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Analysis of craniofacial indices of dry crania in Southeast and Southsouth Nigeria

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Abstract

Objective: To determine the cranial index, upper facial index and frontal index of dry human crania in Nigeria.

Methods: A total of 150 dry adult male crania were studied in two geopolitical zones (Southeast and Southsouth) in Nigeria. Measurements were taken with spreading caliper and Vernier caliper. The following variables were measured: Maximum cranial length (MCL, g-op), Maximum cranial breadth (MCB, eu-eu), Minimum frontal breadth (MFB, ft–ft), Upper facial height (UFH, n-pr) and Bizygomatic breadth (BZB, zy-zy). From these variables, cranial index (CI), frontal index (FI) and upper facial index (UFI) were calculated. Data analysis was done with the Statistical Package for Social Sciences (SPSS version 25).

Result: In the Southeast group, the values of MCL, MCB, BZB, UFH and MFB (in mm) were 181.4 (±10.3), 135.3 (±6.7), 135.3 (±6.0), 68.0 (±4.1) and 97.9 (±7.4) respectively. In the Southsouth group, the values of MCL, MCB, BZB, UFH and MFB (in mm) were 180.0 (±7.8), 133.9 (±6.7), 135.0 (±7.2), 67.5 (±6.6), and 98.1 (±4.9) respectively. There was no significant difference in these means between the Southeast and Southsouth groups. In the Southeast group, the mean values of CI, FI and UFI (in %) were 75.1 (±5.9), 72.7 (±5.9), and 50.5 (±3.4) respectively. In the Southsouth group the mean values of CI, FI and UFI (in %) were 74.5 (±4.0), 73.3 (±3.6) and 50.0 (±4.4) respectively. There was no significant difference in the means of the cranial indices among the two groups.

Conclusion: The crania in the southern part of Nigeria are dolichocephalic, eurymetopia and mesene type.

Keywords: Cranial index; Frontal index; Upper facial index; Nigeria

1. Introduction

The cranium is formed by a set of twenty-two separate bones excluding the hyoid bone and three pairs of ear ossicles [1]. Some of the bones are paired while others are not. The bones are held together by immobilized joints called sutures. The neurocranium consists of bones that enclose the brain while the viscerocranium (splanchnocranium) consists of the bones of the face. Scattered across the cranial bones are standardized landmarks by which measurements can be taken across the bones.

Anthropometry is a study of the dimensions of the human body. Craniometry on the other hand is an aspect of anthropometry which studies the shapes and sizes of components of the cranium [2]. Craniometry provides information about growth and development. Therefore, it is important in the field of anatomy, anthropology, plastic surgery [1] craniofacial and reconstructive surgery, genetic counselling, orthogenetic surgeries and forensic applications [3]. Craniometry is equally important in population study and analysis of skeletal variation [3,4, 5].

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Cranial index (CI) is the ratio of the maximum cranial breadth to the maximum cranial length, multiplied by hundred. The CI was described by a Swedish professor, Anders Retzius (1796-1860) and was first used in physical anthropology to categorize remains of ancient humans found in Europe [4]. It is very useful in classifying human races. It can portray the appearance of an individuals and may be used to calculate the age of the fetuses in obstetrics and forensics [4]. There are four main categories of CI according to Frankfurt craniometric conference 1884 agreement: dolichocephalic (narrow cranium, CI ≤ 75), mesocephalic (75.1 to 79.9), brachycephalic (broad cranium, 80-85) and hyperbrachycephalic (very broad, ≥ 85.1) [5,6].

The frontal index (FI), also called Transverse Fronto-Parietal Index, is the ratio of Minimum Frontal Width to Maximum Cranial Width multiplied by 100. The FI is used to define the relationship between frontal and cranial width. The index values are examined in three categories, which are sthenometopia / narrow forehead (≤ 66), metriometopia / middle face (66 - 68.9), eurymetopia / wide forehead (≥ 69) [1].

Upper facial index (UFI) on the other hand, is calculated as upper facial height divided by bizygomatic breadth multiplied by 100. It assess the relationship between the height of the upper face and the width of the face. Upper facial index is therefore a reflection of the shape of the upper face. There are five categories which are hypereuryene / very wide / low (≤ 45), euryene / wide / low (45 - 49.9), mesene / medium (50 - 54.9), leptene / narrow / high (55- 59.9), hyperleptene / very narrow / high (≥ 60) [1].

