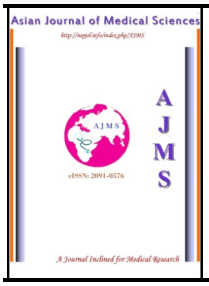
ASIAN JOURNAL OF MEDICAL SCIENCES




# Cephalic Index: A Fetal Gestational Age Dependent Biometric Parameter

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## Abstract

**Objective:** There is limited data on fetal cranial dimensions of Nigerian population. This is important because the study of normal and abnormal growth of children has become an increasingly important part of the practice and research in all fields related to child health; more so that prenatal and postnatal growth is one continuous process.

**Material & Methods:** In a cross-sectional study conducted on 13,740 Nigerian fetuses ranging from 12 weeks to 42 weeks at the Centre for Reproductive Health Research Jos; biparietal diameter and occipitofrontal diameter were measured using ultrasound machine in order to calculate fetal cephalic index. The values were statistically analyzed after deriving the relevant indices.

**Results:** The regression equation was calculated between gestational age and cephalic index of fetuses of Nigerian women. This equation $y = 1.3x + 59.88$; showed a linear relationship which was stronger from 12 to 16 weeks of gestation. Above 16 weeks gestation, the relationship was found to be quite weak. Coefficient of correlation is $r2 = 0.9844$ ($p < 0.0001$).

**Conclusion:** The fetal skulls were found to be mesocephalic in the early weeks and brachycephalic at term.

**Key Words:** Cranial dimensions; Cephalic index; Brachycephalic

## 1. Introduction

Cephalic index is the ratio of biparietal diameter of the skull to the occipitofrontal diameter and can detect asymmetry in the skull during development.[1] Gray et al reported that cephalic index varies with advancing gestational age, with the highest and lowest values being 81.5 and 78.0 at 14 and 28 weeks respectively.[2] On the contrary Jeanty found that cephalic index is independent of gestational age.[3] In India, Tuli et al found dolichocranial type of cephalic index in 73% of fetuses at term.[4] Cussenot et al reported that skeletal measurements were used as the basis of fetal anthropometry and age determination by Balthazard and Dervieux as far back as 1921.[5] Singh and Bhasin have cited the various categories of cranium on the basis of height and breath index and described the commonly accepted seven groups of crania.[6]

Anthropometric studies have shown that the shape of the vault of the skull is not directly related to the cerebral growth but to genetic factors. This is supported by the great range of cranial indices and shapes in racial groups; however sexual differences are minimal.[7] Literature search shows that studies on cephalic index in fetuses have not been carried out in our environment.

The present study provides a baseline data of cephalic index of fetuses of Nigerian women and the formula for the estimation of age of an unknown fetus especially when it is less than 5 months old by using regression equation.

## 2. Material and Methods

This was a cross sectional study with prospective data collection from uncomplicated pregnant women between 12 and 42 weeks of gestation who presented for routine ultrasound at Centre for Reproductive Health Research Jos between December 1997 and April 2002.

The study was approved by the Ethics Committee of Jos University Teaching Hospital and before inclusion of the patient, informed consent was obtained. In seeking the informed consent, the following information was provided

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to each subject: a description of the procedure to be followed, a description of any reasonably foreseeable risks or discomfort, a description of benefits to the subjects or to others which may reasonably be expected from the research, a disclosure of appropriate procedure that might be advantageous to the subject, a statement describing the extent to which confidentiality of records identifying the subject will be maintained, an explanation of whom to contact for answers to pertinent questions about the research and research subjects' rights, and whom to contact in the event of a research related injury to the subject; and a statement that participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and that the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

Only singleton pregnancies were included. Pregnant women with concomitant disease possibly affecting fetal growth (e.g. diabetes mellitus, asthma, hypertension, renal disease, thyroid disease) were not included as were those with complications of pregnancy known at the moment of the ultrasound scan (e.g. bleeding, pre-eclampsia). If a fetal malformation was detected during the examination the patient was excluded. Patients with a history of obstetric complications, intrauterine growth retardation or macrosomia were also excluded. The investigator did not take into account complications or diagnosis that occurred later in the pregnancy, after the ultrasound measurements were performed.

