measured as by zygomatic width between the right and left zygion

**Table 1:** Comparison of parameters between male and female Tiv people

| Parameter              | Male          | Female        |
|------------------------|---------------|---------------|
| Face width (cm)        | 11.54±0.89    | 11.29±0.74*   |
| Face length (cm)       | 11.55±0.95    | 10.93±0.62*   |
| Face index             | 100.35±0.89   | 97.07±0.67*   |

*Significantly different from males at $P<0.05$

**Table 2:** Comparison of parameters between male and female Idoma people

| Parameter              | Male          | Female        |
|------------------------|---------------|---------------|
| Face width (cm)        | 12.11±0.80    | 11.99±0.84    |
| Face length (cm)       | 11.71±0.83    | 11.36±0.88*   |
| Face index             | 96.94±0.80    | 95.00±0.87    |

*Significantly different from males at $P<0.05$

**Table 3:** Comparison of parameters between male and female Igede people

| Parameter              | Male          | Female        |
|------------------------|---------------|---------------|
| Face width (cm)        | 12.20±0.73    | 12.00±0.59*   |
| Face length (cm)       | 12.06±2.18    | 11.32±1.33*   |
| Face index             | 98.96±1.83    | 94.44±1.09*   |

*Significantly different from males at $P<0.05$

**Table 4:** Multiple comparisons showing significant differences in parameters between males in the Tiv, Idoma, and Igede groups

| Parameter              | Tiv           | Idoma         | Igede         |
|------------------------|---------------|---------------|---------------|
| Face width (cm)        | 11.54±0.89*   | 12.11±0.80*   | 12.20±0.73*   |
| Face length (cm)       | 11.55±0.95    | 11.71±0.83    | 12.06±2.18    |
| Face index             | 100.35±0.89   | 96.94±0.80    | 98.96±1.83    |

Significantly different from Tiv at $P<0.05$, bSignificantly different from Idoma at $P<0.05$, cSignificantly different from Igede at $P<0.05$

**Table 5:** Multiple comparisons showing significant differences in parameters between females in the Tiv, Idoma, and Igede groups

| Parameters              | Tiv           | Idoma         | Igede         |
|------------------------|---------------|---------------|---------------|
| Face width (cm)        | 11.29±0.74*   | 11.99±0.84*   | 12.00±0.59*   |
| Face length (cm)       | 10.93±0.62*   | 11.36±0.88*   | 11.32±1.33*   |
| Face index             | 97.07±0.67    | 95.00±0.87    | 94.44±1.09    |

Significantly different from Tiv at $P<0.05$, bSignificantly different from Idoma at $P<0.05$, cSignificantly different from Igede at $P<0.05$
Comparison between males and females in Tiv, Idoma, and Igede ethnic groups

Table 1 and Figure 4 shows a comparison of FW, FL, and FI between males and females in the Tiv ethnic group in Benue State. The results revealed a significant difference in FW (11.54 ± 0.89 and 11.29 ± 0.74 for males and females, respectively), FL (11.55 ± 0.95 and 10.93 ± 0.62 for males and females, respectively), and FI values (100.35 ± 0.89 and 97.07 ± 0.67 for males and females, respectively). Table 2 and Figure 5 shows a comparison of FW, FL, and FI between males and females in the Idoma ethnic group in Benue State, revealing a nonsignificant trend for smaller female FW (11.99 ± 0.84) and female FI values (95.00 ± 0.87) compared with male FW (12.11 ± 0.80) and male FI values (96.94 ± 0.80), respectively, and a significant difference in FL (11.71 ± 0.83 and 11.36 ± 0.88 for males and females, respectively).

Table 3 and Figure 6 shows a comparison of FW, FL, and FI between males and females in the Igede ethnic group in Benue State. The results revealed a significant difference in FW (12.20 ± 0.73 and 12.00 ± 0.59 for males and females, respectively), FL (12.06 ± 2.18 and 11.32 ± 1.33 for males and females, respectively), and FI values (98.96 ± 1.83 and 94.44 ± 1.09 for males and females, respectively). Thus, sex differences were observed in the Tiv, Idoma, and Igede ethnic groups. The results of the current study revealed significant sexual dimorphism in facial parameters, with male participants exhibiting higher values than their female counterparts across all ethnicities. This finding is in agreement with that of Kpela et al.,[18] who reported significant sex differences in FL and FW among Tiv and Idoma people, with males exhibiting