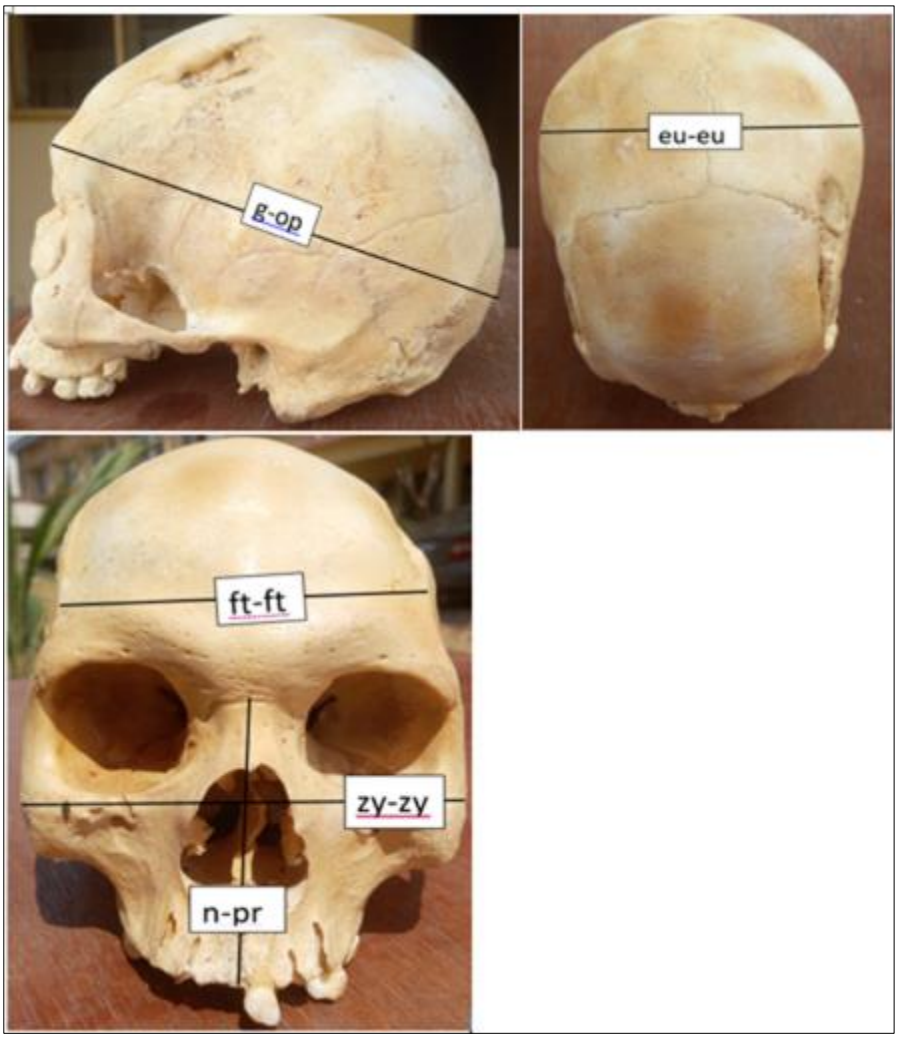
It is a known fact that anthropometric measurements largely varies across different populations; hence the data generated by this research being population specific will be useful not only for forensic application, but also for clinical application.

2. Materials and methods

Ethical approval was obtained from the ethics committee of our Faculty. In this cross sectional study, a total of 150 adult male crania were studied in two geopolitical zones in Nigeria: Southeast (111 crania) and Southsouth (39 crania). The crania belong to Departments of Anatomy of the medical schools within the study area. Southeast zone is mainly occupied by Igbos while the Southsouth region is mainly occupied by the Ijaws [7].

Crania whose landmarks are intact were included in this study, while the poorly preserved crania were excluded. Measurements were taken with spreading caliper (FERVI C028/150 - C028) and Vernier caliper (Gilson tools Japan, 0-150mm X 0.05/6" X 1/128), with precision of 0.05mm).

