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Changes in Cephalic Index and Head circumference of Igbo Children and Adolescents in a Nigerian Population

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Abstract

***Background*:** The cephalic index and head circumference are important anthropometric parameters that can provide insights into the physical characteristics and growth patterns of populations. There is dearth of data on Cephalic Index and Head circumference of Igbo Children and Adolescents. ***Method*:** This study examined 725 Igbo children and adolescents aged 5 to 19 years in Enugu, South-eastern Nigeria, using a cross-sectional approach. ***Results*:** The majority of participants exhibited mesocephalic head shape (43.2%), with brachycephalic and dolichocephalic shapes observed in 32.7% and 14.2% of the population, respectively. Mean head circumference increased with age in both sexes. Cephalic indices in boys under 12 and girls under 15 were below 80 but increased above these ages. Changes in head shape, potentially towards brachycephalization, were noted as children grew. Significant correlations were found between head circumference and cephalic index with age, height, weight, and body mass index, suggesting their relevance in forensic and anthropological investigations. ***Conclusion*:** Our results indicate diversity in head shapes and sizes, with mesocephalic heads being most common. As age increases, head circumference also tends to increase, and changes in head shape towards brachycephalization was observed. These findings underscore the importance of understanding anthropometric variations in different populations and suggest avenues for further research, particularly longitudinal studies, to explore the factors influencing these patterns.

Keywords: Cephalic index; Cephalic anthropometry; Head Circumference, Igbo cephalic index; Cranial index; Brachycephalization; Mesocephalic head; Brachycephalic head.

1. INTRODUCTION

An important anthropometric parameter for identifying the skull or the cranium is the cephalic index or cranial index [1, 2]. It is crucial for the examination of microevolutionary changes in the skull and the research of differences in the human racial population [3]. Cephalic index is used by forensic professionals as a technical aid when identifying human remains [3]. It is sexually dimorphic [3, 4], and varies with age [5].

In order to design corrective surgeries for craniofacial defects and to measure the success of these surgeries after they have been performed, neurosurgeons and plastic surgeons find cephalic index quite useful [2, 6-8].

Head circumference and intracranial volume are key anthropometric characteristic used to examine and track brain growth, particularly in young children [9,

10]. Definition of the normal head circumference for a kid of a specific race, age, and gender is required since the diagnosis of microcephaly and macrocephaly depends on the occipitofrontal circumference of the head. The size of the head has an association with body size [10]. It is important to examine these cranial parameters in children of various ages rather than grouping them all together as is done in many studies. There is dearth of data on the cephalic index and head circumference patterns among Igbo children and adolescents in Enugu, Nigeria. Understanding these patterns is crucial for assessing growth trajectories, identifying potential health risks, and informing targeted interventions to promote the well-being of the Igbo population. This study evaluated Cephalic index and Head circumference of Igbo children and adolescents in a Nigerian Population.

2. MATERIALS AND METHODS

This was a descriptive cross-sectional study of 725 Igbo children and adolescents living in Enugu, Southeastern Nigeria. The calculated sample size was approximately 400 using Bourley's formular (N/1 + N e2) for sample size, with population size being 722,664. Children and adolescents within the age range of 5 to 19 years were chosen for the study. Children and adolescents were randomly selected from some primary schools, secondary schools and higher institutions in Enugu, situated in Southeastern Nigeria by using cluster sampling method.

Informed consent was obtained from the adolescents that were 18 years and above, and from the parents/guardians of the children through the Parent Teachers Association (PTA). Ethical clearance for the original proposal was obtained from the University of Nigeria Teaching Hospital Health and Research Ethics Committee

Only individuals whose parents and grandparents were Igbos were included in the study. Non-Igbos were excluded. Those with any craniofacial anomaly were also excluded from the study. Each child or adolescent was made to stand erect or sit in a comfortable chair with the head in anatomical position and the following parameters were obtained:

1. Head circumference was measured with a non-stretchable tape around the head from a point above the glabella of the frontal bone, maintaining a horizontal plane above the eyebrow, round the occipital protuberance (opisthocranium) and back to the starting point. The tape was drawn firmly to compress the hair as much as possible for males with relatively short hair, while the long hairs of females were lifted from the occipital area to maintain good contact with the skin.
2. Maximum cranial length was measured from the glabella, along the median plane to the opisthocranium on the occipital area using standardized calipers.
3. Maximum cranial width/breadth is the widest transverse diameter of the cranium and it was measured from the right parietal bone to the left one, at the most lateral points of the cranium. Care was taken to avoid exerting significant pressure on the skin while applying the limbs of the calipers during measurement.
4. Cephalic Index was computed using Cephalic Index$= \frac{\text{Maximum cranial breadth}}{\text{Maximum cranial lenght}} X\ 100$
5. Height and Weight measurements were taken using an Avery height and weight scale (Avery, Birmingham, England).
   A. Height: Each patient stood erect, barefooted, with the head held in the Frankfort horizontal plane; and height was measured to the nearest 0.1 cm.
   B. Weight was measured to the nearest 0.1 kg with each subject wearing minimal clothing (school sports dress), barefooted, and mounted on the scale as each reading was taken

All the measurements were taken by the same investigator. Each parameter was measured at least two times and an average of the values were recorded.

The data collected were recorded and analyzed using SPSS version 25. The data was expressed as mean ± standard deviation (SD). The mean value for the sexes were compared using t-test, and p values of less than 0.05 were considered to be statistically significant. The relationship between the parameters and age, height, weight and body mass index respectively were evaluated using Pearson's correlation coefficient (r).

3. RESULTS AND DISCUSSION

Out of the 725 children and adolescents, there were 433 females (59.7%) and 292 males (40.3%). The age range was 5 to 19 years, with a mean age of 12.21 (±4.10).

3.1 Head circumference:

The minimum head circumference was 48.4cm and the maximum was 59.4cm and the overall mean was 54.29 (±1.99). The mean head circumference increased progressively with age in both sexes. The head circumference of males was longer than those of females at all the ages, though the differences between the two sexes were only significant at the ages of 14, 16 and 17 years (see Table 1).

Table 1: Head circumferences of children and adolescents by age

Age(yrs)	Males			Females			P value
	No.	Mean(cm)	SD	No.	Mean(cm)	SD	
5	11	51.4	1.8	11	51.2	1.1	0.76
6	20	52.2	1.6	20	52.0	1.1	0.68
7	26	53.3	1.3	20	52.9	1.6	0.34
8	36	53.4	1.5	38	52.7	1.7	0.07
9	26	53.8	1.2	28	53.3	1.5	0.19
10	18	54.0	1.6	15	53.8	1.3	0.73
11	18	54.0	1.4	26	53.9	1.3	0.83
12	15	53.7	1.5	43	53.6	1.1	0.87
13	21	54.4	1.6	55	54.1	1.2	0.30
14	14	54.8	1.0	32	54.1	1.0	0.04*
15	16	55.4	1.5	34	55.0	1.5	0.38
16	16	56.3	1.0	23	55.1	1.5	0.00**
17	19	56.5	1.0	23	55.4	1.0	0.00**
18	19	57.2	1.0	30	56.5	1.6	0.06
19	17	57.5	0.8	35	56.9	1.8	0.18

**Significant at $p < 0.01$
*Significant at $p < 0.05$

3.2 Maximum cranial length:

The range for maximum cranial length was 156.0 to 210.0mm, and the mean for the sample population was 184.10mm (± 8.10). The mean maximum cranial length did not always increase progressively with age in both sexes. The maximum cranial lengths of male children and adolescents were generally longer than those of females of the same age except at the ages of 18 and 19 where they were longer in females. The differences in cranial lengths were only statistically significant at 8, 13 and 14 years, with p-values of <0.05 (see Table 2).

Table 2: The maximum cranial lengths of children and adolescents by age

Age(yrs)	MAXIMUM CRANIAL LENGHT (mm)				
	Males		Females		
	Means	SD	Means	SD	p value
5	179.7	9.0	178.3	8.6	0.70
6	182.2	7.3	180.9	6.8	0.56
7	187.2	8.1	183.3	9.0	0.13
8	185.1	7.6	180.2	8.3	0.01*
9	185.9	7.0	183.8	7.4	0.30
10	188.0	7.6	182.3	9.3	0.06
11	185.2	8.6	184.9	5.9	0.88
12	183.0	7.8	179.7	8.5	0.19
13	186.1	9.1	180.3	5.8	0.00**
14	184.9	6.7	180.3	6.2	0.03*
15	187.3	10.7	182.3	7.2	0.06
16	187.0	5.8	183.1	6.8	0.07
17	186.8	8.2	185.1	4.6	0.40
18	189.3	6.9	191.5	5.5	0.22
19	187.6	10.7	188.7	7.8	0.68