Every fetus was measured and included only once so that a pure cross-sectional set of data was constructed. For each patient the gestational age was recorded, as were last menstrual period, maternal age and parity. Maternal age was calculated in completed years at the moment of the ultrasound. All biparietal diameter measurements were performed by the investigator using Philips SDR 1000 Real time ultrasound machine equipped with 3.5 MHz transducer and an electronic caliper system set at a velocity of 1540m/s. Fetal biparietal diameter measurements were made in an axial plane at the level where the continuous midline echo is broken by the cavum septum pellucidum in the anterior third and that includes the thalamus.[8] This transverse section should demonstrate an oval symmetrical shape. Measurement of BPD was from the outer edge of the closest temporomandibular bone to the outer edge of the opposite temporomandibular bone. The occipitofrontal diameter (OFD) was measured in the same plane between the leading edge of the frontal bone and the outer border of the occiput. The cephalic index was calculated as the ratio of the same two diameters (BPD/OFD × 100).

## 3. Results

Fetal head measurements were obtained in 13,740 pregnant women. Table-1 gives the number of observations per week of gestation.

**Table-1: Number of examinations at different gestational age, mean cephalic index, SD, SE, 3rd, 5th, 10th, 50th, 90th, 95th, 97th, centile of cephalic index from 12 to 42 weeks.**

