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Relationship between the Anterior Fontanel Size and Occipito-frontal Circumference

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Authors' contributions

This work was carried out in collaboration between all authors. Author EMCO designed the study, did literature search, conducted the field work, analyzed the results and wrote the first draft of the manuscript. Author EADA reviewed the results and discussion and edited the manuscript. Author NAA contributed to literature search and review of the manuscript. Author PIOP reviewed the results and contributed in writing the final manuscript.

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Original Research Article

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ABSTRACT

Aims: To determine the relationship between Anterior Fontanel size (AF) and the Occipito-frontal circumference (OFC).
Study Design: A cross sectional and analytical study of Nigerian newborns and infants.
Place and Duration of Study: Post-natal ward, Special care Baby Unit and Well Infant Clinics of the University of Port Harcourt Teaching Hospital (UPTH) and Braithwaite Memorial Specialist Hospital (BMSH) Port Harcourt, Nigeria. Duration: 10 weeks, between October and December 2011.
Methodology: This is a Cross sectional observational and analytical study of 2895 subjects recruited serially at the Post-Natal Wards and Special Care Baby Unit (SCBU), University of Port Harcourt Teaching Hospital, (UPTH); and the Well Infant Clinics of UPTH and Braithwaite Memorial Specialist Hospital (BMSH), Port Harcourt, Nigeria. AF sizes were measured in newborns at birth and at 6, 10 and 14 weeks; 6, 9, 12, 18 and 24 months of age respectively using

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a modified version of Faix's method.
Results: There were 1391 males and 1504 females giving a male: female (M:F) ratio of 1:1.1. AF sizes decreased significantly with increasing post-natal age, $p < 0.001$. The reverse was the case with OFC which increased significantly from birth to 24 months of age. A strong negative correlation was observed between AF size and OFC with increasing postnatal age.
Conclusion: A statistically significant negative correlation exists between AF size and OFC. This relationship can be represented mathematically by the formula: AF size = 14 - OFC (0.265).

Keywords: Anterior fontanel size; occipito-frontal circumference; correlation; Nigerian children.

1. INTRODUCTION

Examination of the anterior fontanel (AF) and the occipito-frontal circumference (OFC) are essential parts of the neuro-developmental evaluation of newborns and offers the physician the possibility of determining changes in intracranial pressure and abnormalities of skeletal development in infancy [1-3]. The word 'fontanel' which originated from the Latin word 'fonticullus' and the old French Word 'fontaine' meaning little fountain or spring [4-6] is the fibrous membrane-covered gap created where more than two cranial bones are juxtaposed as opposed to sutures which are narrow seams of fibrous connective tissues that separate any two flat bones of the skull [3,4,7]. The OFC is the circumference of the skull enclosing points of maximum bony prominences [4,8].

Various Researchers including Tan [9], Adeyemo et al. [10] as well as Uzoukwu [11] found no correlation between OFC and AF in term neonates. This suggests that at term, increasing OFC with advancing gestational age (GA) has no effect on the AF size [11]. However, Duc and Largo [12] found a negative but not statistically significant correlation between AF size and OFC. Ogunye et al. [13] at Ile-Ife, Nigeria found a mean OFC of 34.2 ± 3.5 cm, with a range of 27.6 – 40.0 cm. The larger fontanel size in this series did not correlate with increase in OFC.

There is a dearth of data on the size of the AF and OFC in Nigeria in particular and Africa in general compared to Western nations [10,11,13,14]. Available data on AF and OFC in Nigerian children were limited to newborns and infants up to 12 months of age [10,11,13,14]. Since the anterior fontanel may remain patent up to 24 months of age, and in view of the established racial differences in anthropometric parameters, it is necessary to have local reference values of AF and OFC in the evaluation of the child with dysmorphic features in order to avoid errors of classification [1-3,12,15]. Moreover the observed trend of decreasing AF size and increasing OFC with post-natal age suggests an inverse relationship between the two which hitherto had not been explored especially in older infants. To the best of this Researcher's knowledge, there are no previous Nigerian studies on AF size and OFC in children up to 24 months of life and no study had established a relationship between AF size and OFC. Practically the AF size measurement is cumbersome and time consuming. Establishing such a relationship may facilitate determination of AF size from the OFC (for a given child) which is easily measured and may therefore circumvent the usually cumbersome methods of AF size measurement.