Figure 5: Comparison of facial width, facial length, and facial index in male and female participants of Idoma ethnic group. Values are expressed as mean ± standard error of the mean. *= Significantly different from males (P < 0.05)

Figure 6: Comparison of facial width, facial length, and facial index in male and female participants of the Igede ethnic group. Values are expressed as mean ± standard error of the mean. *= Significantly different from males (P < 0.05)

Figure 7: Comparison of facial width, facial length, and facial index among male participants across the three ethnic groups. Values are expressed as mean ± standard error of the mean. a = significantly different from Tiv (P < 0.05); b = significantly different from Idoma (P < 0.05); c = significantly different from Igede (P < 0.05)

Figure 8: Comparison of facial width, facial length, and facial index among female participants across the three ethnic groups. Values are expressed as mean ± standard error of the mean. a = significantly different from Tiv (P < 0.05); b = significantly different from Idoma (P < 0.05); c = significantly different from Igede (P < 0.05)
significantly higher FI values than their female counterparts. However, unlike the current study, Kpela et al. did not examine the Igede ethnic group.[13]

**Multiple comparisons for males and females in the Tiv, Idoma, and Igede ethnic groups**

The results [Table 4 and Figure 7] revealed that the overall FI values were 100.35 ± 0.89, 96.94 ± 0.80, and 98.96 ± 1.83 for Tiv, Idoma, and Igede people, respectively. Similarly, the FL values were 11.55 ± 0.95, 11.71 ± 0.83, and 12.06 ± 2.18 for Tiv, Idoma, and Igede people, respectively. No significant differences were found, but a nonsignificant trend for Igede people to have a higher FL value was observed, suggesting that this ethnic group may be predominantly leptoprosopic, whereas Tiv and Idoma may be more facially similar, having mesoprosopic faces. The average FW of Tiv people (11.54 ± 0.89) was significantly different from that of Idoma (12.11 ± 0.80) and Igede (12.20 ± 0.73) people. A comparison with female participants revealed a similar pattern to that observed in male participants across the ethnic groups, as shown in Table 5 and Figure 8. Among females, Tiv FW was significantly smaller (11.29 ± 0.74) compared with the Idoma (11.99 ± 0.84) and Igede (12.00 ± 0.59) groups. In addition, the results revealed a significantly smaller FL among Tiv (10.93 ± 0.62) compared with Idoma (11.36 ± 0.88) and Igede (11.32 ± 1.33), suggesting that Tiv may be mainly mesoprosopic, whereas Idoma and Igede may be more facially similar, having leptoprosopic faces. However, there were no significant differences in the overall female FI values (97.07 ± 0.67, 95.00 ± 0.87, and 94.44 ± 1.09 for Tiv, Idoma, and Igede groups, respectively) across ethnic groups. The parameters studied revealed significant differences between three ethnic groups in Benue State in Nigeria, reflecting the effects of biological, geographical, ecological, gender-related, and ethnic group-related factors as key influential components of facial dimensions in the human body.[19] Compared with previous studies carried out in Benue State, the current study varied in terms of the ethnic groups examined. Most previous studies conducted simple comparisons between two ethnic groups, whereas our study considered three ethnic groups in the region. Kpela et al.[13] reported a significant difference in FL, FW, and FI when comparing two ethnic groups (Tiv and Idoma), but did not consider the Igede group, and concluded that the Tiv were mainly mesoprosopic, whereas the Idoma group were leptoprosopic, in accord with the current findings. In addition, the present results are congruent with the findings of previous studies examining Nigerian ethnic groups with leptoprosopic face types. Oria et al. reported that the primary face type of Idoma people in Benue state was hyperleptoprosopic.[20] Similarly, hyperleptoprosopic face type was reported by Ojeh et al. among the Ukwanis people in Delta state,[21] and Raji et al. reported similar findings in a North-Eastern population[22] in Nigeria, in accord with the current findings. Thus, using facial indices, the current results may be useful for predicting the anthropometric relationships between three ethnic groups as well as providing valuable knowledge for anthropometric and facial biometric applications in Nigeria.

**Recommendations**

The results of the current study may have useful applications in face biometrics and anthropometrics in Nigeria. Based on the current findings, larger anthropometric studies of faces should be carried out in Benue State and in Nigeria as a whole.

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**Conflicts of interest**

There are no conflicts of interest.

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