**Significant at $p < 0.01$
*Significant at $p < 0.05$

3.3 Maximum cranial width:

The range was 122.0 to 188,0mm and the mean was 145.66mm (±7.22) The mean maximum cranial widths for the various ages are shown in Table 3. Between the ages of 5 and 7, girls had wider maximum cranial widths compared to the boys of the same ages. This trend reversed from the age of 8 to 18 years when the male cranium was wider than the females of the same age. The differences in cranial width were statistically significant only at the ages of 12, 13, 14, 16 and 18 respectively.

Table 3: The maximum cranial widths of children and adolescents by age

MAXIMUM CRANIAL WIDTH (mm)					
Age (yrs)	**Males**		**Females**		
	Means	**SD**	**Means**	**SD**	**p value**
5	138.6	6.6	139.1	4.9	0.83
6	141.1	5.2	142.0	5.8	0.61
7	141.8	4.7	144.3	5.4	0.11
8	143.1	5.0	140.9	6.0	0.10
9	147.6	10.5	143.7	6.2	0.10
10	146.2	6.0	143.2	5.5	0.15
11	143.9	6.5	142.4	5.5	0.42
12	146.9	5.6	142.0	6.4	0.01*
13	148.9	7.3	143.7	6.8	0.00**
14	149.7	2.8	143.9	6.0	0.00**
15	149.9	4.7	147.4	5.2	0.11
16	153.4	5.1	146.4	6.3	0.00**
17	150.8	7.8	150.3	6.4	0.83
18	154.2	7.3	148.8	5.3	0.00**
19	150.9	5.3	152.3	6.4	0.42

******Significant at $p < 0.01$
*****Significant at $p < 0.05$

3.4 Cephalic index:

The mean cephalic index for the population of children and adolescents was 79.22, while the range was from 61.62 to 105.03 (± 4.41). The mean cephalic indices of children and adolescents of both sexes were shown in Table 4. Adolescents generally had higher cephalic indices than the children. The mean cephalic indices of boys below the ages of 12 and girls below the ages of 15 were lower than 80. Above these respective ages the mean cephalic indices remained above 80 except at the age of 18 in females when it was 77.8.

Table 4: The cephalic indices of children and adolescents by age

Age (yrs)	**MALES**			**FEMALES**			**p Value**
	No.	**Mean**	**SD**	**No.**	**Mean**	**SD**	
5	11	77.2	4.1	11	78.1	3.4	0.57
6	20	77.5	2.4	20	78.6	4.6	0.33
7	26	75.8	3.6	20	78.9	4.6	0.02*
8	36	77.4	4.3	38	78.3	4.7	0.38
9	26	79.6	7.0	28	78.3	4.5	0.43
10	18	77.9	4.1	15	78.8	5.4	0.58
11	18	77.9	5.5	26	77.1	3.8	0.59
12	15	80.4	3.7	43	79.1	4.3	0.31
13	21	80.1	4.8	55	79.8	3.9	0.72
14	14	81.1	3.3	32	79.9	4.0	0.34
15	16	80.3	5.1	34	81.0	3.9	0.60
16	16	82.1	4.2	23	80.0	3.4	0.09
17	19	80.7	2.9	23	81.2	3.0	0.61
18	19	81.5	4.2	30	77.8	3.0	0.00**
19	17	80.7	5.2	35	80.8	4.2	0.90

******Significant at $p < 0.01$
*****Significant at $p < 0.05$

Majority of the children and adolescents had mesocephalic head (43.2%) while brachycephalic and dolichocephalic heads were seen among 32.7% and 14.2% of the sample population respectively (see Table 5).

Table 5: The distribution of the types of heads in children and adolescents

Types of Heads	Frequency	Percentage (%)
Ultradolichocephalic (≤ 64.9)	1	0.1%
Hyperdolichocephalic (65.0 - 69.9)	8	1.1%
Dolichocephalic (70.0 -74.9)	103	14.2%
Mesocephalic (75.0 -79.9)	313	43.2%
Brachycephalic (80.0 - 84.9)	237	32.7%
Hyperbrachycephalic (85.0 - 89.9)	56	7.7%
Ultrabrachycephalic (≥ 90.0)	7	1.0%
TOTAL	725	100.0%

Only 1 person (0.1%) had ultradolichocephalic head. This pattern of distribution of the types of head seen in the general population was the same seen in males and females when looked at separately (see Figure 1).

