Head Circumference of Babies at Birth in Nigeria

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ABSTRACT

Background and Objectives: Measuring head circumference (HC) of newborns is an important tool for evaluating intra-uterine brain development. HC reference charts currently in use in Nigeria are not representative of the local population. We thus present locally derived HC reference data for Nigerian infants at birth.

Subjects and Methods: We reviewed birth records of all infants at the Jos University Teaching Hospital (JUTH) over a 10 year period from January 2006. JUTH is a tertiary care center offering obstetric services to a large population of women in Jos and its environs. All births with gestational age between 28 and 42 weeks were included in the study. STATA version 14 was used to calculate gestational age associated HC percentile measurements.

Results: We included 18 282 babies to generate the reference values. The mean HC value was 34.4 ± 2.1 cm ($M = 34.6 \pm 2.16$ cm, $F = 34.1 \pm 2.02$ cm, $p < 0.001$). Our HC reference values significantly differ from the USA and INTERGROWTH-21 charts currently in use in our country. Mean HC was higher in male infants compared with female infants. This difference was uniformly so across all gestational age groups.

Conclusions: The use of our locally derived HC reference values could be more appropriate in defining normal head growth in Nigerian infant populations thereby improving newborn care.

KEYWORDS: head circumference, neonates, birth, nigeria, normogram

INTRODUCTION

Measuring the head circumference (HC) of neonates at birth is a fast, easy, non-invasive and reliable way of determining the brain size of the infant at birth [1]. This is because HC at birth reflects brain development in utero and when it is outside the normal range, it becomes a critical risk factor of cognitive and motor delay [1–3]. The best reference chart for any anthropometric parameter is the one developed and customized for the same local population and preferably updated every 5–15 years [3–5]. Since fetal growth is affected by fetal, maternal, placental, racial, environmental and geographic factors, locally produced reference charts will be more useful tool for anthropometric evaluation of newborns [5–8]. Neonatal anthropometry can therefore be variable in different populations and regions of the same country [5–8].

Most of the HC charts being used in Nigeria today were developed for use in different Caucasian and non black populations and may not accurately reflect the HC of neonates in our settings [4, 5]. Misclassification of neonates born into normal, microcephalic and macrocephalic ranges is therefore expected to be significant using the current reference curves [4–8]. This is because the mean HC of children in affluent countries may be higher than the HC of children born in low income countries due to the influence of better nutrition [9–12]. Therefore, a well-constructed normogram for HC at birth would help in the correct classification of babies into normal range, microcephaly and macrocephaly categories [9]. Evaluating HC at birth can thus be a useful and informative tool pointing to events that have a potential for adversely affecting brain development in postnatal life [13, 14]. This will aid in the early risk identification, specialist referral and close monitoring of infants requiring prompt attention [1, 15]. The advent of the global Zika epidemic and its relationship with brain development makes HC normogram assessment critical especially in developing countries where local data is limited [16]. In addition, developing a locally adaptable normogram is

thus a key first step in the quest for identification and management of infants that might potentially have been affected in utero with the Zika virus [16]. This study thus aims to develop current population and gender-specific HC reference for new born babies by gestational age in our locality.

SUBJECTS AND METHODS

Design

This is a 10-year retrospective analysis of all babies born at the Jos University Teaching Hospital (JUTH), Jos Nigeria between the 1st January 2006 and 31st December 2015. The socio-demographic, obstetric and clinical information such as parity, human immunodeficiency virus (HIV) status and complications of pregnancy were collected on the mothers. The anthropometric measurements of the neonate at birth were also abstracted.

Study area

Jos, a cosmopolitan city is a sort of miniature Nigeria because of the presence of not just the indigenous Plateau tribes of Berom, Ngas, Mwaghavul and many other smaller tribes, but also because of the presence of a large number of the three major Nigerian tribes of Igbo, Hausa and Yoruba as well as a lot more of the other southern minority tribes like the Urhobos, Efiks and Ijaws [17]. It is a highland city with a mix of both tropical hot weather between February and May and a favorable near-temperate climate between October and January making it an ideal settlement area for many [17].

Study population

The population studied consists of all newborns delivered at the JUTH during the study period and who have complete records for inclusion in the study. All live births of infants at 28th to 42 weeks gestation were eligible to be included in the study. Stillborns and abortuses as well as live borns with incomplete records were excluded from the study.

