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Outer and Inner Canthal Distances and their Stature Estimation Potentials among Nigerian Igbos and Ibibios Residing in Rivers State, Nigeria

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Abstract: Both inner (ICD) and outer canthal distances (OCD) are some examples of facial parameters often applicable in forensic anthropology as these differ among ancestries. Despite numerous reports on stature estimation using various facial parameters across several ancestries and ethnic groups including those of Nigeria, paucity of literature on the potentials of ICD and OCD in the estimation of stature among global populations, including Nigeria, remain evident. Thus, the present study was carried out to fill this gap for two Nigerian ethnic groups, the Igbos and Ibibios. A total of 300 adults of 18 years and above (150 Igbos and 150 Ibibios) comprising 75 males and 75 females each were randomly selected. The ICD and OCD were measured between the medial canthi and lateral canthi of the palpebral fissures of the two eyes, respectively using a transparent metric rule. Stature (height) was measured using a stadiometer using a standardized method. From the results, the mean heights for the combined population of males and females were 180.57±0.74 cm and 175.28±0.65 cm respectively. The differences between sexes for height were statistically significant ($p<0.05$) while there was no ethnic difference in heights of both ethnic groups observed. The present study showed that the mean ICD in males and females were 3.31 cm and 3.35 cm respectively. The Ibibio males had mean ICD of 3.32 cm compared to 3.29 cm in their females. However, ICD values of Igbos showed a higher mean in females (3.42 cm) compared to males (3.30 cm). The average OCD in males for both ethnic groups were slightly higher compared to females. Significant correlations between ICD, OCD, and stature were observed in both males and females while linear regression equations for stature

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estimation were derived. For males, it was as follows; Stature = 23.65(ICD) + 102.177, and Stature = 3.44(OCD) + 140.932. For females, it was thus, Stature = 4.38(ICD) + 160.575, and Stature = 2.83(OCD) + 143.518. Conclusively, there were strong associations between both canthal parameters and height in both sexes irrespective of ethnic differences.

KEY WORDS: canthal distance, stature, estimation, Ibibios, Igbos, anthropology

Introduction

The identification of individuals using the anthropometry of the human face remains an integral part of biological anthropology. The concept of facial anthropometry in anthropology deals with the measurement of physical components of human face in relation to their racial and ethnic differences (Jahanshahi 2012; Darkwah et al. 2018). Both the inner canthal distance (ICD) and outer canthal distance (OCD) of the canthi (the corners of the eyes where the upper and lower eyelids meet) are important facial measurements that are applicable in both anthropological and forensic studies (Oladipo et al. 2011; Yadav et al. 2019; Bahşi et al. 2021). Furthermore, the understanding of the variations between sexes and ancestries in the assessments of canthal anthropometry could be applied in reconstructive and cosmetic surgeries that usually involve carrying out surgical procedures that are aimed at correcting deformities and enhancing facial aesthetics (Raschke et al. 2013; Bouhadana et al. 2022; Celikoyar et al. 2022). Currently, it is generally accepted that there are morphological differences based on several literature on variations in canthal anthropometry among ethnic groups in Nigeria (Osunwoke et al. 2010; Anibor et al. 2014; Ogoun et al. 2021), and between ancestries globally (Yadav et al. 2019; Bahşi et al. 2021; Radha and Srinivasan 2021; Bouhadana et al. 2022; Ndombolo et al. 2024).

Together with sex, age and ancestry, the estimation of stature is a key biological means of identification in humans (Oladipo et al. 2015; Cunha and Ubelaker 2020). Despite the generalization of knowledge among anthropologists that support the accuracy and reliability of long bones as the most suitable body components for predicting stature across different racial populations (Cunha and Ubelaker 2020), the application of soft tissues in stature prediction has been gaining momentum in recent times. The profiling of unidentifiable human remains by forensic anthropologists to estimate stature using soft-tissue craniofacial measurements has become a common practice by various researchers in the field of biological anthropology (de Acuerdo and de la Cabeza 2015; El-Kelany et al. 2015; Yadav et al. 2019; Bashar et al. 2024). It is worthy of note that there are limited studies on the prediction of stature using canthal anthropometry in non-Negroid populations, and there are arguably none that has been studied using a Nigerian population. In estimating stature from canthal anthropometry, individuals can be positively identified especially in forensic cases where soft tissue remains are incomplete.