This cross sectional and analytical study was carried out to determine the normal range of values of OFC and AF size in the study population and to explore the relationship between AF size and OFC.

2. MATERIALS AND METHODS

This is a cross sectional and analytical study carried out to determine the AF size and OFC from birth to 24 months of age in apparently healthy Nigerian children in Port Harcourt and to explore the relationship between AF and OFC. The study sites were the Post-Natal Wards and Special Care Baby Unit (SCBU) of two tertiary institutions in Southern Nigeria.

All healthy Nigerian newborns and infants aged 6 weeks to 24 months seen at the study sites during the study period who met the inclusion criteria constituted the study population.

Excluded were neonates < 48 hours or > 7 days, babies born to non-Nigerian parents, those with caput succedaneum and cephalhaematomas, critically ill babies, and those with features suggestive of chromosomal anomalies or hypothyroidism and those whose parents did not give consent.

Using standard statistical methods [16], a minimum sample size of 313 newborns and 321infants were recruited at defined ages from 6 weeks, 10 weeks, 14 weeks, 6 months,9 months, 12 months, 18 months and 24 months of age respectively. A modified version of Faix's [17] method was employed to measure the AF. Each subject was held upright in a sitting position by the mother/care-giver with the head supported and held firmly by the Research Assistant while the Measurer introduced the tip of the index and the middle fingers of his/her left hand into the two corners of the lateral dimensions of the anterior fontanel. The Measurer then used a pair of dividers (made blunt by removing the pointed ends) to measure the distance between the outer borders of the two fingers of the left hand at the corners of the fontanel. The distance between the inner borders of the pair of dividers was then read off on a tape measure held firmly in position on table. The size of the anterior fontanel was taken as the mean of the length and the width along the sagittal and coronal sutures respectfully i.e. (length of AF + width of AF)/2. Any fontanel too small to be measured was adjudged closed.

Data were collected on a Proforma. Information obtained included demographic information of the child and mother, as well as other relevant obstetric data. Measurements were filled in as they were being taken. Ethical clearance was obtained from the Ethics Committee of UPTH and BMSH respectively. Written informed consent was also obtained from the parent(s) or care-giver(s) of each child. Data were analysed using the Statistical Package for Social Sciences (SPSS) Version 15.0 [18]. The mean, standard deviation and range of each continuous variable and other derived indices including the 5^{th}, 10^{th}, 25^{th}, 75^{th}, and 95^{th} percentiles were computed and presented as graphs, and tables in simple proportions. The differences in means were compared using Student's t test while Chi–square test was used to compare proportions and rates. Test of Statistical significance at 95% confidence interval was set at *p*- value < 0.05.

3. RESULTS

3.1 Socio-demographic Characteristics of the Study Group

Two thousand eight hundred and ninety nine subjects were recruited into the study. Of these, 1391 (47.5%) were males and 1504 (52.5%) females, giving a male to female ratio of 1:1.1. There was no statistically significant difference between the proportion of males and females in any of the recruitment ages (Table 1).

3.2 Variation in Anterior Fontanel Size and OFC

There was a highly statistically significant trend of decreasing AF size with age in both males and females with all the *p*-values < 0.001 for ANOVA. There was no significant difference in mean AF size between males and females except at 10 weeks (p = 0.029), 6 months (p = 0.04), 12 months (p = 0.008) and 24 months (0.002). The mean AF size in males was significantly higher than that in the females. The mean OFC of male infants was significantly higher than that of females at 6 weeks (P <.05) and at 6, 9, 12 and 18 months (P<005). Mean OFC increased from 35.8 ± 2.8 cm in newborns to 48.0 ± 2.3 cm at 24 months of age (Tables 2 and 3).

The variation in percentile of anterior fontanel size with age is illustrated in Table 4. The 5^{th}, 50^{th}, and 95^{th} percentiles of the AF size at birth were 1.3, 4.7 and 6.7 cm. At 24 months, the values were 0.0, 0.0 and 1.4 cm respectively. The variations in mean AF size with increasing post-natal age was statistically significant (ANOVA = 537.37). The variation in mean AF size and OFC with age is illustrated in Figs. 1 and 2. Table 5 shows the mean, range and percentile values of the OFC in the study subjects. The $5,^{th}$ 50^{th} and 95^{th} percentiles of OFC of 32.2 cm, 35.2 cm and 38.8 cm, respectively at birth increased to 45.3 cm, 48.0 cm and 50.6 cm, respectively, at 24 months of age. The variation in 5^{th}, 50^{th} and 95^{th} percentile values of AF and OFC with postnatal age is illustrated graphically in Figs. 3 and 4.

