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Full Length Research Paper

Adult cephalic index of the Igbo people in and around Nnewi town in Nigeria using computed tomography

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In disaster victims' identification in forensic science, every piece of evidence is relevant. Biochemical assays, anthropometry, and recently, medical imaging, have all provided some form of evidence. Cephalic index, popular derived by ultrasound in utero, and with sliding calipers ex utero, can also be accurately derived ex utero using the medical imaging tool of computed tomography. To derive cephalic index for an adult Igbo population in Nigeria using computed tomography, with a view to encouraging its adoption by future researchers in the locality. Digital computed tomography (CT) images of one hundred and thirty-seven (137) male and sixty-five (65) female patients aged 18 - 93 years were electronically measured using on-screen measurement cursors (OMC) on CT monitor. For each patient, two scanograms were acquired supine at an azimuth of 90 degrees (lateral) and 180 degrees (postero-anterior). Measurements were for occipito-frontal diameter (OFD) and biparietal diameter (BPD) after which simple mathematical calculations were used to derive cephalic index, in percentage. Cephalic index was eventually computed for the entire population. Enlisted images had the three major categorizations of cephalic index in the following proportion: brachycephalic (16.3%), mesocephalic (32.2%) and dolicocephalic (51.5%), respectively. However, when the entire population was normalized using mathematical averaging, the observed variations gave way to a clear evidence of mesocephalic head type for Igbo population (male = 77.23 ± 4.8; female = 77.46 ± 5.1; combined = 77.35 ± 5.2). Cephalic index measurement is replicable using an advanced medical imaging modality like computed tomography. This possibly pioneering work in the entire southeast geopolitical zone of Nigeria using Igbo population indicate that they belong to the mesocephalic head type which corroborates several studies done with sliding calipers. This knowledge is useful in first line compartmentalization in disaster victims' identification.

Keyword: Cephalic Index, Cranial Index, Computed Tomography, Scanogram, Radiographs, Azimuth.

INTRODUCTION

Cephalic index (CI), also known as cranial index, is the percentage of width to length in any skull. It is an objective and highly useful parameter for determining skull shape and racial variations. It is also helpful in forensic medicine, plastic and reconstructive surgery, orthodontics and clinical diagnosis (Likus, et. al., 2014;

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Van Lindert, 2013; Adejuwon, et.al. 2011). The rounder a head is, the higher is its cephalic index, and vice versa (Adejuwon, 2011). According to Enwunonu (2016), CI is categorized as dolichocephalic (≤ 75%; long head), mesocephalic (75–79.9%; medium skull) and brachycephalic (≥ 80%; short skull). Mongoloids, Negroids and Caucasoids are characterized by brachycephalic, mesocephalic and dolichocephalic head shapes, respectively (Paulinus, et. al., 2019; Jervas. et. al., 2016). Cephalic index may be determined by applying anthropometric methods, dry skull measurements and through radiological methods such as computed tomography (Adejuwon, 2011).

Computed tomography (CT) is an imaging modality which is considered an excellent tool for the assessment of cranial morphology. It is also highly reliable, reproducible, and devoid of projection errors associated with superimpositions of bones in traditional x-ray imaging. In addition, CT has a wide range of tools, such as 3-D reconstructions in any direction to permit accurate identification of landmarks

Likus, 2014; Adejuwon, 2011). There are however,

concerns about accessibility, complexity of operation, cost, and radiation risks with CT. But just as in routine diagnostic procedures, radiation risks and cost are surmountable through the principles of justification of investigation, optimization of dose and minimization of exposure. In addition, CT is no longer as inaccessible or seemingly complex as it was some decades ago (Adejoh, et. al., 2018). Furthermore, requests for cephalic index are not routinely made, and where made, they would more likely be in the reasonably justified investigations involving disaster victims' identification and pre-and post-surgical evaluations (Nguyen & Doyle, 2018; Likus, 2014).

Nigeria is reputed to be the most heterogenous and populous country in Africa, therefore, the findings from this work can validly be extrapolated to other African countries [Adejoh, 2018]. Igbo people are one of the three most populous groups in Nigeria. They occupy the rain forest belt known as Southeast Nigeria. Contiguous people groups to Southeast may share some similarities with them in language, culture, and phenotype yet, they are not Igbo but part of the over two hundred and fifty (250) distinct peoples groups. No matter the heterogeneity in accent, and complexion amongst Igbo, their names are homogenous. This is one key way to identify them. However, whereas studies on cephalic index using sliding calipers amongst the Igbo are numerous, there are conflicts as regarding the specific head shape for them in some studies (Jervas, 2016; Enwononu, 2016; Enwononu, 2014; Oladipo, 2013; Esomonu & Badamasi, 2012; Eliakim- Ikechukwu, et. al., 2012).