In south-southern Nigeria, some of the residents that live in the multilingual city of Port Harcourt (which is in Rivers State) are of Igbo and Ibibio ethnic extractions as the city is bordered by Imo and Akwa-Ibom states, respectively. Arguably regarded as the

most populated region within southern Nigeria, Rivers State is not without its challenges that are usually associated with crimes, such drug abuse, human trafficking, and other forms of social vices (Abiodun et al. 2017; Joab-Peterside et al. 2021). These vices could in turn lead to deaths of victims found in such crime scenes thereby posing unique difficulties to local security agencies in trying to identify discovered victims. In high profile forensic cases, local anthropologists are consulted by these security agencies to assist in the forensic identification of the discovered victims – which could be challenging as well due to the lack of forensic databases in the region. Also, in line with studies done by Gao et al. (2024), and Chalkis et al. (2024), surgical outcomes could be affected by anatomical differences in eyelid shape, orbital structure, and overall facial proportions across different racial populations and these variations could in turn impact the selection of techniques and aesthetic consequences in oculoplastic surgeries. The current study was done to investigate the stature estimation potentials of outer and inner canthal distances among Nigerian Igbos and Ibibio adult populations residing in Port Harcourt, Rivers state.

Materials and Methods

A total of 300 adults (150 Ibibios and 150 Igbos) were randomly selected for this study and were limited exclusively to adults of Madonna University, Elele Campus in Rivers State of Nigeria. Minimum sample size was determined using Fisher's formula for infinite population or population larger than 10,000 (Cocharan 1963). The subjects were from Ibibio and Igbo ethnic origins of Nigeria by both parents and genealogies and were between the age of 18 and 30 years. Subjects with outside age range of 18 and 30 years, those with any form of facial anomalies, prior facial surgeries and those from heterogeneous parents were excluded. Subjects were selected in line with the Declaration of Helsinki research ethics protocols for human research. Ethical clearance was obtained from the Research Ethics Committee of the University of Port Harcourt Teaching Hospital, Port Harcourt (with registration number NHREC/UPTHREC/03/2023 and protocol number, UPTH/ADM/90/S.11/VOL.XI/1722). All subjects gave their informed consent, and their personal information were kept confidential.

The measurement of inner canthal distance [ICD] and outer canthal distance [OCD] were carried out with the aid of transparent meter rule and recorded in centimeters (cm). The distance between the lateral canthi of the right and left eyes gave the outer canthal distance while the distance between the medial canthal of the right and left eyes gave the inner canthal distance [Figure1]. Height (stature) was measured with the aid of a stadiometer and recorded in cm. Subjects were barefooted (thin socks were also allowed). Subjects were asked to stand on the base of the stadiometer in an erect position. The heels were placed together and arms relaxed at the sides. The head board of the stadiometer was adjusted to the top of the head (vertex) and readings were taken from the calibrations of the stadiometer. 2) All the measurements were performed twice and average of the two scores were used for precision purpose. Reading was taken to two decimal places.

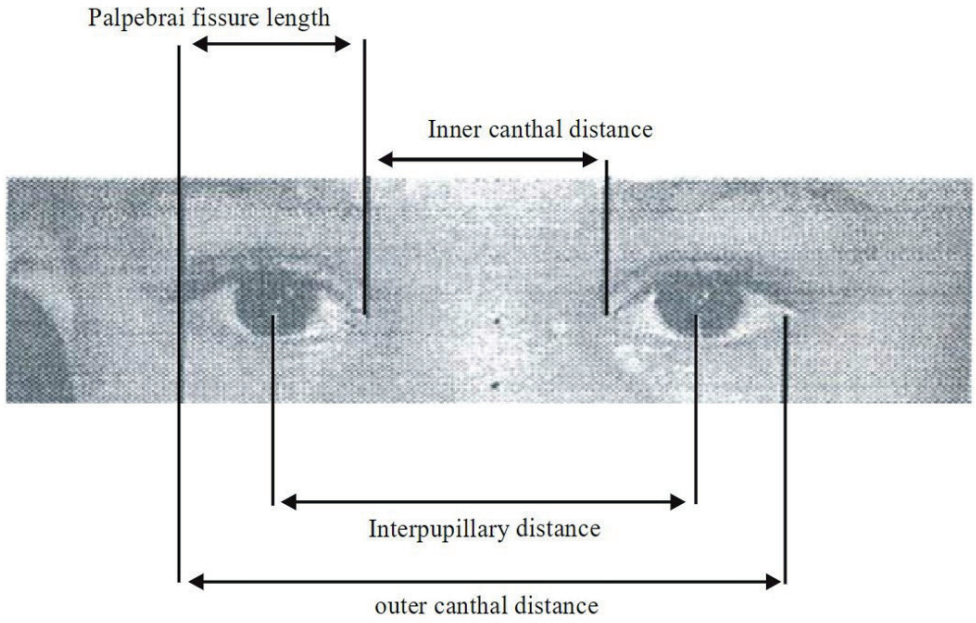

Fig.1. Measurement of inner and outer canthal distances [Oladipo et al. 2011, page 15]

