Gestational Age-specific Centile Charts for Anthropometry at Birth for South Indian Infants

HEMASREE KANDRAJU, SHILPA AGRAWAL, K GEETHA, *LAKSHMI SUJATHA, SREERAM SUBRAMANIAN AND SRINIVAS MURKI

*From the Department of Neonatology and Department of Obstetrics and Gynecology, Fernandez Hospital, Hyderabad, India; and *Department of Statistics, Nizam's College, Hyderabad.*

Correspondence to: Dr Srinivas Murki, Consultant Neonatologist, Fernandez Hospital, Hyderabad,Andhra Pradesh 503 001, India. srinivas_murki2001@yahoo.com

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Objective: To construct centile charts for birth weight, length and head circumference for infants born from 24 to 42 weeks of gestation and to compare with the other national and international growth charts.

Study design: Observational descriptive study.

Subjects: All consecutively live born singleton infants from 24 to 42 weeks of gestation.

Methods: Data were retrieved for the birth weight, length and head circumference of infants born from July 1999 to October 2009. Smoothened percentile curves were created separately for the male and female infants by Lambda Mu Sigma (LMS) method. The new curves were compared with the other Indian and international growth charts.

Results: Raw and smoothened curves for weight, length and head circumference centiles at birth were created from 31,391 (males: 16,054 and females: 15,337), 28,812, (males: 14,730 and females: 14,082), and 28,790 (males: 14,724 and females: 14,066) infants, respectively. Females infants were lighter than the male infants, especially from 35 weeks onwards. On comparing the study curves with the other Indian growth curves, for infants less than 35 weeks, the mean birth weight for the study infants were similar or lower and for infants greater than 35 weeks, they were higher. On comparison of our weight centiles with the international data, across all gestations and across all centiles, our birth weights are lower.

Conclusion: The updated centile charts in this study may be used as reference charts for the birth weight, length and head circumference for the local population. Using earlier growth charts or the Western charts would misclassify the infants at birth into SGA or LGA.

Key words: *Birth centiles, Gestational age, Anthropometry, Indian infants.*

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Lubchenco, *et al*. [1] were the first to describe anthropometry at birth as centiles for various gestations. These centiles, still used widely in many centers, were based on data from live births from an ethnically mixed group in Colorado. However, these charts are not universally applicable because the growth potential of the fetus is influenced by sex of the infant, ethnic group and geographical factors.

India specific intrauterine growth curves were constructed by many authors [2-5]. Changes in the parity, socioeconomic and environmental conditions necessitate an update in the existing growth charts. We planned the present study to derive a gestation specific reference growth chart for our local population. The objective was to construct centile charts for birthweight, length and head circum-ference for infants born from 24 to 42 weeks of gestation.

METHODS

This was a medical record review of the period from July 1999 to October 2009 at a maternity and newborn level III care hospital in South India. All consecutively live born singleton infants from 24 to 42 weeks of gestational age during the study period were eligible. The gestational age had been calculated in completed weeks from the findings of the early dating ultrasound or from the last menstrual period. Infants with major congenital anomalies and those with uncertain gestational age were excluded. The weights had been measured on a digital weighing machine with a variability of ± 10 grams. The head circumference had been measured using a non- stretchable tape and recorded in centimetres, and the length of the infant with an infantometer in centimetres.

All the relevant risk factors [hypertensive diseases of pregnancy, maternal medical disorders, severe anemia (Hb <7g/dL) in the mother] were noted from the maternal and neonatal database and in select cases, from the case records. The perinatal details were obtained from the neonatal database.

The LMS method [6] was applied for normalizing the raw data. The scatter data plots and *Z* scores obtained from the LMS method were used to identify the outliers. Observations lying beyond ±3 *Z* score were deleted. The centiles (3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, and 97th) for the birthweight, length and head circumference were calculated using the LMS method which uses the Box-Cox power transformation to obtain normally distributed data within each group.

Six sets of charts were constructed defined by the sex of the infant for the birthweight, length and head circumference. The normal distribution of the *Z* scores resulting from the fitting of the LMS models within each group was verified by obtaining normal probability plots (Q-Q plots). Centiles were calculated using the LMS Chart Maker software and the other analyses was carried out using SPSS, version 16.

