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ANTHROPOMETRIC STUDY OF THE CRANIAL PARAMETERS USING COMPUTED TOMOGRAPHY (CT) SCAN TO ESTABLISH CEPHALIC INDEX OF A SAMPLED POPULATION IN CALABAR, NIGERIA.

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ABSTRACT

BACKGROUND: Ethnic characteristics of individuals are best described with the skull. Cranial index is one of the most important variables for determining sexual dimorphism and of course racial differences. Parameters used in establishing cephalic index vary considerably depending on the age, sex, geographical habitat, ethnic background of the individuals involved and the methods employed. Such has not been documented in Calabar, especially with the use of advanced imaging modality such as the Computed Tomography (CT) scans. This is the rationale of the study.
OBJECTIVE: To determine the cephalic index of Nigerians residing in Calabar using CT scan.
MATERIALS AND METHOD: A total of 200 cranial Brivo 385 16 slice CT scan images of Nigerians aged from 18 to 87 years were obtained from the Asi-Ukpo Diagnostic Medical Centre Calabar. A simple random probability sampling technique was employed. Variables measured were the Maximum Cranial Length (MCL), Maximum Cranial Width (MCW), Bizygomatic Length (BZL) and the Orbital Length (OBL). The cephalic index was obtained by measuring the ratio of the maximum head width (MCW) or the Biparietal Diameter (BPD) to maximum head length (MCL) or the antero-posterior diameter then multiplied by 100.
RESULTS: Cranial length was 182.9 ± 0.657mm in males and 178.53 ± 0.09mm in females. Cranial width was 138.59 ± 0.56mm in males and 137.21 ± 0.65mm in females. The orbital length was 34.35 ± 0.31mm in males and 33.37 ± 0.29mm in females while bizygomatic length was 130 ± 0.31mm in males and 127.54 ± 0.84mm in females. Cranial index was 76.09mm in males and 75.81mm in females. No significant difference between males and females of the study population as the subject appears to be largely mesocephalic ($p<0.05$).
CONCLUSION: Cranial index of the study sampled population is majorly mesocephalic. Therefore, CT scan is very important a tool in the assessment of cranial parameters in anthropometry.

KEYWORDS: Anthropometry, Calabar, Cranial index, Computed Tomography, Mesocephalic.

INTRODUCTION

Anthropometry is the measurement of the human body; a reliable method for quantifying body size, proportion or shape using body length and width, circumference and skin fold thickness (Williams and Rogers, 2006). Craniometry is a branch of

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anthropometry that is useful in evaluating the cranial capacity of individuals and to characterise cranial morphology peculiar to different races and ethnic groups (Williams *et al*., 1995; Shah and Jadhav 2004; Williams and Rogers, 2006). The international classification standard of head types has it that an index of <75 defines a long skull (dolicephalic) which is typical of the Austrians and natives of Southern Africa, an index of >81 defines a broad and short skull (bradycephalic); typical of the Europeans and Chinese while index range of 76-81 defines an intermediate skull or mesocephalic (Williams *et al*., 1995; Williams and Rogers, 2006). A study by Adebisi (2003) reported that the characteristics of individuals are best described in the skull, with cranial index as one of the most important parameters for determining sexual dimorphism and even racial differences.

There have been many approaches to the study of the skull shape, each having its own advantages and disadvantages (Bunn and Turner, 1956; Williams *et al*., 1995; Chamella, 1997; Williams and Rogers, 2006). Initially, visual observation was one of the methods used to compare human skulls (Bunn and Turner, 1956). Photographing the skull into several standard planes (another method), provided a means of systematic examination with certain advantages such as the ability to view in detail, landmarks of the skull. This method experienced certain shortcomings in the nature of distortions of near and far features of an object resulting from the fact that landmarks of an object which lie near the camera, appears relatively larger than those farther away (Bunn and Turner, 1956). The second distortion is in exactness in the image profile of the object being photographed which also results mainly from the masking effect produced by surface prominence (Bunn and Turner, 1956).

The method of representing skull shape by using contours consists essentially of drawing contours of the skull in three planes at right angles to one another and in this way, obtaining cranial ‘maps’ (Bunn and Turner, 1956). One of the limitations of this method was that the drawings were not sufficiently accurate to describe dimensions of the skull. The most common and widely used approach of skull measurement was the Hrdilicka’s method in which the spreading of calliper and steel tapes were use to determine dry skull shape (Bunn and Turner, 1956; Chamella, 1997). This approach is still in vogue and has over the years, been proven by several researchers to be accurate. It however requires anatomical experts who have mastered landmarks of the skull to ensure accuracy, though, time consuming and characterised with inter-observer errors (Bunn and Turner, 1956; Chamella, 1997).