Statistical Analyses

Raw data collected from the subjects were recorded in a Microsoft Excel 2019 version and analyzed using the Statistical Package for Social Sciences (SPSS version 20.0). Differences between sexes and ethnic groups in canthal distances and heights were determined using the independent sample t-test while test of association was done with the aid of Pearson's correlation and regression analyses. Confidence interval was set at 95%.

Results

The results of the various analyses are presented in table 1 to 8. In the general population [Table1], males had a mean height of 180.57±0.74 cm while females had a mean height of 175.28±0.65 cm. The mean ICD in males was 3.31±0.02 cm while in females it was 3.35±0.02 cm. The mean OCD was 11.52±0.04 cm in males and 11.23±0. 04 cm in females.

Using independent sample t-test to compare the above variables between males and females, it was observed that there was a statistically significant difference in the mean height of males and females ($p<0.05$) with males showing significantly higher value than females. Also, there was a statistically significant difference between the mean OCD of males and females ($p<0.05$) with males showing higher mean OCD than females. However, no significant difference was observed between the mean ICD of males and females ($p>0.05$).

Table 2 contains the results of the ethnic comparison of Height, OCD and ICD between Igbos and Ibibios. The mean

heights of the Igbo and Ibibio subjects were 177.87±0.69 cm and 177.98±0.76 cm respectively. Those of ICD were 3.36± 0.17 cm and 3.31±0.12 cm respectively while the mean OCD for Igbos and Ibibios were 11.39±0.04 cm and 11.36±0.04 cm respectively. It is worthy of note that the difference in the mean heights of the Igbos and Ibibios were not statistically significant ($p>0.05$). Also, the mean OCD in the Igbos and Ibibios were not statistically significant ($p>0.05$). However, there was a statistically significant difference between the mean ICD of the Igbos and the Ibibios ($p<0.05$) with Igbos showing higher mean value.

Table 3 to 6 show the descriptive statistics for height, ICD and OCD of Igbo males and females, Ibibio males and females, Igbo males and Ibibio males and Igbo and Ibibio females respectively. Regression products of the correlation of height and ICD and OCD are shown in table 7 and 8. It can be observed that Pearson R value for the correlation between height and ICD in males is 0.507. This correlation is statistically significant ($p<0.05$). Although the correlation between height and OCD in males with R value 0.172 is weak, it is however statistically significant ($p<0.05$). On the other hand, no significant correlation was observed between ICD and height ($R=0.121$, $p>0.05$). In females, there was a weak but statistically significant correlation between OCD and height ($R=0.200$ $p<0.05$).

On carrying out the linear regression to obtain the linear relationship between height, OCD and ICD in females, the Pearson constant (C) which indicates the Constant value in a linear equation and the slope (R coefficient) was obtained as shown in table 7. The derived equations follow the linear equation $y = mx+c$ and are represented in table 8. This could be used to determine the height of males and females when the ICD and OCD is measured accurately.

Table 1. Independent T-test Analysis on Height, ICD and OCD in Males and Females

Variables	Min (cm)	Max (cm)	Mean (cm)	P-value
Height				
Male	157	194	180.57±0.74	0.001
Female	157	194	175.28±0.65	
ICD				
Male	3.0	3.7	3.31±0.02	0.06
Female	3.0	4.0	3.35±0.02	
OCD				
Male	10.5	12.0	11.52±0.04	0.001
Female	10.0	12.7	11.23±0.04	

P-value is significant at 0.05 when comparing the means of the different parameters

Table 2. Independent T-test on Height, ICD and OCD of the Igbos and Ibibios

Variables	Min (cm)	Max (cm)	Mean (cm)	P-value
Height				
Igbo	157	195	177.87±0.69	0.91
Ibibio	160	195	177.98±0.76	

Table 2. (cont.)