The mean AF size decreased significantly with age (ANOVA = 784.72), whereas the mean OFC increased significantly with age (ANOVA = 1368.68). Correlation analysis revealed that there was a highly statistically significant correlation (r = 0.648, p = 0 .001) between AF size and OFC with postnatal age (Table 6), given by the formula y = 14 - 0.265x, where y = AF and x = OFC. The mean AF size decreased even as the mean OFC increased with age (Fig. 5).

Table 1. Distribution of the subjects by age and gender

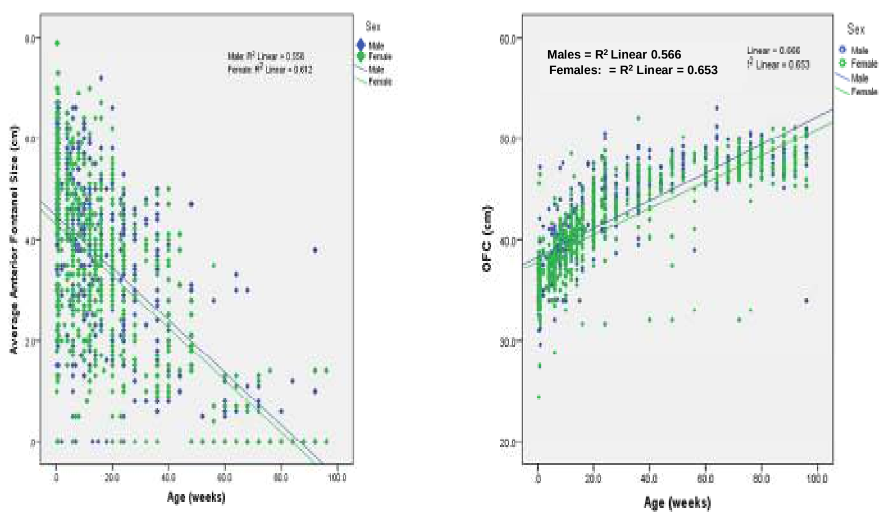
Age	Male		Female		Total	
	No.	(%)	No.	(%)	No.	(%)
2-7 days	153	(11.00)	160	(10.6)	313	(10.8)
6 wks.	165	(11.9)	157	(10.4)	322	(11.1)
10 wks.	167	(12.0)	158	(10.5)	325	(11.2)
14 wks.	155	(11.1)	168	(11.2)	323	(11.2)
6 mo.	159	(11.4)	166	(11.1)	325	(11.2)
9 mo.	156	(11.2)	165	(11.0)	321	(11.1)
12 mo.	164	(11.8)	157	(10.4)	321	(11.1)
18 mo.	139	(10.0)	182	(12.1)	321	(11.1)
24 mo.	133	(9.6)	191	(12.7)	324	(11.2)
Total	**1391**	**(100.0)**	**1504**	**(100.0)**	**2895**	**(100)**

χ^2 = 12.34, df = 8, p = 0.137

Table 2. Variation in mean AF sizes by postnatal age and gender

Age	Anterior fontanel size (cm)									t-test	*p*-value
	Male			Female			All subjects				
	No.	Mean	(SD)	No.	Mean	(SD)	No.	Mean	(SD)		
2-7 days	153	4.5	(1.6)	160	4.5	(1.8)	313	4.5	(1.7)	-0.06	0.096
6 wks	165	4.3	(1.5)	158	4.2	(1.3)	323	4.3	(1.4)	1.18	0.239
10 wks	167	4.1	(1.3)	158	3.8	(1.6)	325	3.9	(1.5)	2.19	0.029
14 wks	154	3.6	(1.2)	168	3.5	(1.2)	322	3.6	(2.2)	0.43	0.667
6 mo	158	3.3	(1.2)	167	2.9	(1.4)	325	3.1	(1.3)	2.21	0.028
9 mo	156	2.3	(1.3)	165	2.6	(1.3)	321	2.5	(1.2)	-1.45	0.148
12 mo	164	2.0	(1.6)	157	1.6	(1.0)	321	1.8	(1.3)	2.67	0.008
18 mo	140	0.3	(0.7)	181	0.1	(0.4)	321	0.2	(0.6)	1.89	0.060
24 mo	134	0.4	(1.0)	190	0.1	(0.4)	324	0.2	(0.7)	3.08	0.002
All subjects	**1391**	**2.9**	**(2.2)**	**1504**	**2.5**	**(2.0)**	**2895**	**2.7**	**(2.1)**	**4.39**	**0.001**
***F**		**226.93**			**16.07**			**537.37**			
***p*–value**		**< 0.001**			**< 0.001**			**< 0.001**			