JUTH is a 500-bed hospital, a referral center for neighboring states of Nassarawa, Benue, Taraba, Kaduna, Bauchi and parts of Kano State. In addition, it provides maternal and newborn health services resulting in about 3000 deliveries yearly.

Inclusion/exclusion criteria

This study included only live singleton babies whose mothers were HIV negative and were given birth to after the age of viability which is 28 weeks of gestation in our environment to 42 weeks of gestation. The gestational age of each baby was calculated using Naegale's formula which depends on the last normal menstrual period before the pregnancy. For women who were not sure of their last menstrual period, an early ultrasound scan was then used to date the pregnancy. The gestational age of the babies at birth was recorded in completed weeks. Prematurity was defined as any birth before 37 completed weeks of gestation.

Stillbirths and babies with gross congenital anomalies were excluded from the data. Also, babies with missing records of HC measurement and/or gestational age at delivery and babies following complicated pregnancies and deliveries were excluded.

Measurement of HC

The HC was measured by trained Nurses/Midwives using an inelastic measuring tape immediately after the delivery of the neonate. The tape was passed above the supra-orbital ridges in front, above the ears and right across to the maximum occipital prominence at the back of the head. Tukey's statistical method was used to eliminate implausible HC measurements for each gestational age in the dataset [18]. This consisted of constructing a range of percentiles of the HC measurements at each gestational age. The interquartile range (IQR) is the range from the 25th to 75th percentiles. Within each gestational age, HC measurements that are larger than 1.5 multiples of IQR from the 75th percentile were eliminated. Similarly, data points that were smaller than 1.5 multiples of the IQR from the 25th percentiles were discarded from the lower end.

Data analysis

The data analysis was carried out using Stata 14.1 (copyright 1985-2015 StataCorp, 4905 Lakeway

Drive, College Station, Texas 77845 USA). Tables and graphs were employed to present the means, standard deviations and different percentiles of the HC of boys and girls separately. The curves were produced using Microsoft Excel 2010.

Smoothing method

The data was smoothened using a robust local regression model (rlowess) that uses weighted linear least squares and a 1st degree polynomial model and assigns lower weight to outliers in the regression. The method assigns zero weight to data outside six mean absolute deviations. We smooth the data using a span of 50% of the total number of data points. This method was implemented using Matlab R2015a

IRB approval

The ethical clearance Number JUTH/DCS/ADM/127XIX/6603 for the study was obtained from the JUTH Human Research Ethical Committee.

RESULTS

The study population

There were a total of 20 093 singleton deliveries in the hospital during the study period. From this, 778 (3, 9%) of the data points without gestational age records, 343 (1.9%) without HC and 417 products of non singleton pregnancies were excluded giving rise to a final 18 282 (91.0%) records of babies was available for the study. Of the 18 282 (91.0%) infants studied, 9 396 (51.4%) males and 8886 (48.6%) female neonates gave a male: female sex ratio of 1.06: 1. [Fig. 1](#) shows the flowchart of mothers-infants pairs included in the study.

Descriptive characteristics

The baseline socio-demographic characteristics of the mothers and some of their reproductive indices are depicted in [Table 1](#). Most (99.9%) of the women had at least primary school education. The mean age of the women was 28.7 ± 5.49 years (95% Confidence interval = 28.6–28.8). In addition, the mean infant HC value was 34.4 ± 2.1 cm (Male = 34.6 ± 2.16 cm, Female = 34.1 ± 2.02 cm, $p < 0.001$).

FIG. 1. Showing the flowchart of mothers-infants data points included in the analysis [Figure 1](#).

TABLE 1. The baseline socio-demographic and reproductive indices of women in the study

Characteristics	N = 18 164	Frequency	Percentage (%)
Mean maternal age (Years) 28.7 (95% CI = 28.6–28.8)			
Religion			
Christianity		13 634	75.1
Islam		4530	24.9
Educational status			
No formal education		26	0.1
Primary education		2070	12.0
Secondary education		8 1002	46.8
Tertiary education		7 122	41.1
Facility Antenatal care (ANC) undertaken			
JUTH		16 735	91.7
Other than JUTH		1488	8.0
No ANC done		57	0.3
Parity			
Primigradae		5335	30.4
Multigravidae		12 747	70.6
HIV status			
Non-reactive		16 919	94.0
Reactive		1077	6.0

JUTH = Jos University Teaching Hospital.