RESULTS

Thirty three thousand and seven hundred and forty infants were born alive in the hospital during the study period. 787 infants were products of multiple pregnancies and in 28 infants gestation was either less than 24 weeks or more than 42 weeks. From the eligible 32,925 infants, gestation was not certain in 1444 infants. Among the remaining 31,481, the data was available for 31,391 (males, 16,054), 28,812, (males, 14,730), and 28,790 (males, 14,724) infants for the plotting of weight, length and head circumference centiles, respectively. After removing the outliers, the data was available for 30,016, 27,228 and 26,974 infants for the final plotting of weight, length and head circumference centiles, respectively (***Table* I**). Sixty percent of the pregnancies were booked in the hospital before 20 weeks of pregnancy and 40% of the infants were born to primiparous mothers. The number of infants with birthweight less than 2500 grams were 5,921 (19%) and those with birthweight less than 1500 g and 1000 g were 1,023 (3.3%) and 282 (1%) infants, respectively. The incidence of PIH was 6.5% (*n*=2060) and that of diabetes and severe anemia was 5.5% (*n*=1736) and 1% (*n*=313), respectively among the mothers of infants included in the study.

The Q-Q plot for z scores of birth weight, length and head circumference displayed good correlation for the data between 5th and 95th centiles. The crude curve for the raw data of male infants displayed a bump in the 97th percentile from 30 to 32 weeks. The crude curves of female infants were relatively smoother. Female infants were lighter than the male infants especially from 35 weeks onwards (***Fig.* 1**). However, there was not much difference in the length and head circumference (***Fig*. 2,3**).

On superimposing our charts on the most widely used Lubchenco intrauterine growth charts [1], for the 10th, 50th and 90th centiles, our preterm babies (< 35 weeks) were lighter than Colorado babies. For late preterm and term babies (≥35 weeks), the 90th centile birthweights were lower, the 50th centile birth weights were similar and the 10th centile birth weights were higher. Similar pattern was noted for both the sexes. However, length and head circumference centiles were similar to that of Lubencho, *et al*. for lower gestational ages (< 35weeks) and at term gestation, study centiles were higher or similar.

On comparing the weight centiles with the Canadian [7] and Scottish [8] data, birthweights were lower across all the gestations and centiles. Superimposition of study centiles of male infants on the recently published North American centiles [9] revealed, lower birthweights for the 50th and 90th centiles at term gestation and similar birthweights for the 10th centile across all gestations. However, the length and head circumference centiles were similar across all gestations and centiles.

DISCUSSION

The study presents the centiles, means, standard deviations and smoothened curves of birth anthropometry in a large cohort of neonates for weight, length and head

TABLE I INFANTS AT EACH GESTATIONAL AGE AFTER REMOVING THE OUTLIERS

Gestation (weeks)	*Weight (n= 30,016) (M/F)*	*Length (n= 27,228) (M/F)*	*Head circumference (n=26,974) (M/F)*
24	15 (9/6)	7 (4/3)	7 (4/3)
25	23 (9/14)	9 (4/5)	9 (4/5)
26	68 (34/34)	36 (20/16)	35 (19/16)
27	56 (31/25)	37 (20/17)	39 (21/18)
28	132 (81/51)	96 (60/36)	90 (53/37)
29	106 (57/49)	79 (45/34)	82 (45/37)
30	159 (88/71)	133 (74/59)	131 (71/60)
31	166 (78/88)	136 (69/67)	136 (65/71)
32	302 (154/148)	273 (138/135)	265 (135/130)
33	342 (181/161)	308 (180/128)	308 (180/128)
34	508 (291/217)	494 (278/216)	491 (280/211)
35	712 (387/325)	662 (349/313)	651 (335/316)
36	1652 (897/755)	1537 (807/730)	1543 (813/730)
37	4210 (2254/1956)	3876 (2028/1848)	3814 (1964/1850)
38	8002 (4024/3978)	7316 (3657/3659)	7221 (3620/3601)
39	6373 (3159/3214)	5640 (2855/2785)	5570 (2853/2717)
40	6580 (3366/3214)	6023 (3056/2967)	6030 (3088/2942)
41	574 (281/293)	524 (264/260)	509 (251/258)
42	36 (17/19)	42 (20/22)	43 (21/22)