**F statistic for ANOVA, wks = Week, mo = months, SD = Standard deviation*



Figs. 1 and 2. Scatterplots of variations of AF and OFC by postnatal age in males and females

Table 3. Variation of mean occipito-frontal circumference by age and gender

Age	Mean SD OFC (cm)						t-test	*p*-value
	Male		Female		All subjects			
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)		
2-7 days	153	35.9 (2.5)	160	35.6 (2.8)	313	35.8 (2.7)	0.47	0.335
6 wks	165	36.9 (1.8)	158	36.7 (2.3)	323	36.8 (2.1)	2.02	0.045
10 wks	167	39.7 (2.9)	158	39.1 (2.4)	325	39.4 (2.7)	0.88	0.381
14 wks	154	43.2 (2.3)	168	41.9 (2.8)	322	42.6 (2.6)	1.31	0.190
6 mo	158	44.5 (3.4)	167	46.1 (1.6)	325	45.3 (2.5)	2.00	0.046
9 mo	156	47.1 (1.3)	165	45.2 (3.2)	321	42.6 (2.3)	5.27	< 0.001
12 mo	164	47.9 (1.5)	157	47.2 (2.5)	321	47.6 (2.0)	7.15	< 0.001
18 mo	140	47.5 (1.3)	181	47.1 (2.1)	321	47.3 (1.7)	2.85	0.005
24 mo	134	49.0 (2.9)	190	48.0 (1.8)	324	48.0 (2.3)	-0.64	0.526
All subjects	**1391**	**43.5 (4.8)**	**1504**	**43.0(2.4)**	**2895**	**42.6 (4.9)**	**1.70**	**0.090**
***F**		**728.70**		**507.22**		**7461.14**		
***p*-value**		**< 0.001**	**< 0.001**		**< 0.001**			

**F statistic for ANOVA, wks = Week, mo = months, SD = Standard deviation, OFC = Occipito-frontal circumference*

4. DISCUSSION

The progressive decrease in AF size in this study is keeping with the trend previously documented by other authors [3,4,7,10,12]. The mean AF size of 4.5 ±1.7 cm of newborns in this study was significantly higher than that in previous reports from Nigeria Adeyemo et al. [10] (4.0 ± 1.0 cm), Ogunye et al. [13] (3.3 ± 2.0 cm) and Uzoukwu [11] (2.78 ± 0.82 cm)]. Possible reasons for this could be the timing of the measurements, the method of measurement and the nature of the subjects studied. Although the exact duration of the effects of molding on the AF is uncertain, it is likely that measurements taken after 48 hour and up to 7 days post-natal age as was done in the present study could reduce the effects of molding compared to other studies in which measurements were done earlier [Popich and Smith, [7] Adeyemo et al. [10,11,13] - 12 to 24 hours after birth, Ogunye et al. [13] - 30 hours; and Uzoukwu [11] - 24-48 hours)] [9,10,13], Secondly, accurate delineation of the limits of the AF is paramount to getting a reliable measurement [19]. Compared to the method of Faix, [17] adopted by Uzoukwu [11] would appear less suitable for our newborns with luxuriant scalp hair, as it can predispose to falsely higher values, the use of a pair of dividers aided by palpation employed in the present study would appear more appropriate as the limits of the AF can easily be delineated despite the luxuriant scalp hair in Nigerian newborns. Also previous studies involved homogenous groups while this study involved subjects from different ethnic groups.

That the mean size AF in this study was also higher than the figures obtained from Caucasian [7,17] and Oriental populations is in accord with previous studies that have documented racial differences in the size of the anterior fontanel. [9,13,14,17] It is also possible that these differences may be related to the different methods employed in the measurement of the AF size. However, although the extent to which the use of different methodologies influence the size of the AF remains to be determined, a generally larger AF size has been documented in Black neonates compared to their White counterparts. This is thought to be due to delayed osseous maturation akin to that seen in small-for-dates neonates and those with skeletal dysmorphogenesis [7,13].