Literature on CI using computed tomography in Nigeria specifically, and on the African continent generally, were sparse, an indication that the procedure may not be popular. This study was therefore, conceptualized to replicate earlier studies from other continents that used advanced medical imaging tools like computed tomography. Since Nigeria now has about one hundred and eighty-three (183) CT scanners, one of the largest on the continent (Adejoh, 2018), future researchers may readily find the modality an accessible tool in the quantification of cephalic index.

METHODS

Ethical approval was obtained from the institutional Human Research Ethics Committee on 24th February, 2016. The study was retrospective and cross sectional, and was undertaken in the computed tomography suite of the study centre in March, 2016. It involved CT monitor measurements and calculations of digital images of the head generated in 2015. As at the time of the study, the centre had a functional GE Bright speed CT scanner, manufactured in 2007 and installed in 2011, with 4-slice per rotation capacity. The scanner also had capabilities for helical and axial scan modes. The machine, aside benefiting from routine quality control, also had self-calibrating software for quality assurance and, this was activated daily. Radiographers, radiologists, nurses and a retinue of trainees and other ancillary staff were employed at the centre.

The population of head CT in the centre in 2015, as ascertained from departmental records, was three hundred and thirty-five (N = 335). This comprised both paediatric and adult subjects of different ethnic groups but predominantly, Igbo. Due to the small population, total enumeration was adopted rather than sampling. Excluded were non-Igbo names, paediatric folders, images with evidence of head and neck apparel artefacts, scalp oedema, images with distorted bony skull tables or facial bones, evidence of head rotation as well as incomplete data on age and gender (Fig. I). Eventually, only two hundred and two (n = 202) digital folders were included. Folders were for subjects aged ≥ 18 years, with two scanograms derived supine at an azimuth of 90 (lateral) and 180 degrees (postero-anterior), respectively. Confidentiality was maintained on the CT monitor through activation of 'partial image anonymity' feature which masked names, examination number and clinical impressions.

Measurements in this work were fairly in tandem with methods described by Paulinus, et al. (2019) and Both ocipito-frontal (OFD) and biparietal (BPD) diameters are needed for calculation of cephalic index. For BPD, on-screen linear measurement cursor was activated on a postero-anterior (PA) scanogram. The most elongated bilateral bony prominences were then identified. A horizontal line was then drawn from one prominence to the other, at an azimuth of 90 degrees. The azimuth (degree) appears automatically when a line is moved from rest on CT monitor. This line was consistently maintained at distance of 4 to 5.5cm superior to supraorbital margin. This represented biparietal (BPD) diameter. Conversely, lateral scanogram is used to derive OFD. On lateral scanogram showing good perpendicularity of base of skull (BOS) to CT couch, occipito-frontal diameter (OFD) was measured using a straight line which bisected the hypodense frontal sinus (glabella) at an azimuth of 77 to 90 degrees. The cursor was then extended to the most protuberant part of the occipital bone (inion) posteriorly (Fig. II & III). The percentage of the BPD to the OFD was then calculated according to a recommended method found in the literature (Van Lindert, 2013). On-screen digital measurements outputs were recorded in a data sheet rather than being electronically saved on the monitor, in order to allow images revert to their original state for medico-legal reasons. Statistical Package for Social Sciences, version 20.0 (SPSS Incorporated, Chicago,

Figure I: Lateral scanogram generated at 90 degree azimuth is used for measurement of OFD. This type was however excluded because it was a paediatric skull that was still growing in addition to being distorted.