| | | | | | Centiles | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GA (wk) | Fetus | C. I | SD | SE | 3rd | 5th | 10th | 50th | 90th | 95th | 97th |
| 12 | 49 | 75.6 | 10.3 | 1.5 | 57.6 | 57.6 | 59.4 | 77.8 | 86.7 | 95.7 | 100 |
| 13 | 384 | 76.4 | 7.9 | 0.4 | 62.3 | 63.9 | 66.7 | 77.1 | 85.2 | 87.5 | 90.8 |
| 14 | 371 | 78.4 | 7.5 | 0.4 | 63.6 | 68.3 | 71.8 | 78.4 | 85.7 | 87.9 | 93.0 |
| 15 | 351 | 79.4 | 6.5 | 0.3 | 65.4 | 69.4 | 72.3 | 79.5 | 85.4 | 88.9 | 94.3 |
| 16 | 505 | 80.6 | 6.1 | 0.3 | 68.6 | 70.2 | 74.5 | 80.4 | 86.7 | 89.8 | 92.1 |
| 17 | 427 | 80.1 | 5.3 | 0.3 | 67.2 | 71.2 | 73.2 | 80.4 | 85.7 | 89.3 | 92.7 |
| 18 | 446 | 79.4 | 6.5 | 0.3 | 64.8 | 67.2 | 72.9 | 79.6 | 86.2 | 91.8 | 93.5 |
| 19 | 282 | 79.6 | 6.1 | 0.4 | 67.2 | 70.1 | 72.1 | 79.7 | 85.5 | 90.0 | 97.9 |
| 20 | 553 | 78.9 | 5.0 | 0.2 | 68.3 | 71.9 | 73.8 | 79.4 | 83.8 | 86.2 | 87.8 |
| 21 | 400 | 79.1 | 4.3 | 0.2 | 69.6 | 70.7 | 74.0 | 79.1 | 83.1 | 85.2 | 89.8 |
| 22 | 398 | 80.3 | 5.0 | 0.2 | 72.4 | 74.0 | 75.3 | 80.3 | 84.3 | 86.2 | 87.7 |
| 23 | 478 | 80.2 | 5.4 | 0.2 | 72.5 | 73.3 | 75.0 | 79.7 | 84.9 | 87.9 | 92.1 |
| 24 | 520 | 79.7 | 4.5 | 0.2 | 70.0 | 72.7 | 75.0 | 79.9 | 84.0 | 86.1 | 91.2 |
| 25 | 388 | 79.7 | 5.1 | 0.3 | 70.7 | 72.8 | 75.0 | 79.3 | 83.3 | 88.6 | 92.0 |
| 26 | 511 | 79.5 | 4.6 | 0.2 | 71.2 | 72.7 | 74.7 | 79.3 | 85.0 | 87.5 | 89.5 |
| 27 | 432 | 78.7 | 4.4 | 0.2 | 71.7 | 72.0 | 74.1 | 78.3 | 82.6 | 86.7 | 89.2 |
| 28 | 548 | 79.0 | 5.0 | 0.2 | 71.7 | 73.4 | 74.7 | 78.9 | 83.0 | 85.2 | 88.1 |
| 29 | 484 | 79.7 | 4.5 | 0.2 | 72.3 | 73.3 | 75.2 | 79.2 | 84.6 | 88.1 | 92.8 |
| 30 | 625 | 79.5 | 4.7 | 0.2 | 72.4 | 73.0 | 75.2 | 79.2 | 83.7 | 85.4 | 87.1 |
| 31 | 523 | 79.8 | 4.6 | 0.2 | 74.0 | 74.3 | 75.7 | 79.4 | 83.5 | 86.2 | 92.0 |
| 32 | 583 | 79.7 | 3.6 | 0.1 | 73.9 | 74.5 | 75.9 | 79.8 | 83.3 | 84.6 | 86.6 |
| 33 | 516 | 79.9 | 3.7 | 0.2 | 73.9 | 74.8 | 76.1 | 79.6 | 83.3 | 85.3 | 85.6 |
| 34 | 744 | 79.3 | 3.1 | 0.1 | 72.7 | 74.4 | 75.9 | 79.3 | 83.0 | 84.2 | 85.3 |
| 35 | 739 | 79.7 | 3.2 | 0.1 | 74.3 | 75.0 | 76.3 | 79.6 | 83.2 | 84.5 | 85.6 |
| 36 | 599 | 79.8 | 3.0 | 0.1 | 74.3 | 75.0 | 76.9 | 79.6 | 83.5 | 84.3 | 85.7 |
| 37 | 532 | 79.7 | 3.5 | 0.2 | 73.8 | 74.5 | 76.1 | 79.3 | 83.8 | 86.6 | 88.7 |
| 38 | 481 | 79.4 | 3.6 | 0.2 | 72.0 | 74.8 | 76.5 | 79.5 | 83.5 | 83.8 | 85.8 |
| 39 | 525 | 79.7 | 3.5 | 0.2 | 71.4 | 74.6 | 76.3 | 79.7 | 83.3 | 85.3 | 86.6 |
| 40 | 252 | 79.8 | 3.0 | 0.2 | 72.2 | 74.6 | 76.6 | 79.8 | 83.3 | 83.9 | 84.7 |
| 41 | 72 | 79.6 | 2.8 | 0.3 | 72.4 | 74.1 | 75.6 | 80.0 | 82.8 | 84.2 | 85.0 |
| 42 | 22 | 80.6 | 3.7 | 0.8 | 73.9 | 73.9 | 73.9 | 79.8 | 85.8 | 85.8 | 85.8 |
| **Total** | **13740** | | | | | | | | | | |

Both the length and breath of the cranium correlated well with gestational age with a positive correlation coefficient of 0.9968 and 0.9978 respectively.

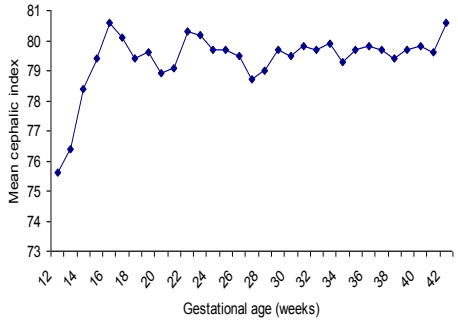


**Figure-1: Mean cephalic index values in 13,740 fetuses of Nigerian women from 12 to 42 weeks of gestation.**

The Anderson-Darling normality test for BPD was 0.99956, P = 0.001 and for OFD, 0.99956, P = 0.0001; thereby confirming the normal distribution for all the variables.