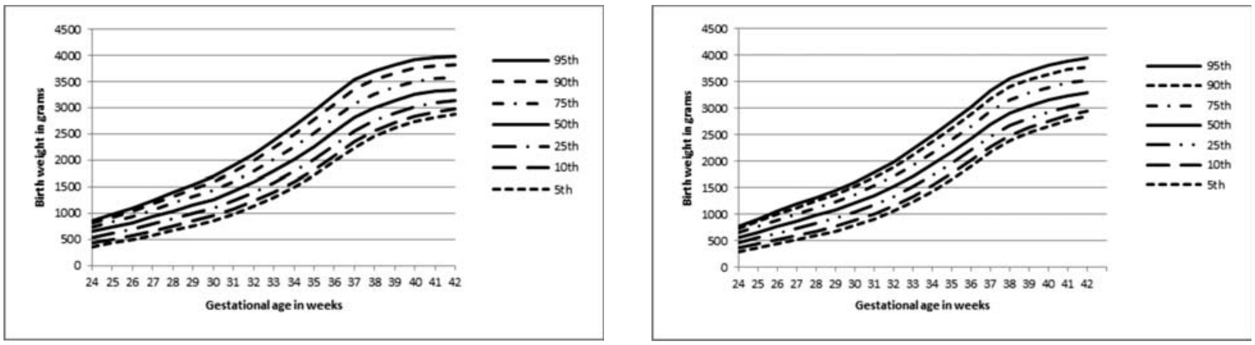
M-male; F-female.

WHAT IS ALREADY KNOWN

- Multiple growth centiles are available for weight, length and head circumference at birth.

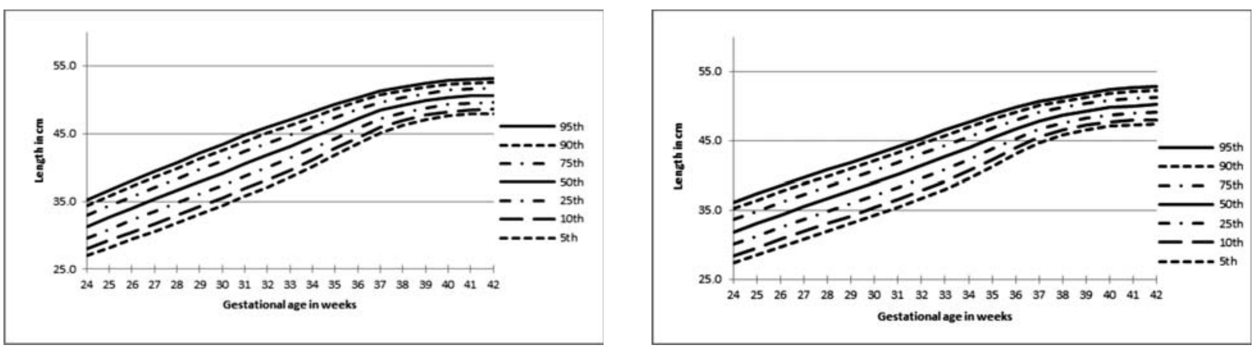
WHAT THIS STUDY ADDS?

- The updated sex-specific centile charts in this study may be used as reference curves for various gestational for the birthweight, length and head circumference, in South Indian infants.