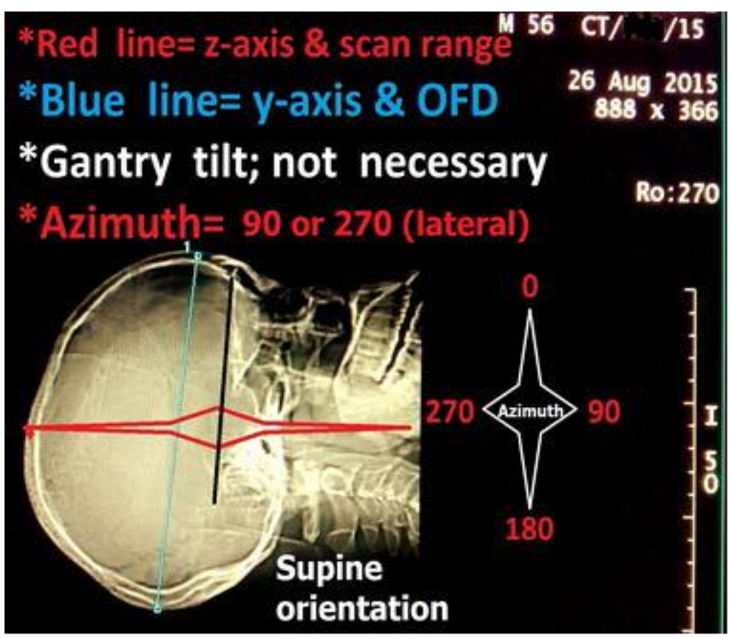

Figure II: Lateral scanogram generated at 90 degree azimuth is used for measurement of OFD. Base of skull (drawn, dark, suspended, vertical line) must be perpendicular to horizontal CT couch to indicate perpendicularity of cantho-meathal line and to avoid gantry tilt which is a stress on machine. If head is well positioned during image acquisition, blue horizontal line should maintain an azimuth of 180 degree, otherwise, it should be parallel to BOS

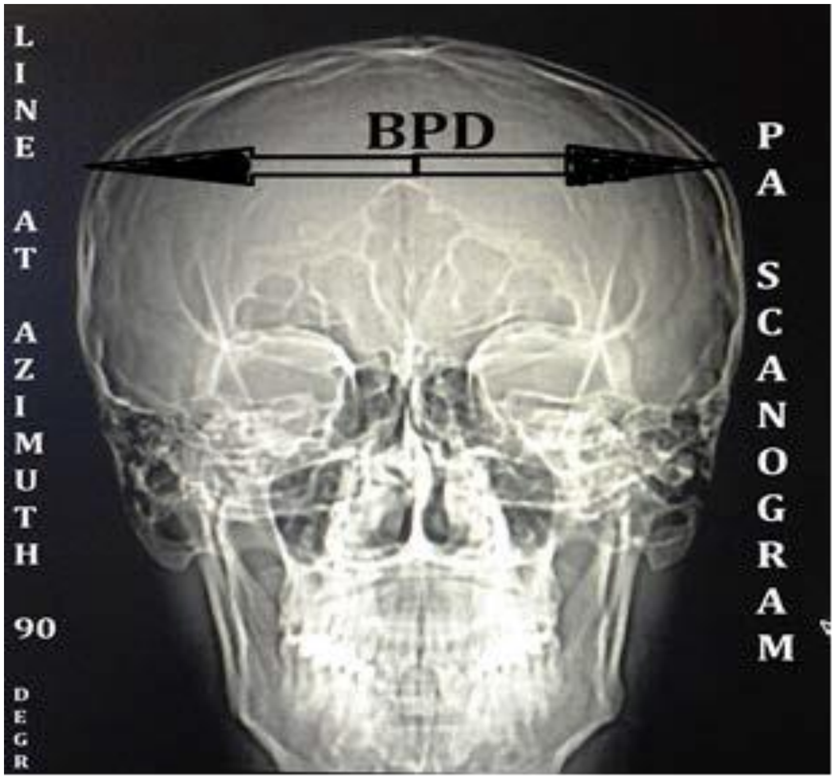

Figure III: Postero-anterior scanogram generated at azimuth 180 degree is for measurement of BPD. When the horizontal measurement cursor maintains an azimuth of 90 degrees, it is an indication that the head was non-rotated during positioning.

Illinois, USA) was used to analyze the data. Statistical significance was set at $p < 0.05$. Focus was on descriptive statistics like central tendencies and range, as well as inferential statistics like test of means.

RESULTS

Three hundred and thirty-five (335) subjects had CT of the head at the study centre in 2015. However, only 60.3% (n = 202), comprising 137 (68.0%) males and 65 (32.0%) females, met inclusion criteria (Table 1). Their ages ranged from 18 to 93 years and with a mean age of 53.62 ± 16.4 years. The mean BPD, OFD and CI were 137.16 ± 8.3 mm, 184.02 ± 7.2 mm and 77.35 ± 5.2 %, respectively (Table 2). The mean CI for the population placed them at mesocephalic head shape, and this was derived from a heterogeneous population (brachycephalic: 16.3 %; mesocephalic, 32.2 %; dolicocephalic, 51.5 %) as shown in Table 3. The present work was compared with previous local studies that used other methodologies as shown in Table 4. An independent-sample t-test was carried out to ascertain sexual dimorphism. Levene's test assumed equal variances. The little difference found was not statistically significant ($p = 0.493$).