Variables	Min (cm)	Max (cm)	Mean (cm)	P-value
ICD				
Igbo	3.0	4.0	3.36±0.17	0.03
Ibibio	3.0	3.7	3.31±0.12	
OCD				
Igbo	10.0	12.7	11.39±0.04	0.58
Ibibio	10.5	12.5	11.36±0.04	

P-value is significant at 0.05 when comparing the means of the different parameters

Table 3. Descriptive Statistics of Height, ICD and OCD of the Igbo Males and Females

	Sex	N	Minimum	Maximum	Mean	Standard Deviation
Male	Height (cm)	75	160.00	195.00	180.40	9.41
	ICD (cm)	75	3.00	3.50	3.30	0.17
	OCD (cm)	75	10.50	12.00	11.48	0.44
Female	Height (cm)	75	157.00	194.00	175.35	6.54
	ICD (cm)	75	3.00	4.00	3.42	0.24
	OCD (cm)	75	10.00	12.70	11.30	0.61

Table 4. Descriptive Statistics of Height, ICD and OCD of the Ibibio Males and Females

	Sex	N	Minimum	Maximum	Mean	Standard Deviation
Male	Height (cm)	75	162.00	195.00	180.75	8.62
	ICD (cm)	75	3.00	3.70	3.32	0.21
	OCD (cm)	75	10.50	12.00	11.55	0.46
Female	Height (cm)	75	160.00	194.00	175.21	9.26
	ICD (cm)	75	3.00	3.60	3.29	0.19
	OCD (cm)	75	10.50	12.50	11.17	0.52

Table 5. Descriptive Statistics of Height, ICD and OCD of Igbo males and Ibibio males

	Ethnicity	N	Minimum	Maximum	Mean	Standard Deviation
Igbos	Height (cm)	75	160.00	195.00	180.40	9.41
	ICD (cm)	75	3.00	3.50	3.30	0.17
	OCD (cm)	75	10.50	12.00	11.48	0.44
Ibibios	Height (cm)	75	162.00	195.00	180.75	8.62
	ICD (cm)	75	3.00	3.70	3.32	0.21
	OCD (cm)	75	10.50	12.00	11.55	0.46

Table 6. Descriptive Statistics of Height, ICD and OCD of Igbo and Ibibio Females

Ethnicity		N	Minimum	Maximum	Mean	Standard Deviation
Igbos	Height (cm)	75	157.00	194.00	175.35	6.54
	ICD (cm)	75	3.00	4.00	3.42	0.24
	OCD (cm)	75	10.00	12.70	11.30	0.61
Ibibios	Height (cm)	75	160.00	194.00	175.21	9.26
	ICD (cm)	75	3.00	3.60	3.29	0.19
	OCD (cm)	75	10.50	12.50	11.17	0.52

Table 7. Correlation Statistics for the of OCD, ICD and Height in Males and Females Subjects

Variables	r	R^2	R Coefficient	R Constant	p-value
Male					
ICD	0.507	0.257	23.65	102.177	0.001
OCD	0.172	0.300	3.44	140.963	0.03
Female					
ICD	0.121	0.015	4.38	160.575	0.01
OCD	0.200	0.040	2.83	143.518	0.01

Key: r = Pearson correlation coefficient, R^2 = coefficient of determination

Table 8. Linear Regression Equations for the Estimation of Height from ICD or OCD in Male and Females

Sex	Variable	Regression Formula
Male	ICD	Y = 23.65(x) + 102.177
	OCD	Y = 3.44(x) + 140.932
Female	ICD	Y = 4.38(x) + 160.575
	OCD	Y = 2.83(x) + 143.518

Note: Y = Height (cm), x = ICD (cm) or OCD (cm)

Discussion

It is true that the understanding of the anatomy of the human face brings to light a myriad of applications in the subject fields of ophthalmic, reconstructive, and plastic surgeries, as well as anthropometric evaluations in both forensic and biological identification. As stated earlier, the anthropometric profiling of human subjects by various anthropologists to estimate stature (height) using soft-tissue craniofacial measurements has become a common practice by various researchers in the field of biological anthropology (de Acuerdo and de la Cabeza 2015; El-Kelany et al. 2015; Yadav et al. 2019; Bashar et al. 2024). However, this study is arguably the foremost research that has been done with regards to the relationship between stature, inner (ICD) and outer canthal distances (OCD) for any given Nigerian population.