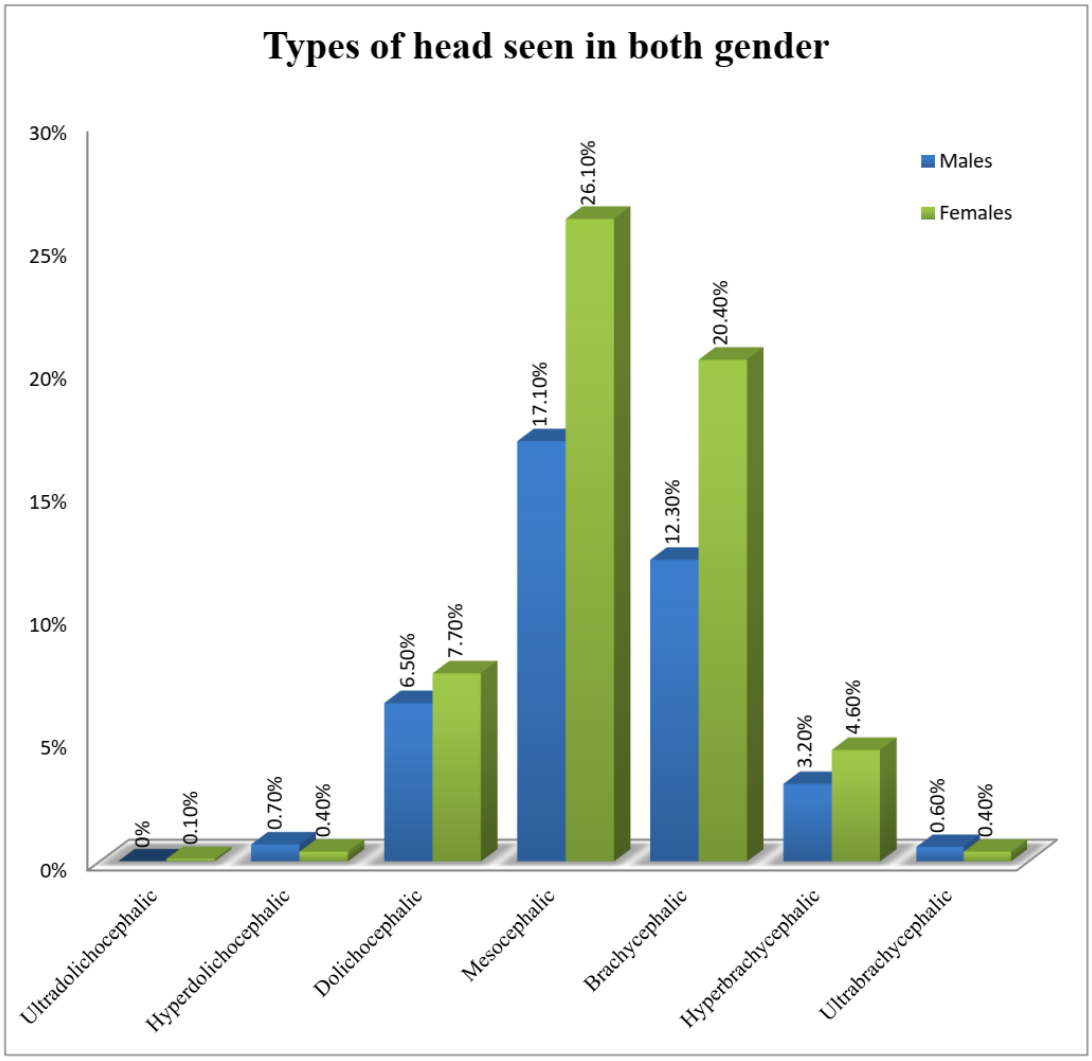

Figure 1: The types of heads in children and adolescents by sex

3.5 Correlations:

There was significant correlation between head circumference and age, height, [8] weight and body mass index respectively (P < 0.01) as shown in Table 6. Maximum cranial width and cephalic index both had significant correlations between them and age, height, [8] weight and body mass index respectively (p <0.01). However, maximum cranial length did not have significant correlation between it and body mass index, but it had significant correlation between it and age, height [8] and weight like the other parameters.