DISCUSSION

There are several methods for quantifying skulls for topographical relations but cephalic index, in case of measurements taken on the living human, is the most important. Cephalic index (CI) can be quantified in utero with ultrasound, and ex utero with anthropometry and imaging tools like computed tomography (Adejuwon, 2011). The present study aimed at deriving cephalic index ex utero, in an adult Igbo population in a town in Anambra State of Nigeria using computed tomography. This was with a view to encouraging future researchers in Nigeria to adopt the continentally-incipient methodology. During data collection, all three major categorizations of CI were found in the population to varying degrees and with dolichocephalic as the dominant group (51.5%), mesocephalic as intermediate (32.2%) and brachycephalic as least dominant (16.3%). This variation in our work was similar to the experience of Jervas, et al (2016) who carried out a similar work with anthropometry in Owerri town in the same Southeast Nigeria and observed heterogeneity in their recruited subjects. Dolichocephalic subjects were 66.7%, while brachycephalic and mesocephalic were 21.7% and 11.6%, respectively. After mathematical averaging in our

Table 1: Throughput of CT subjects (N) and sample size (n) of head CT at the study centre in 2015

Parameter	N			n		
	Male	Female	**Total**	Male	Female	**Total**
Head	208	127	335	137	65	202
Abdomen	11	8	19	-	-	-
Chest	8	8	16	-	-	-
Others	1	6	7	-	-	-
Total	228	149	377	137	65	202

Table 2: Mean biometric characteristics of subjects

Variable	**Sample size (n = 202)**			
	Range	Male	Female	Combined
AGE (year)	18 - 93	54.05 ± 19.5	52.20 ± 13.5	53.62 ± 16.4
BPD (mm)	114 - 164	138.12 ± 8.5	137.08 ± 8.1	137.16 ± 8.3
OFD (mm)	163 - 198	185.32 ± 5.7	183.33 ± 6.1	184.02 ± 7.2
CI (%)	64.4 - 92.2	77.23 ± 4.8	77.46 ± 5.1	77.35 ± 5.2
Inference	D, M & B	Mesocephalic	Mesocephalic	Mesocephalic

Legend: D = Dolichocephalic; M = Mesocephalic; B = Brachycephalic

Table 3: Cephalic index categories during data collection

Variable	**Range (this work, %)**	**Normal range (literature, %)**	**Frequency**		**Total**	**%**
			Male	Female		
Dolichocephalic	64.4 - 74.9	≤ 75	73	31	104	51.5
Mesocephalic	75.0 - 79.9	75 – 79.9	44	21	65	32.2
Brachycephalic	80.0 - 91.5	≥ 80	20	13	33	16.3
Total	64.4 - 91.5	100	137	65	202	100

Table 4: Comparison of current CT-based work with other local works done with calipers

Tribe	**Author**	**Population**	**Location**	**Methods**	**Gender**	**Sample**	**CI (mean ± SD)**	**Remark**
Igbo	Present study, 2016	Adults	Nnewi	Images	Male	137	77.23 ± 4.8	Mesocephalic
					Female	65	77.46 ± 5.10	Mesocephalic
Igbo	Esomonu & Badamasi (2012)	mixed	Abia State	Subjects	Male	300	80.41 ± 5.50	Brachycephaly
					Female	300	81.41 ± 4.90	Brachycephaly
Igbo	Eliakim-Ikechukwu, (2012)	Adults	Owerri	Subjects	Male	170	81.79±0.43	Brachycephalic
					Female	130	81.68±0.52	Brachycephalic
Igbo	Odokuma, (2010)	Adults	Delta State	Subjects	Male	141	77.62	Mesocephalic
					Female	145		Mesocephalic
Hausa	Umar, (2011)	Mixed	Kano	Subjects	Mixed	410	75.85	Mesocephalic
Yoruba	Umar, (2011)	Mixed	Ilorin	Subjects	Mixed	410	79.52	Mesocephalic
Yoruba	Adejuwon, (2011)	Adult	Ibadan	Cadaver	Male	56	72.97 ± 2.16	Dolicocephalic
					Female	29	71.72 ± 2.48	Dolicocephalic
Edo	Odokuma, (2010)	Adults	Delta State	Subjects	Male	64	78.21	Mesocephalic
					Female	46		Mesocephalic
Itsekiri	Oladipo, (2013)	Adults	Delta State	Subjects	Male	250	71.96±4.66	Dolicocphalic
					Female	250	74.11±4.70	Dolicocephalic
Urhobo	Odokuma, (2010)	Adults	Delta State	Subjects	Male	156	78.04	Mesocephalic
					Female	147		Mesocephalic