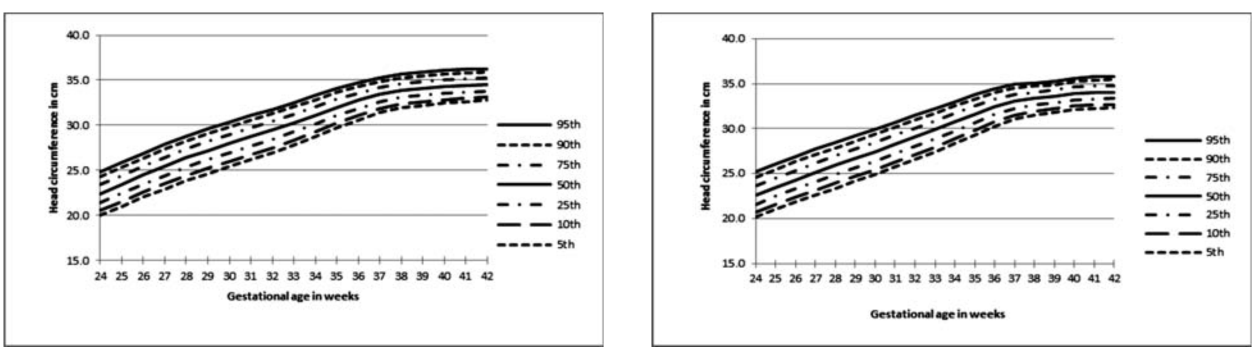
(*a*) (*b*)

FIG. 1 *Smoothened centile curves for the birthweight of (a) male and (b) female infants (without outliers).*



(*a*) (*b*)

FIG. 2 *Smoothened curves for length of (a) male and (b) female infants (outliers removed).*



(*a*) (*b*)

FIG. 3 *Smoothened curves for head circumference of (a) male and (b) female infants (outliers removed).*

circumference. It is the first study from our country involving neonates from 24 to 42 weeks of gestation. Another unique feature was the presence of significant number of babies at lower gestations (<30 weeks). The study cohort was stratified for sex unlike other Indian studies [2,3]. The study population was representative of the population in this part of country as evidenced by the similarity in the incidence of prematurity and obstetric morbidities like multiple pregnancies, maternal hypertension and maternal diabetes to the large hospital based data from the country [10].

The study met most standards required to obtain an ideal reference growth chart [11]**.** The data included singleton babies born from a monoethnic group and most importantly the best method for gestational age estimation (first trimester based ultrasound dating) was used in more than 60% of the included infants as they were born of pregnancies registered early in our hospital. Gestational assessment was mandatory for our hospital records. The gold standard LMS method [6] was used for estimating the centiles and for the smoothening of the centile curves.

Most of the recent studies have shown a secular trend of increasing birthweight at higher gestational ages. This is also evident in our cohort. The mean birthweights after 34 weeks were higher in our cohort compared to the previous studies [2-5]. At term gestational age the mean birthweights were almost 100 to 200 grams higher in our present cohort. However, at lower gestations, our birth weights were similar or lower (***Web Table* I**). This may be attributed to improved survival of smaller babies at lower gestations over the last two to three decades. Similar trends were observed for the length at birth. There was a trend of increased length at higher gestations. However, there was no change in head circumference centiles across all gestations.

Most of the units in our country still use Lubchenco, *et.al*. [1] charts for classifying the infants at birth into small for gestation (SGA) and large for gestation (LGA). However, our data in comparison with that of Lubchenco, *et al*. suggest that the 10th and 90th centiles of our babies are lower. This leads to overestimation of the incidence of SGA and underestimation of LGA babies, the consequence being many AGA infants labelled as SGA, and LGA infants being overlooked as they are misclassified as appropriate for gestational age (AGA). On comparing with the other international growth charts [7, 8], the birthweights of our babies were lower across all the gestations and centiles. Population specific and updated growth charts should be used for the appropriate classification of infants into SGA or LGA or AGA.

Inspite of the best effort in calculating the centiles using the large cohort and also best statistical methods, this study still has few limitations. Gestational age estimation was not ultrasound based in all the included infants. Anthropometric measurements were done by different nurses and this may have contributed to the inter-observer variability. We did not construct separate curves for parity and maternal height. This is a single centre cross-sectional study spanning 10 years. This growth data is from all the socioeconomic strata and hence might not reflect the ideal potential for intrauterine growth. An ideal chart should be multicentred and involve data from 2 to 5 years. Ideally, at each gestation, we would require 100 babies for estimating all the centiles. Our data lacks this parameter at lower gestations (less than 32 weeks). We did not include stillbirths in our data for the ease of data collection, as it was retrospective.

Contributors: SM and GK designed the study. HK collected the data. SM and SS monitored the data collection. HK and SM analyzed data and wrote the manuscript with inputs from SS.
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