Table 6: Pearson Correlation coefficients of the variables with age, height, weight and body mass index in children and adolescents

Variables	Age		Height		Weight		Body mass index	
	r	P value	R	P value	r	P value	r	P value
Head Circumference (cm)	.704	.00**	.569	.00**	.694	.00**	-.404	.00**
Max Cranial Length (mm)	.199	.00**	.126	.00**	.197	.00**	-.064	.09
Max Cranial Width (mm)	.452	.00**	.346	.00**	.430	.00**	-.236	.00**
Cephalic Index	.240	.00**	.206	.00**	.223	.00**	-.160	.00**

4. DISCUSSION

In the present study the mean cephalic indices of boys between the ages of 5 and 11 and girls between the ages of 5 and 14 were within the range for mesocephalic head (75.0 – 79.9), while children above these ages and the adolescents had cephalic indices that are for brachycephalic head (80.0 – 84.9). The pattern here suggests a brachycephalization of the head as children grow into adults. Brachycephalization or "rounding" of the head is a phenomenon that has been reported as a microevolutionary alteration in various racial groupings [5, 12]. The observation in the present study shows age-dependent changes of cephalic index that occurs in Igbo children as they grow towards adulthood, with head transiting from mesocephalic to a brachycephalic type. This finding of brachycephalization with age is similar to the finding among Igbos of 11 to 25 years living in Benin as reported by Omotoso *et al*., 2019 [13]. The adult Igbos ended up having a head that is predominantly brachycephalic in contrast with mesocephalic head of the young Igbo children [13, 14].

Mesocephalic head was the predominant type of head (43.2%) seen among the Igbo children and adolescents put together, followed by brachycephalic head (32.7%). This was different from the study among Igbos of Benin where brachycephalic head was the most common (66.9%) followed by mesocephalic head (14.7%). The difference in the two studies corresponds to the difference in the two age groups studied because the present study included a younger age group that has been shown to have higher tendency of having mesocephalic head, in contrast with the other study of the Igbos in Benin which included more adults (of 20 to 25 years). Both studies noted that Igbo adults have brachycephalic head. The predominant head type of Igbos under 6 years was also reported to be mesocephalic by Ukoha *et al*., 2013, [15] similar to the findings among young children in this present study.

The mean maximum cranial lengths of children and adolescents between 11 and 19 years in this study, fell between 183.0mm and 189.3mm for males and 179.7mm and 191.5mm for females. This is similar to the findings of Akinbami *et al*., 2014 [16]. The study by Akinbami *et al*., [16] showed that 74.86% of Nigerian children and adolescents between the ages of 11 and 20 had maximum cranial lengths that were within the range of 180.0mm to 189.9mm. Only 14.26% of the sample population had lengths that were within 170.0mm and 179.9mm, while 7.14% of the population had lengths that were between 190.0 and 199.9mm.

On the other hand, the mean maximum cranial widths of children between the ages of 11 and 19 were between 143.9mm and 154.2mm and for the females, they were between 142.0 and 152.3mm. The findings for males were similar to the those of Akinbami *et al*., [16] where 81.14% of the male children and adolescents had maximum cranial length that were between 140.0mm and 149.9mm. The findings for females differed from that of Akinbami *et al*., [16] where majority (48,86%) had MCW that were between 130.0mm and139.9mm, though 37.04% of them were between 140.0 – 149.9 mm. The differences noted in the two studies could be attributed to different natures of the two sample populations; the present study comprise only Igbos while the other study was a mixed population of various tribes.

The cephalic index of children and adolescents has a pattern that can be applied in forensic investigations. The significant positive correlations of these cranial parameters with age, height, weight and body mass index could be used in deriving formulars in forensic studies. There is need to explore these changes further using focused longitudinal studies.

5. CONCLUSION

Our results indicate diversity in head shapes and sizes, with mesocephalic heads being most common. As age increases, head circumference also tends to increase, and changes in head shape towards brachycephalization was observed. These findings underscore the importance of understanding anthropometric variations in different populations and suggest avenues for further research,

particularly longitudinal studies, to explore the factors influencing these patterns.

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