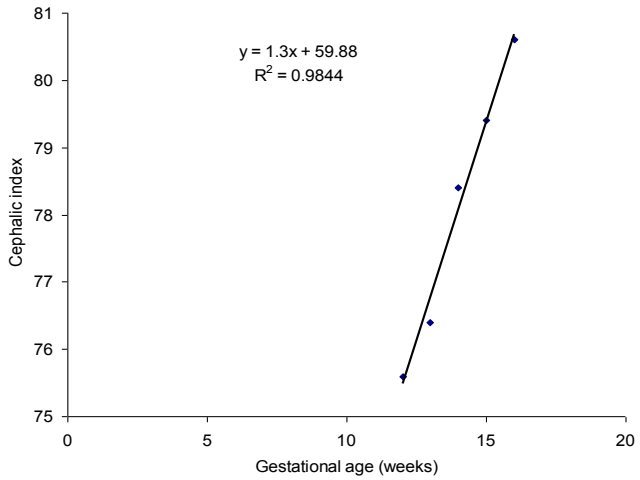


Figure-2: Mean cephalic index of fetuses from 12 to 16 weeks of gestation with regression equation.

Fig-1 show the mean cephalic index of fetuses from 12 to 42 weeks while Table 2 show the 3rd, 5th, 10th, 50th, 90th, 95th, 97th centile values of cephalic index of fetuses from 12 weeks to 42 weeks of gestation. From 12 to 16 weeks, the relationship between cephalic index and gestational age was found to be linear (Fig. 3) but thereafter, there was a weak relationship.

## 4. Discussion

A constant cephalic index of 78.3 ± 4.4 from 14 – 40 weeks was observed by Hadlock *et al* with no significant change as the fetal age increases.[9] Tuli *et al* too noted a constant value of 76.4 ± 5.1 from 12 – 40 weeks.[4] Jeanty *et al* found that cephalic index was age independent.[3] On the contrary, Gray *et al* observed a change in cephalic index with increasing age of fetus, and reported a wide normal range for cephalic index.[2] The findings of the present study are similar to those of Gray *et al* and with cephalic index of 75.6 ± 10.3 at 12 weeks, 76.4 ± 7.9 at 13 weeks, 78.4 ± 7.5 at 14 weeks, 79.4 ± 6.5 at 15 weeks and cephalic index of 80.6 ± 6.1 at 16 weeks.[2] During this period of intrauterine development, the relationship between gestational age and cephalic index is linear with regression equation of y = 1.3x + 59.88; where y is the cephalic index while x is the gestational age in weeks. From 17 weeks to term, the cephalic index becomes relatively constant. When the 50th centile values of our cephalic index were compared with those of Kurmanavicius *et al*, it was found out that their values were significantly higher than our own values (P < 0.001) throughout pregnancy.[10]

Cephalic index was first developed in the 1840s by Anders Retzius as one of the most influential craniometric techniques. Retzius used precision calipers to measure the heads of people from different backgrounds. He generally classified peoples as having one of two characteristic head shapes—*brachycephalic* (broad-headed) or *dolichocephalic* (long-headed). People with intermediate head shapes were assigned to a third type, *mesocephalic*. Soon after its development, the cephalic index gained popularity in Europe and the United States as a way to classify individuals into races based on similar measurements. As a measure of racial differences, however, the cephalic index proved problematic. For example, Germans were largely dolichocephalic, but so were many West African tribes. In 1911 German-born American anthropologist Franz Boas mounted the most convincing challenge against the classification of races based on the cephalic index or any other anthropometric measurements. Boas demonstrated that the stature and head shapes of children born and raised in the United States differed from those of their parents from Europe. He thus showed that skull shape was significantly influenced by the environment (the basis for this influence remains unknown), undermining the use of the cephalic index as a racial marker. Nonetheless, scientists continued to use this and other anthropometric measurements as bases for racial classification, age determination and identification well into the mid-20th and 21st century. In our environment, this is the first time, cephalic index is determined in fetuses.

It is concluded that the cephalic index of fetuses of Nigerian women changes from mesocephalic type at 12 weeks of gestation to brachycephalic type at term.

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