The lack of statistically significant gender difference in the mean size of the AF among younger infants in in this study is in accord with previous studies, both locally [11,31,14,20,21] and internationally [7,13,15,22]. However in this study, at 24 months of age, females had a significantly lower mean AF size was compared to males. This finding is in contrast to that by Tan [9] who reported no gender difference with respect to the size and time of closure of the AF among Chinese children. It also contrasts with findings by Acheson and Eirly [23] who demonstrated earlier closure of the AF in European boys. However, Acheson and Eirlys study [23] was conducted during a period of male preference with better nutrition in male children which could explain their findings. Further studies are required to confirm the findings in this study and to seek explanations for the male-female difference.

Table 4. Mean, range and percentiles of AF in the study group

Age	Days	Weeks			Months				
AF characteristics	**2-7 (n = 313)**	**6 (n = 323)**	**10 (n = 325)**	**14 (n = 322)**	**6 (n = 325)**	**9 (n = 321)**	**12 (n = 321)**	**18 (n = 321)**	**24 (n = 324)**
Mean size ± SD	4.5±1.7	4.2±1.4	3.9±1.5	3.7±2.2	3.1± 1.0	2.5±1.3	1.8±1.3	0.2±0.6	0.0±0.7
Minimum size	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum size	7.9	6.6	6.9	3.6	6.6	5.0	4.7	3.3	0.0
5th centile	**1.3**	**1.8**	**1.4**	**1.5**	**0.5**	**0.9**	**0.0**	**0.0**	**0.0**
10th centile	2.0	2.2	2.0	1.9	1.5	1.0	0.0	0.0	0.0
25thcentile	3.5	3.5	2.9	2.8	2.1	1.3	0.5	0.0	00.0
50th centile	**4.7**	**4.5**	**4.1**	**3.6**	**3.3**	**2.4**	**1.9**	**0.0**	**0.0**
75th centile	5.8	5.2	5.0	4.3	4.1	3.6	2.8	0.0	0.0
90th centile	6.40	5.9	5.9	5.1	4.7	4.3	3.3	0.7	1.0
95th centile	**6.7**	**6.2**	**6.2**	**5.9**	**5.0**	**4.7**	**4.7**	**1.2**	**1.4**

F statistic for ANOVA = 537.37, p < 0.001 for the variation of mean AF size with postnatal age, Figures given in cm

Table 5. Mean, range and percentiles of OFC in the study subjects

OFC characteristics	Days	Weeks			Months				
	2-7	**6**	**10**	**14**	**6**	**9**	**12**	**18**	**24**
	(n = 313)	**(n = 323)**	**(n = 325)**	**(n = 322)**	**(n = 325)**	**(n = 321**	**(n = 321)**	**(n = 321)**	**(n = 324)**
Mean (SD) OFC	35.8 (2.7)	37.5 (2.1)	139.9 (2.6)	40.23 (2.6)	42.2 (2.5)	45.3 (2.3)	46.2 (2.)	47.4 (1.7)	47.8 (2.3)
Min. OFC	24.4	28.8	33	31.6	31.6	32.0	32.0	32.0	34.0
Max .OFC	47.2	47.6	44.1	48.5	38.8	52.0	50.1	53.2	51.1
5th centile	32.4	35.0	34.15	35.5	39.89	41.2	40.3	45.8	43.3
10th centile	33.1	35.2	36.3	37.0	40.1	43	44.8	46.04	46.1
25th centile	34.2	36.2	38.0	39.1	41.8	44.5	45	46.8	47.0
50th centile	35.8	37.3	39.5	40.5	43.1	45.9	46.7	47.6	48.o
75th centile	37.0	38.4	40.7	42.0	45.0	47.0	47.8	48.3	49.1
90th centile	38.2	39.5	41.5	43.0	46.7	47.2	48.3	49.1	50.3
95th centile	38.8	40.5	42.0	44.46	47.1	48.1	48.79	49.99	50.6

ANOVA = 46.14, p < 0.001 for the variation of mean OFC with postnatal age.
Min. = Minimum, Max. = Maximum