HC percentile

The average HC values at 5th, 10th, 50th, 90th and 95th percentile cut off points for infants born at 28–42 weeks is shown in [Tables 2](#) and [3](#).

Gender specific data is shown for males ([Table 2](#)) and females ([Table 3](#)) for HC at 5th, 10th, 50th, 90th and 95th percentile cutoff points. Male infants have comparatively larger HC especially at 28–

TABLE 2. Showing the frequency, mean, P5, P10, P50 (median), P90, P95 of the head circumference in centimetres of boys by gestational age

GA	Frequency	Mean	5	10	50	90	95
28	47	28.23	20.40	21.80	27.00	35.20	38.20
29	23	28.91	18.00	18.00	28.00	35.30	36.00
30	72	30.54	20.00	26.00	30.00	35.70	37.00
31	51	31.31	22.00	26.30	32.00	35.00	36.00
32	128	32.03	25.65	28.00	32.00	35.70	36.00
33	98	32.93	28.00	30.00	33.00	36.00	36.60
34	252	33.41	29.00	30.00	34.00	36.00	37.00
35	242	34.14	31.00	32.00	34.00	36.00	37.00
36	1082	34.37	31.00	32.00	34.00	36.00	37.00
37	914	34.59	32.00	33.00	34.00	36.00	37.00
38	2667	34.88	32.00	33.00	35.00	37.00	38.00
39	1373	34.88	32.00	33.00	35.00	37.00	37.00
40	1547	35.16	32.25	33.00	35.00	37.00	38.00
41	600	35.43	32.20	33.00	35.00	37.00	38.00
42	299	35.47	32.00	33.00	35.00	38.00	38.00

NB: GA = gestational age, P5, 10, 50, 90, 95 = 5th, 10th, 50th, 90th and 95th percentile.

TABLE 3. Showing the frequency, mean, P5, P10, P50 (median), P90, P95 of the head circumference in centimeters of girls by gestational age

GA	Frequency	Mean	5	10	50	90	95
28	39	28.59	20.00	20.00	29.00	35.00	36.00
29	26	29.07	23.35	24.00	29.00	33.00	34.30
30	84	30.88	24.00	25.00	31.00	35.00	35.70
31	49	31.00	21.65	26.10	32.00	35.00	36.00
32	102	31.65	24.30	26.60	32.00	35.00	36.00
33	79	32.49	26.00	28.50	32.50	35.00	35.00
34	229	33.10	28.00	30.00	33.00	35.00	36.35
35	215	33.51	30.00	31.00	34.00	36.00	36.20
36	1087	33.92	31.00	32.00	34.00	36.00	36.00
37	834	34.08	31.00	32.00	34.00	36.00	37.00
38	2539	34.38	32.00	32.00	34.00	36.00	37.00
39	1290	34.41	32.00	32.00	34.00	36.00	37.00
40	1541	34.64	32.00	33.00	35.00	36.00	37.00
41	523	34.81	32.00	33.00	35.00	37.00	37.00
42	248	35.00	32.00	33.00	35.00	37.00	38.00

NB: GA=gestational age, P5, 10, 50, 90, 95 = 5th, 10th, 50th, 90th, and 95th percentile.

35 weeks gestational age. Similar difference was also observed in the mean difference in HC for both sexes.

Smoothen curves

Smoothen curves generated for males and females at 5th, 50th and 95th percentile is shown in Figs 2a and 2b, 3a and 3b, respectively. There is wide variation at infants with lower gestational ages (28–36 weeks) compared with infants beyond 36 weeks gestation. The Nigerian data showed larger HC for both boys and girls compared with the INTERGROWTH data across all gestational ages (Figs 2b and 3b).

DISCUSSIONS

This study attempts at defining HC normograms for Nigerian infants at birth using a large dataset. It is significant in that it contains datasets for both pre-term and term infants.