Recently, skull shape and size has been precisely measured using quantitative imaging and automated machines (El-Feghi *et al*., 2004). Anatomical landmarks of the skull can also be established using various radiographic or radiologic techniques such as conventional x-rays, Computed Tomography (CT) scan and the Magnetic Resonance Imaging (MRI) (El-Feghi *et al*., 2004). Before the advent of modern CT scan, automatic measurement of cranial size and shape was not easily achievable. Currently, the CT scan provides adequate image data to create three dimensional images with reduced scanning time (Cavalcaroti *et al*., 2004). The CT scanner, with built-in cursor allows electronic measurements of distances and areas. It also provides an opportunity for those who review CT images to determine cranial size directly from it. Three dimensional CT techniques such as the multi-planar reformatting, shaded surface display, volume rendering and the maximum intensity projection are protocols which permits the evaluation of the CT data in three dimensions (Cavalcaroti *et al*., 2004). In a study by Hilgers *et al*. (2005), conventional cephalometric radiography and CT values of the tempero-mandibular joint and associated structures were compared. The CT proved to be more reliable, with good number of cephalometric measurements statistically significant from the actual anatomical measurement.

Presently, in Nigeria, there is no basic anthropologic data on the use of CT scans to establish cranial dimensions as existing studies were only restricted to the use of manual methods such as the use of calliper, tape and rulers in anthropological measurement. Normal measurements will be a very useful tool to rule out the presence or absence of craniofacial abnormalities which underscores the need for the study. The study was designed to provide local baseline values for residents in Calabar, by documenting the cranial length, cranial width, orbital length and bizygomatic length with a view to establishing cephalic index of males and females of the study population.

MATERIALS AND METHOD

A retrospective and prospective study of 200 subjects (100 male and 100 female) with cranial images from a Brivo 385 16 slice CT scan of Nigerians residing in Calabar, aged from 18 to 87 years obtained from the Asi-Ukpo Diagnostic Medical Centre Calabar. This is in accordance with Management’s permission and clearance by the Committee on Research Ethics. A simple random probability sampling technique was employed. Images used were inclusive of the patient’s age and sex, devoid of any anomaly or pathology while images with incomplete information, bony deformity, pathology and fracture affecting the skull, were excluded from the study.

Parameters measured were the Maximum Cranial Width (MCW) or biparietal diameter which is the maximum point of biparietal axis around the skull. Maximum Cranial Length (MCL) or head length which is the maximum point on the sagittal axis of the skull from the glabella to the inion. The Orbital Length (OBL); the horizontal distance (line) between the medial and lateral canthi of an open orbit and the Bizygomatic Length (BZL) which is the horizontal distance from one zygomatic bone to the other.

The images were displayed on the CT monitor. The mid-ventricular head section that demonstrated the largest size of the frontal horns of the lateral ventricles was selected for evaluation of the head size. Using the built in cursor, edges of the outer cranium were traced. The MCL was obtained from the glabella to the inion using the axial image (figure1). Also, the MCW was traced using the maximum point of biparietal axis around the skull with an axial image (figure1). The BZL was traced with the horizontal distance from one zygomatic bone to the other (figure 2) using a coronal image while the OBL (the distance between the medial and lateral canthi of an open orbit) was obtained with axial image (figure 3).

The cephalic index was obtained by measuring the ratio of MCW to MCL and then multiplied by 100 according to Williams *et al*., (1995) and Williams and Rogers (2006) as shown in figure 4. The international classification standard was adopted in classifying the different head shapes as dolicephalic (cephalic index of <75), bradycephalic (an index of >81) and mesocephalic; index range of 76-81 (Williams *et al*., 1995; Williams and Rogers, 2006). Descriptive statistics including frequency, standard deviation and standard error of mean were used. Analysis was done using the SPSS version 21. Student T-test was used to test the level of difference in mean of the variables at $p < 0.05$.

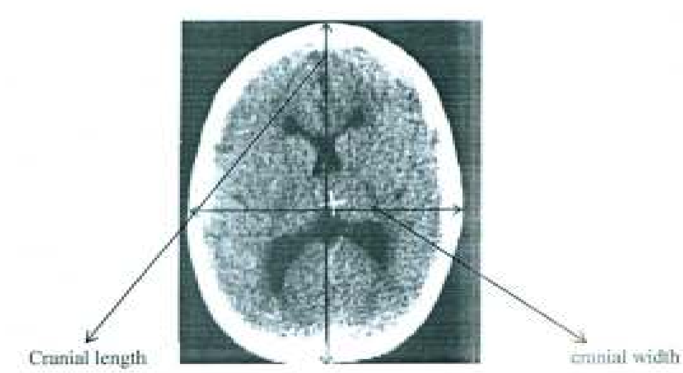

Figure 1: Cranial Length (MCL) and Cranial Width (MCW)