The present study showed that the mean ICD in males and females were 3.31 cm and 3.35 cm respectively, while

the mean OCD in males and females were 11.52 cm and 11.23 cm, respectively. A related study done to evaluate the ICD in a Saudi population reported from their results that the mean ICD when the sexes were combined was 3.03 cm (ranging from 2.22 cm to 3.78 cm), with a mean ICD of 3.11 cm for males, and a mean ICD of 2.96 cm for females (Hamid et al. 2021). Earlier, a research by Ozturk et al. (2006) on a Turkish population found that the males and females had a mean ICD of 3.07 cm and 3.03 cm, respectively, while El-Sheikh et al. (2010) reported mean ICD values for a Sudanese population to be slightly higher compared to this present study to be 3.34 cm and 3.24 cm for their males and females, correspondingly. Furthermore, studies done using different south Asian populations by Adhikari et al. (2016), and Iqbal et al. (2024) both revealed similar findings to the present study results on Ibibio population that the males had higher ICD values in association with the female subjects. Within Nigeria, Oladipo et al. (2011) had earlier reported from a survey of 800 participants from Ibibio ethnic group that the ICD of males and females were 3.52 cm and 3.36 cm, respectively – which is in line with the present study that showed that the Ibibio males had a mean ICD of 3.32 cm while their female counterparts had a mean of 3.29 cm. However, the ICD values of the Igbo population in this present study showed a higher mean for the females (3.42 cm) compared to the male counterparts (3.30 cm).

As seen in this study, the average OCD in males for both ethnic groups were slightly higher compared to the female counterparts. These results were in accordance with the studies done among certain ethnicities in Nigeria by Oladipo et al. (2009), Osunwoke et al. (2010), and Anibor et al. (2014). However, in comparisons to other racial populations, the OCD was higher as the mean OCD for a studied population by Rajput et al. (2022) was 9.23 cm for males and 7.31 cm for females while another related study done by Srivastava et al. (2023) using an Indian population noted from their results that the mean OCD was 8.23 cm for males and 7.22 cm for females. Furthermore, similar research done to evaluate OCD using both Indian and Nepalese undergraduate students (Adhikari et al. 2016) revealed that the males had respective higher OCD values (9.49 cm and 9.35 cm) in association with the female subjects (9.13 cm and 9.15 cm) – which agrees with the current study despite reporting higher values in comparison to the south Asian subjects. It could be explained that a host of diverse factors such as changes in lifestyle and dietary habits have had a direct relation to human growth and development over the years and these factors, which are generally population-specific, can affect the morphology and morphometry of the faces among the studied ethnicities.

Suffice it to say that despite that there are some works that has been done to estimate stature (height) using selected facial and nasal parameters (Kumar and Chandra 2006; Kalia et al. 2008; Agnihotri et al. 2011; Wankhede et al. 2012), it has proven to be a challenge to come across studies that have used periorbital (or canthal) parameters to predict stature talk less of a Nigerian population. The applications of both ICD and OCD in stature prediction were shown to be relevant in this study as there were significant relationships between both canthal parameters and height in both sexes ir-

respective of ethnic differences using the Pearson correlation. These study observations were followed up by deducing linear regressions for estimating the height in males and females based on the measured ICD and OCD values. Although this study was able to establish the significant relationships between stature, ICD and OCD, the researchers recognize that these observations do not make up for a possible generalization of the total population of Nigerian Igbos and Ibibios due to the limited sample size.

Conclusion

The study concluded that there were significant differences in both sexes despite no ethnic differences in terms of stature, ICD and OCD. Also, there were strong associations between both canthal parameters and height in both sexes irrespective of ethnic differences. These study values could assist local ophthalmic, reconstructive, and plastic surgical practitioners who practice in both ethnic regions in managing surgical issues related to the human face. Also, this study could enable local anthropologists and researchers to digress further on analysing the applications of canthal anthropometry in the prediction of stature across different ethnicities in Nigeria, thereby adding to the growth of physical and forensic anthropology in the country.

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Conflict of interest

All authors declare that there is no form of competing interests.

Authors' contributions

GSO was the lead researcher, conceived the concept of the study and design, critical revision of the article for important intellectual content, provided some materials for the study and wrote the manuscript; BBJ provided some materials for the study, performed the data collection, compilation and statistical analysis. EA and OMA provided some materials for the study and carried out some critical revision of the article. All authors discussed the results and contributed to the final manuscript for publication.

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