Validity of the study

This study draws strength from two basic considerations. First, our weight measurements are standardized and done by trained Nurse Midwives within a few minutes of the birth of the infant. Our gestational age assessment combines both last menstrual period and ultrasound dating which is available and done by trained obstetricians within the antenatal clinic. These two being the greatest challenging factors associated with the development of growth references improve the validity of our normogram [19].

Overall, the HC measures were higher in male infants compared with their female counterparts. This also holds true for pre-terms especially at gestational ages lower than 36 completed weeks. This gender difference is not unexpected considering the genetic differences in growth between the two sexes [10, 20, 21]. In addition, our reference chart compares favorably with other growth charts developed for evaluating HC such as the INTERGROWTH-21 working group [4] and the US derived charts [4] which also found a higher HC values at each percentile point and gestational age for the males compared with the female infants [4, 5].

However, we noted that the HC percentiles in this study differed from the INTERGROWTH -21, Israeli and American references especially at the 5th,

FIG. 2. (a) Head circumference nomogram curves for Boys showing 5th, 50th and 95th percentiles. (b) Head circumference nomogram curves for boys comparing our newborn population and the INTERGROWTH dataset at the 5th, 50th and 95th percentiles. OX = INTERGROWTH data points.

90th and 95th percentile cutoff points [4, 5, 9]. In contrast to the INTERGROWTH data points, our infants have a higher HC at each gestational point and also for both sexes [4, 5]. This is significant considering the fact that HC nomograms are clinically relevant in defining cutoff for microcephaly and thus diagnosis of same in any given population [4, 5]. Using the INTERGROWTH and other non locally derived charts may thus predisposed to identifying and thus misclassifying many infants as being normal when in fact they have a smaller HC as seen in the

FIG. 3. (a) Head circumference nomogram curves for girls showing 5th, 50th and 95th percentiles. (b) Head circumference nomogram curves for girls comparing our newborn population and the INTERGROWTH dataset at the 5th, 50th and 95th percentiles. OX = INTERGROWTH data points.

nomogram displayed [4, 5]. While our chart represents a fairly homogenous set of infants residing in a low middle income country, the INTERGROWTH-21, Israeli and the CDC charts were drawn for a mix racial group with different socio-economic characteristics residing in higher income countries [4, 5, 9]. The inclusion of infants from affluent countries in the INTERGROWTH-21 and US derived reference charts might have influenced the higher HC considering that nutrition, and thus anthropometry and growth, has a strong linear correlation with affluence

[4, 5]. This further underscore our earlier call for a locally adaptable growth references since environment, genetics and socioeconomic factors play important role in growth and nutrition of infants in utero.

Limitations

This was a single center-study and we think a city wide evaluation of birth records might have being a better representation of the HC data of infants born in Jos. However, the large dataset collected over a 10 year period improves the power of the study and thus improves the reliability of our findings [22]. This is even made more plausible as JUTH is a public health institution that is accessible to individuals from different social backgrounds. Second, even though our cohort may not be representative of the national growth cohort as our center is only one of many tertiary care centers in the country, Jos being a cosmopolitan city with most of the major Nigerian tribes' resident is best suited for a random selection of a nationally representative sampled population. This strengthens the external validity of our findings to the general Nigerian population [22]. Third, we used LMP for gestational age assessment in most of the women because not all of them had first trimester ultrasound dating of their pregnancy. Combining the ultrasound dating with their last menstrual period, even though subjective, helped in reducing the error rates for gestational age assessment [19].

Clinical usefulness and applicability of our study findings

Our nomogram is derived from a single racial group (Black African infants) residing in a single country. This is very relevant because of the relationship between genetic endowment and the environment on growth and development in utero [23, 24]. Therefore, the HC references developed in the present study are more appropriate for the Nigerian population compared with the currently available references such as the INTERGROWTH and US derived HC normogram [4, 5]. Therefore, our nomogram may find wide acceptance and applicability as an epidemiologic tool in evaluating and making comparisons about the HC of black African children, especially because of genetic and also socio-economic similarities in our populations [25–27].

CONCLUSION

The current study presents gender specific HC references for a relatively homogenous population from a low middle income country. This new HC nomogram will be useful in neonatal care especially with respect to evaluating head size and by extension, brain development in utero. However, studies with larger sample size may still be needed in future to improve accuracy of the newborn normogram.

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