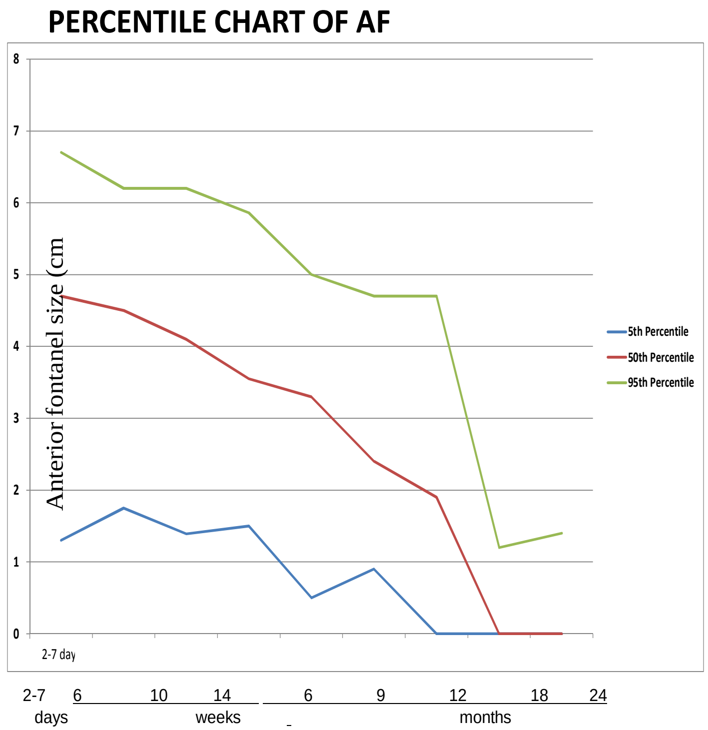


Fig. 3. Variation in 5th, 50th and 95th percentile of AF size with postnatal age

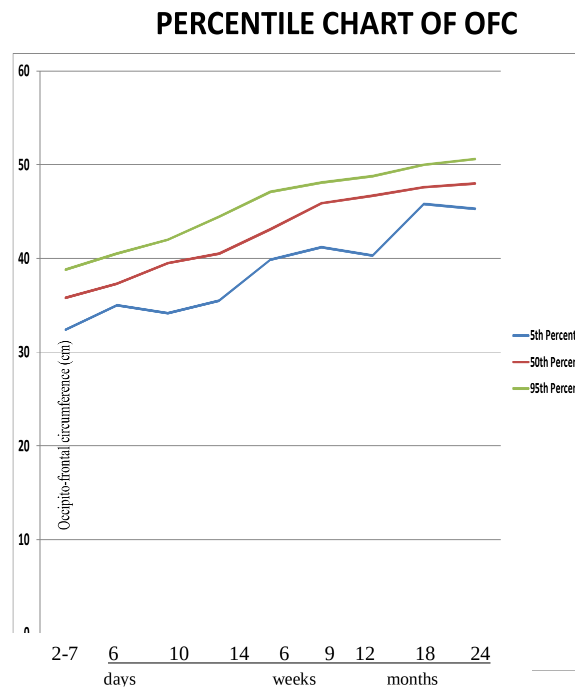


Fig. 4. Variation of the 5th, 50th and 95th percentiles of OFC with postnatal age

Table 6. Correlation between the AF size and OFC and age

Age	2-7days (n= 313)	6 mo (n = 325)	12 mo (n = 321)	18 mo (n = 321)	24 mo (n = 324)	ANOVA	*p*-value
Mean (SD) AF in cm	4.5 (2.0)	3.1 (1.3)	1.8 (1.3)	0.2 (0.6)	0.2 (0.7)	784.72	< 0.001
Mean (SD) OFC in cm	35.8 (2.6)	43. 2 (2.5)	46.2 (2.6)	47.5 (2.1)	48.0 (2.2)	1368.68	< 0.001