work, the mean CI were 77.23 ± 4.8 % (male), 77.46 ± 5.1 % (female) and 77.35 ± 5.2 % (combined populations), which clearly placed the population in mesocephalic group. Jervas (2016) reported a similar trend. It was intriguing to note that despite the preponderance of dolichochephalic category, the population ended up being mesocephalic after analysis. An independent-sample t-test did not reveal any sexual dimorphism in the population (p = 0.493). The differences observed pre-data analysis may be a remote indication of significant phenotypic variability amongst the Igbo population, while their central tendency of mesocephalic head shape after analysis strongly suggests that the population is Negroid, and not Mongoloid or Caucasoid (Jervas, 2016; Umar, 2011).

The Igbo population share this mesocephalic head shape with some not-too-distant neighbours like Delta Igbo, Urhobo, Edo (Odokuma, 2010), and Ogoni female (Oladipo, 2013). The Yoruba of Ilorin and Hausa of Kano also share in this similarity (Umar, 2011). This similarity between the far-flung Ilorin Yoruba and Hausa tribes does not necessarily denote common ancestry with the Igbo since DNA evidence proves that they are distinct (Olukanni, et. al., 2018). This may just be evidence of their common Negroid brotherhood. While the preponderance of mesocephalic head shape amongst Negroid tribes may be justifiable, the heterogeneity in subjects during recruitment throw up some complexities. This may be one of the weak points in using cephalic indices for categorizing head shapes of diverse tribes. However, this flaw appears extenuated when CI is combined with DNA evidence in forensic investigations (Olukanni, et. al., 2018).

Are the Igbo generally mesocephalic? According to Esomonu & Badamasi (2012), Eliakim-Ikechukwu (2012), and Enwunonu (2014), the Igbo of Abia, Owerri and Igbo adult males from Abakaliki in Ebonyi State were not mesocephalic but predominantly, brachycephalic. Enwunonu (2016) however, explained that a deviation from mesocephalic head shape amongst the Igbo is a result of an ongoing global phenomenon of brachycephalization arising from changing BPD, influence of heredity, environment and nutrition. The inference therefore, is that authors see the Igbo as mesocephalic but with tendency for brachycephalization.

No work was located by us that placed an entire Igbo population in the dolicocephalic head category, a feature of Itsekiri in Delta State (Oladipo, 2013), and Yoruba of Ibadan (Adejuwon, 2011). Ireyefoju & Ireyefoju (2014) hinted that historians link Itsekiri and Yoruba with a common language. Now, the evidence of common head shape may have added to the weight of evidence about their ties with each other (Oladipo, 2013, Adejuwon, 2011). One could infer that in view of the weight of evidence from this work and from the literature, whereas the Igbo residing in and around Nnewi may have some modicum of common ancestry with Delta Igbo, Urhobo, Edo and Ogoni, there is no such evidence to suggest a similar common ancestry with the Yoruba and Itsekiri. Where evidence from CI place various Nigerian tribes in the same head shape, it is strongly suggestive of a common Negroid background (Enwunonu, 2016). This work had noticeable limitations. The inability to verify Igbo ancestry beyond name, as well as the inability to link subjects with their specific locations in Southeast Nigeria is such. Also, a larger sample size would have made the generalizations more convincing. However, since our limitations were shared by previous works where valid inferences were made, we are of the opinion that our work is a contribution that future researchers will find useful. These researchers may wish to follow up cases from referring clinics to verify ancestry and roots. Furthermore, a follow up study involving subjects with similar ancestry up to four generations may help to neutralize the influence of variations arising from inter-tribal marriage and environmental factors.

CONCLUSION

Although there are several works on cephalic index using calipers in the locality, this work contributes to the body of knowledge by encouraging the use of computed tomography as an alternative method. Furthermore, despite the heterogeneous nature of the sample size for the study, statistical analyses eventually placed the Igbo population in the mesocephalic head group (Negroid).

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