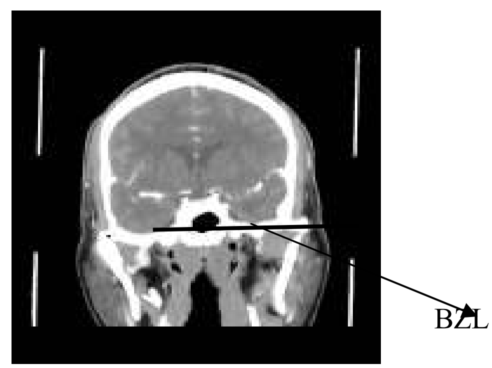

Figure 2: Bizygomatic Length (BZL)

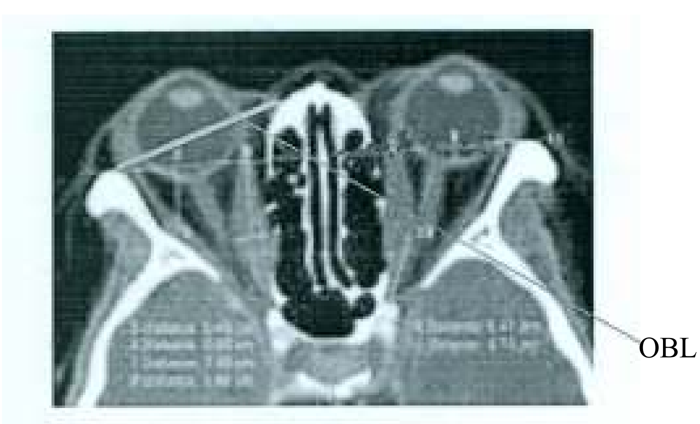

Figure 3: Orbital Length (OBL)

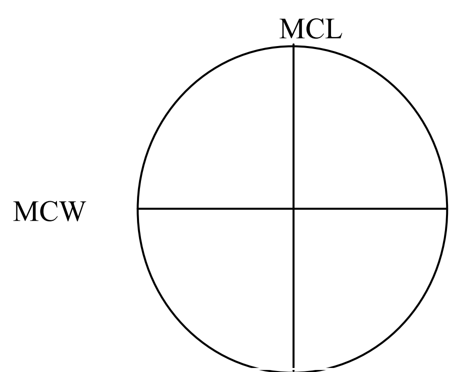

Figure 4: Cephalic index = $\frac{MCW}{MCL} \times 100$

RESULTS

Table: 1

Socio-demographic characteristics of the subjects

Variables	Frequency (N)	Percentage (%)
Age group (years)		
18-27	18	9.00
28-37	34	17.00
38-47	56	28.00
48-57	36	18.00
58-67	35	17.50
68-77	07	3.50
78-87	14	7.00
Total	200	100
Gender		
Male	100	50
Female	100	50
Total	200	100
Occupation		
Student	35	17.50
Trading/Business	52	26.00
Public/Civil servant	68	34.00
Farming	16	8.00
Artisan	17	8.50
Others	12	6.00
Total	200	100

Table 2:

Cranial parameters of the study population

Variables	Sex	N	Mean	SD	SEM
MCL	Male	100	182.99	6.57	0.66
	Female	100	178.53	9.08	0.91
MCW	Male	100	138.59	5.63	0.56
	Female	100	137.21	6.51	0.65
OBL	Male	100	34.35	3.17	0.32
	Female	100	33.57	2.98	0.30
BZL	Male	100	130.13	6.93	0.69
	Female	100	127.54	8.50	0.85

MCL= Maximum Cranial Length, MCW = Maximum Cranial Width, OBL=Orbital Length, BZL= Bizygomatic Length, SD=Standard Deviation, SEM= Standard Error of Mean, significant at $p < 0.05$

Table 3:

The mean cephalic index of males and females with the use of CT scan in the study population

Male	Frequency	CI	SD	SEM
Male	100	76.09	3.69	0.37
Female	100	75.81	4.49	0.45

Table 4:

Cephalic indices of different populations

S/n	Population	Authors	Year	Method of measurement	Cephalic index
I	Kvangaja race	Basu	1963	Caliper	79.50
II	Bhils race	Bhargav and Kher	1960	Caliper	76.98
III	Gujarat (Indian)	Shah	2004	Caliper	80.81
IV	Barelis (Indian)	Shah & Jadhav	2004	Caliper	79.80
V	Ijaws Male Female	Oladipo and Olutu	2006	Caliper	80.98 78.24
VI	Igbos Male Female	Oladipo and Olutu	2006	Caliper	79.04 76.83
VII	Urhobos	Oladipo and Paul	2009	Caliper	82.16
VIII	Iteskiris	Oladipo and Paul	2009	Caliper	86.80
IX	Igedes Male Female	Obaji	2015	Caliper, tape & ruler	78.86 79.43
X	Idomas Male Female	Objai	2015	Caliper, tape & ruler	78.47 79.43
XI	Ibibios Male Female	Oladipo and Isong	2010	Caliper	79.85 78.36
XII	Nigerians in Calabar Male Female	Present study	2017	CT scan	 76.09 75.81

Table 5:

Distribution of the different skull shapes obtained in the study population

S/n	Skull shape	Frequency (N)	Percentage (%)
1	Long head (dolicocephalic)	5	2.5
2	Middle head (mesocephalic)	191	95.5
3	Short head (brachycephalic)	3	1.5
4	Very short head(hyperbrachycephalic)	1	0.5

DISCUSSION

The socio-demographic characteristics including the age, sex and the occupation obtained from the present study (table 1) were taken into consideration with respect to the cranial dimensions or parameters of the Nigerian sampled population in Calabar. On the gender distribution, results of the present study showed no significant difference between males and females which corroborates similar work by Ekizoglu *et al*. 2016 on the assessment of sex in a modern Turkish population using cranial CT anthropometric parameters. Results in table 2 showed that the MCL, MCW, OBL and the BZL of males are higher than females. These results support similar work on sex identification from the skulls of Hausa/Fulani in northern Nigeria (Adebisi, 2003). Also, results in table 2 support the inference that sex determination from the human skull is of paramount value and interest to forensic experts in the identification of human remains and racial identity of the deceased, since the race and sex of a human skull can in many cases, be assessed anthropometrically (Deshmukh and Devershi, 2006).

The MCL and MCW of males and females in the studied population were sexually dimorphic, with the males having higher values at $p<0.05$ (Table 2). The result agrees with anthropometric comparison of cephalic indices between the Ijaw and the Igbo tribes in a sampled south-south and south-east Nigerian population (Oladipo and Olotu, 2006). The result is also in line with similar studies in which the cephalic length and breadth of the Urhobos and the Itsekiris, the Ibibios, the Ijaws and the Igbo tribes in Nigeria were studied (Oladipo and Paul, 2009; Oladipo, 2010).

The mean cranial index (Table 3) showed that both males and females of the study population were mesocephalic (intermediate head) in about 95.5% of the total sampled population as shown in table 5. Similar results have also been found among the Japanese and Australian populations (Kasai *et al*., 1993). Also, results of the present study (table 3 and 5) corroborate similar work on the Ijaws and the Igbos with established mean cephalic indices of 80.98 and 78.24, 79.04 and 76.83 for the Ijaw males and females, Igbo males and females respectively (Oladipo and Olotu, 2006). In addition, the mean cranial index of the present study agrees with anthropometric study of cranial index amongst the Ibibios and the Efiks which showed that both were mesocephalic (Oladipo, 2010). Therefore, findings of the present study revealed that sexual dimorphism in cranial dimensions are best pronounced in the mesocephalic form which validates similar works on craniofacial classifications of normal newborn and morphological evaluation of head and face shapes, all in a sampled north-eastern Nigerian population (Maina *et al*., 2011; Raji and Garba, 2010).

The use of CT scan in comparison with other methods of measurement (Table 4), provides a more reliable method as the multi-planar reformatting, shaded surface display, volume rendering and the maximum intensity projection in measuring the cranium, permits evaluation of the CT images in all three dimensions. However, result of the present study agrees with similar works (Table 4), using conventional anatomical methods which measured distances and areas around the skull with the subjects standing or sitting with their heads in anatomical position, depending on the dimensions measured (Bhargav and Kher, 1960; Basu, 1963; Shah and Jadhav, 2004; Oladipo and Olotu, 2006; Williams and Rogers, 2006; Oladipo and Paul, 2009). Also, results of the present study support similar work on the assessment of sex in a modern Turkish population using cranial CT anthropometric parameters (Ekizoglu *et al*., 2016). The use of CT scan in the study population shows a good number of cephalometric measurements statistically significant from actual anatomical measurement. With the available data obtained from the study population, clinicians may transform decision making to diagnose the presence or absence of craniofacial abnormalities or pathology. In addition, the available results may provide opportunity for further research.

CONCLUSION

The cranial index of the studied population is majorly mesocephalic. Parameters of sexual dimorphism in cranial dimensions have thus, been established in the sampled Nigerian population in Calabar. Therefore, the role of CT scan in anthropometry of the skull cannot be overemphasised.

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