The variables were measured from standard landmarks as follows (figure 1):



Maximum cranial length (MCL, g-op): The straight-line distance from glabella (g) to opisthocranion (op) in the midsagittal plane; **Maximum cranial breadth** (MCB, eu-eu): The maximum width of the skull perpendicular to the mid-sagittal plane; **Minimum frontal breadth** (MFB, ft–ft): The distance between the right and left frontotemporale; **Upper facial height** (UFH, n-pr): The distance from nasion (n) to prosthion (pr); **Bizygomatic breadth** (BZB, zy-zy): The maximum breadth across the zygomatic arches, wherever found, perpendicular to the mid-sagittal plane

Figure 1 Landmarks for measurement

Based on these variables, the following indices were calculated:

- **Cranial index** (CI) is the ratio of the maximum cranial breadth to the maximum cranial length, multiplied by hundred. There are four main categories of CI according to Frankfurt craniometric conference 1884 agreement: dolichocephalic (narrow cranium, CI ≤ 75), mesocephalic (75.1 to 79.9), brachycephalic (broad cranium, 80-85) and hyperbrachycephalic (very broad, ≥ 85.1) [5,6]
- **Frontal index** (FI), Transverse Fronto-Parietal Index, is the ratio of Minimum Frontal Width to Maximum Cranial Width, multiplied by 100. The FI is used to define the relationship between frontal and cranial width. The index values are examined in three categories, which are sthenometopia / narrow forehead (≤ 66), metriometopia / middle face (66 - 68.9), eurymetopia / wide forehead (≥ 69) [1].
- **Upper facial index** (UFI) is calculated as upper facial height divided by bizygomatic breadth multiplied by 100. There are five categories which are hypereuryene / very wide / low (≤ 45), euryene / wide / low (45 - 49.9), mesene / medium (50 - 54.9), leptene / narrow / high (55- 59.9), hyperleptene / very narrow / high (≥ 60) [1].

Data analysis was done with the Statistical Package for Social Sciences (SPSS version 25). Descriptive statistical methods (mean and standard deviation) were applied to the data. Test of significance of difference between means was done with students'd t test.

3. Result

The means and standard deviations of the studied variables are shown in table 1. There was no significant difference in the mean values of studied variables between the Southeast and Southsouth region.

Table 1 Means and Standard deviations of variables

	Southeast	**Southsouth**			**Combined**
Variables	Mean (mm) (±SD)	Mean (mm) (±SD)	t	P value	Mean (mm) (±SD)
Maximum cranial length (g–op)	181.4 (±10.3)	180.0 (±7.8)	.668	.506	180.9 (±9.6)
Maximum cranial breadth (eu–eu)	135.3 (±6.7)	133.9 (±6.7)	1.234	.219	135.1 (±6.7)
Bizygomatic breadth (zy–zy)	135.3 (±6.0)	135.0 (±7.2)	.269	.788	135.2 (±6.3)
Upper facial height (pr–n)	68.0 (±4.1)	67.5 (±6.6)	.474	.636	67.8 (±4.8)
Minimum frontal breadth (ft–ft)	97.9 (±7.4)	98.1 (±4.9)	-.286	.776	97.9 (±6.8)

The mean values and categories of various cranial indices from this research work are shown in table 2 and table 3. As regards cranial index, Southsouth region showed predominantly mesocephalic type, while southsouth region showed dolichocephalic type.

Table 2 Categories of cranial indices

Variables	**Southeast Mean (%)**	**Category**	**Southsouth Mean (%)**	**Category**
cranial index	75.1 (±5.9)	dolichocephalic	74.5(±4.0)	mesocephalic
frontal index	72.7(±5.9)	eurymetopia	73.3(±3.6)	eurymetopia
upper facial index	50.5(±3.4)	mesene	50.0(±4.4)	mesene

The category of frontal index found in both Southeast and Southsouth regions is eurymetopia (wide forehead). Both regions also exhibit mesene (medium) type of upper facial index. There was no significant difference in the means of various cranial indices between the Southeast and Southsouth geopolitical region.