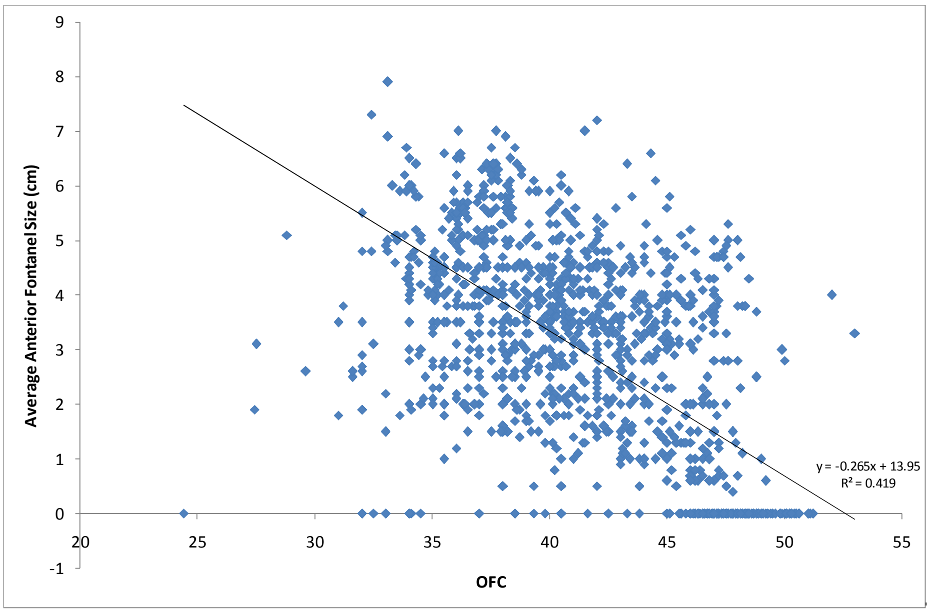


Fig. 5. Scatter plot of the correlation between anterior fontanel size and occipito-frontal circumference with post natal age

The mean OFC at birth in the present study (35.8 ± 2.7 cm) is significantly higher than the 34.2 ± 3.5 cm reported by Ogunye et al. [13] in Ile-Ife, and the 34.5 ± 3.2 cm reported by Lubchenco et al. [24] for United States Caucasians. It is uncertain whether the larger OFC observed in this study at 0 to 12 months compared to those from previous studies [13,24] is a reflection of the previously reported cyclical trend of a larger OFC in succeeding generations as documented by Ounsted et al. [2].

Whereas AF size and OFC are well documented for Caucasian, Asian and Arab Children [7,9,12,15,17,25] previous Nigerian scholars had reported on occipito-frontal circumference in newborns and children up to 12 months [11,9,13,]. This Author did not come across published Nigerian studies on OFC in children up to 24 months of age. This is perhaps, therefore, the first of such, and the values reported in this study may be the only currently available standard for OFC in Nigerian children from 12 to 24 months of age.

The values of OFC obtained in this study were significantly lower at 18 months and 24 months than that reported for Oxford children by Ounsted et al. [26] It is possible that the lower occipito-frontal circumferences obtained in this study beyond 12 months compared to that of Caucasian figures may be due to the high prevalence of malnutrition in our environment [27]. This buttresses the need for local reference standards which should be updated as necessary with each succeeding generation.

Although different researchers have reported separately on the trends of AF size and OFC, few had demonstrated a definite relationship between OFC and AF size. In contrast to the findings by Popich [7], Duc and Largo [12], and Tan [9] who found no significant correlation between AF size and OFC, in the present study, we found a strong negative correlation between AF and OFC in relation to increasing post-natal age. Regression analysis showed that this co-relationship can be represented mathematically by the formula AF = 14 - 0.265 (OFC).

Thus the expected anterior fontanel for a given child can be derived from his OFC using the above formula. The measurement of the AF is time consuming, involves some technicalities and requires an assistant to ensure a reliable measurement [19]. Clinically, the technicalities involved in the measurement of AF size may prevent its measurement and thus some information relevant to the patient in relation to OFC may also be lost. Therefore, the availability of a simple formula can be helpful especially in a busy clinic setting in identifying infants with abnormal fontanel size. However, large scale multi-center study is recommended to validate this formula.

5. CONCLUSION

The mean AF size and OFC of Nigerian infants in Port Harcourt metropolis varied widely from birth to 24 months of age. There exists an inverse relationship between the two with a strong negative correlation represented mathematically by the formula: AF size = 14 – OFC (0.265).

The clinical relevance of this study lies in the fact that an infant's AF size can be quickly determined from the above relationship thereby avoiding the usually cumbersome and time consuming methods of measurement of AF Size especially in a very busy out-patient clinic. It will also serve as screening too to quickly identify infants with abnormal AF size and/OFC who would then benefit from further evaluation to determine any underlying factor /disease.

6. LIMITATION OF THE STUDY

A major limitation of this study was the time frame during which it was carried out. A longitudinal study rather than a cross sectional one as in the present study would have elucidated more information in terms of the rate of the head growth as well as the actual timing of the closure of the anterior fontanel in a given infant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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