Table 3 Comparison of means of cranial indices

	Southeast	**Southsouth**			**Combined**
Variables	Mean (mm) (±SD)	Mean (mm) (±SD)	t	P value	Mean (mm) (±SD)
cranial index	75.1 (±5.9)	74.5 (±4.0)	0.725	0.470	75.0 (±5.4)
frontal index	72.7(±5.9)	73.3 (±3.6)	-0.859	0.392	72.7 (± 5.3)
upper facial index	50.5(±3.4)	50.0 (±4.4)	0.642	0.522	50.3 (± 3.6)

4. Discussion

Craniometry as an aspect of anthropometry deals with metric assessment of the cranium, which could be useful in various fields such as anthropology, forensics, neurosurgery, facial reconstructive surgery amongst others. Variations in form, size and shape of cranial structures arise from interplay of genetic, racial and cultural factors. Hence population specific studies are necessary in order to generate population specific data which could be applied in various fields or profession.

With the exception of maximum cranial breadth, the values of the other linear variables (MCL, BZB, MFB and UFH) in our study was higher that the values reported by Senol et al [1] in Turkey. Maximum cranial length and MCB in our

study were comparable with that reported by Vaidya et al, 2020 in India; but the values for their MFB, UFH and BZB were lower than our reported values. A comparison of the values obtained from our study with the values obtained from other studies is given in table 4.

Table 4 Comparison of means of variables with other literary works

Variable / Study	Maximum cranial length (mm) (±SD)	Maximum cranial breadth (mm) (±SD)	Bizygomatic breadth (mm) (±SD)	Upper facial height (mm) (±SD)	Minimum frontal breadth (mm) (±SD)
Index study	180.9 (±9.6)	135.1 (±6.7)	135.2 (±6.3)	67.8 (±4.8)	97.9 (±6.8)
Senol et al [1] (Turkey)	172.20 ± 7.90	139.15 ± 9.89	125.24 ± 9.47	65.07 ± 5.40	95.33 ± 5.09
Vaidya et al, [8] (India)	180.25 ± 6.0	135.57 ± 9.89	119.75 ± 9.05	62.58 ± 5.40	83.87 ± 5.09
Ulcay et al, [3] (Turkey)	162.45 ±6.20	129.45±4.99	112.07±4.91	63.98±4.15	99.46±4.42
Herrerín et al, [9] (Egypt)	185.67	135.54	131.62	65.42	96.13
Mahakkanukrauh et al [10] (Thailand)	172.64±6.23	144.44±5.69	133.81±3.97		92.94±5.02
Ramamoorthy et al [11] (India)	178.3±8.1	133.0±6.2	113.6±6.1		96.4±4.7
Padala et al, [12] (South India)	179.2±6.0	134.0±9.6	54.7±5.2		
Pasa et al [13] (Harappa, India)	183.8	130.4			103.6
Pasa et al [13] (Kumhar Tekri, India)	180.9	127.5			103
Pasa et al [13] (Contai, India)	173.8	131.1			101.4
Pasa et al [13] (24 Parganas, India)	179	129.9			102.1
Dattatray et al [14] (India)			127.63	61.71	
Rathod et al [15] (India)			127.1	63.4	
Orish et al [16] (Nigeria)	180.4±8.12	137.2±7.95			
Kaithackal et al [17] (Kerala)	178.74	131.37			

The value of the cranial index (CI) in our study was comparable (or higher) than reports from several works in India [8,13,17] (Table 5).

Table 5 Comparison of means of various cranial indices with other works

Variable / Study	population	Cranial index	Frontal index	Upper facial index
Index study	Nigeria	75.0 (±5.4)	72.7 (± 5.3)	50.3 (± 3.6)
Sen ol et al [1]	Turkey	81.59	68.76	52.61
Vaidya et al [8]	India	75.17 ± 5.40	61.89 ± 5.89	52.28 ± 5.19
Herrerín et al [9]	Egypt	73.07	70.95	49.57
Mahakkanukrauh et al [10]	Thailand	83.7	64.3	
Pasa et al [13]	Harappa, India	71.01		
Pasa et al [13]	Kumhar Tekri, India	70.59		
Pasa et al [13]	Contai, India	75.57		
Pasa et al [13]	24 Parganas, India	72.66		
Kaithackal et al [17]	Kerala	73.71		
Dattatray et al [14]	India			48.36
Rathod et al [15]	India			49.9

However, it was lower than the values reported from works done in Turkey [1] and Thailand [10]. This finding suggests that the population in our study (Nigeria) has narrower crania than Turkey and Thailand.

One of the importance of cranial index is in understanding population variation. Historically, this was used to divide Europeans into three races: long-headed "Teutonics" in the north, round-headed "Alpines" in the center, and long-headed "Mediterraneans" in the south [18]. The variation in cranial index was then attributed to migration of some ancient races with different head shapes, with the assumption that a pure breed of population is expected to have the same cranial index. This assumption was later challenged as it was noted that variation in cephalic index does not only exist between populations, but also within populations [18].

Knowledge of cranial indices equally has clinical significance. One of the best clinical uses of CI is to identify infant cranial disproportions and to determine the need for three dimensional assessment of the skull [5].

Craniosynostosis is the premature closure of the cranial sutures in the growing child cranium. When it does, compensatory growth occurs at the other non closed sutures to make room for the growing brain [19]. Therefore, the head of the affected child assumes abnormal shape. The cranial index in this instance is quite skewed. It is crucial to understand the dimensions of cranial indicies for diagnosis. It may also be necessary to study the parent's cranial indices in order to better understand the condition and to plan for surgery [20]. Several surgical techniques have been employed for surgical correction of such cases [21]. But one common thing among all techniques is that cranial index is used to assess the effective of the procedure and to monitor progress [19].

Cranial index also has application in forensic anthropology. This is usually in situation where corpses need identification [20]. An instance of this is where bodies suffered some type of traumatic death, or where bodies were burnt beyond face recognition [22].

Cranial index is closely related to cephalic index. While cranial index deals with the ratio of cranial breadth to cranial length in dry human cranium, cephalic index deals with the ratio of the breadth to the length of the head in living subjects [18]. The difference between the two is that whereas cephalic index includes the soft tissues external to the skull, cranial index includes the shrinkage of the skull as it dries [18]. However, some researchers use the two terms interchangeably.

Additionally, cranial index has been related with bone grafting. Bone grafting is the technique of harvesting a bone or bone segment in one part of the body and grafting it into another part of the body. Bone can be harvested from the iliac crest as well as from calvaria [23]. Parietal bone is one bone that is frequently harvested in the calvaria. A study has

associated the thickness of the parietal bone with cranial index [24] in order to recommend which part of the parietal bone that will be ideal for harvesting with respect to the type of cranial index that the individual has.

The frontal index reported in our study was higher than works done in Turkey [1], India [8], Egypt [9] and Thailand [10]. The reason is probably due to interplay of ethnic or racial factor with genetics.

To a large extent, frontal and facial indices are necessary considerations in aesthetics and reconstructive facial surgeries [20,25]. Although the concept of beauty may appear subjective, it is enshrined on some anatomical basis [26]. This includes the shapes and sizes of the underlying bones and body structures. At its early development, the major goal of orthognathic surgery is to achieve occlusal restoration. However, it evolves to also aim to improve respiration and enhance phonation. More recently, one of the major goals of orthognathic surgery is facial aesthetics [26]. Prachodh et al [27] has associated cranial and facial indices with malocclusion. Trauma or congenital abnormalities can deform the face by disrupting joints or bones of the face. As such, the integrity or aesthetics of the face is impaired to certain degree. Reconstructive surgeries are required to correct such deformities. Facial indices are necessary tools for proper aesthetic diagnosis, surgical planning and follow up during postoperative recovery. Individuals may prefer certain face types than others. Similarly, a particular race may be more comfortable with certain face types than others [20]. These are things the facial reconstructive surgeons need to discuss with the patients before and after surgery. Frontal index and upper facial index, amongst other indices are the tools to analyse these types of face.

5. Conclusion

The crania in the southeast of Nigeria is dolichocephalic while the crania in the southsouth is mesocephalic. The frontal index and upper facial index in the two populations are eurymetopia and mesene respectively. There is great variation of cranial indices not only across races but within races.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicting interest.

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