Original Articles

BIRTHWEIGHT STANDARDS FOR SOUTH INDIAN BABIES

Matthews Mathai, Saramma Jacob and N.G. Karthikeyan

From the Departments of Obstetrics & Gynecology and Child Health, Christian Medical College Hospital, Vellore 632 004.

Reprint requests: Dr. Matthews Mathai, Department of Obstetrics & Gynecology, Christian Medical College Hospital, Vellore 632 004.

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ABSTRACT

Objective: *To obtain birthweight standards for south Indian babies.* ***Design:*** *Prospective cohort study. Setting: A tertiary care hospital in south India.* ***Patients and Methods:*** *Data from 11, 641 singleton live births between 1991 and 1994 were used to calculate smoothed gestation specific birth weight centiles for four categories based on sex of the infant and birth order. Smoothed gestation specific birthweight centiles were also calculated for all births between 37-41 weeks without adjustments for sex of infant or birth order. Data for births between 37 and 41 weeks were reanalysed using non-adjusted birth weight centiles and birthweight centiles adjusted for sex and birth order to determine misclassification of data. Multiple regression analysis was used to determine the influence of various variables on birth weight.* ***Results:*** *Factors influencing birth weight were gestaion at birth, sex of infant, birth order and maternal height. A quadratic equation including these variables and the square of the gestational age explained 18% of variation in birth weight. Female infants were on the average 113 g (95% CI 26-200 g) lighter than male infants. Later born babies were on the average 130 g (95% CI 40-220 g) heavier than first born babies. Therefore significant misclassification of infants occurred when non-adjusted birth weight centiles were used. Babies born to women whose heights were outside the interquartile range (150-158 cm) were 81 g lighter or heavier than those born to women within this range.* ***Conclusions:*** *Birth weight centiles for gestation when used should be adjusted for birth order, sex of infant and maternal height.*

Key words: *Birthweight centiles, adjusted birthweight centiles.*

VARIOUS factors influence birth weight. All these factors act by influencing either the rate of intrauterine growth or gestation at birth, or both. Appropriateness of growth should be determined by whether or not the infant has achieved its growth potential for that particular gestation. Lubchenco, *et al.(l)* were the first to describe birth weight as centiles for various gestations. These birth weight centiles were based on data from live births from an ethnically mixed group in Colorado. However these data are not universally applicable since the growth potential of the fetus depends on factors such as sex of the infant, birth order, maternal size and ethnic group. It is therefore appropriate that each center should have its own birth weight centiles for gestation based on locally collected data. Birth weight centiles for north Indian babies have been described (2-6). We are not aware of published data on birth weight centiles for south Indian babies. Hence we decided to analyze data from births in our institution to establish

birth weight standards for gestation for south Indian babies.

Patients and Methods

The Christian Medical College Hospital, Veil ore delivers approximately 5500 women every year, of which approximately 75% are booked for antenatal care and delivery at this institution. Ninety five per cent of these women are residents of the North Arcot, Ambedkar District, Tamil Nadu. The remainder is mostly residents of neighboring districts in Tamil Nadu and Andhra Pradesh.

This report is based on 13,217 consecutive singleton normally formed live births, among women booked for antenatal care and delivery, between 1991 and 1994. Data from these births was stored on a computer. The best estimate of gestation based on reliable menstrual history, early antenatal clinical examination and sonographic fetal biometry was used. Birth weights were measured to the nearest 50 g on a Braun weighing scale within one hour of birth. In 792 (6%) births, gestational age could not be accurately determined. In 780 (5.9%) births, records were incomplete for one or more of the other variables studied. Data from these 1,572 (11.9%) births were excluded from further analyses. Thus data were available from 11,645 singleton live births for analyses.

Data were analyzed using the SPSS-PC package (SPSS Inc, Illinois, USA). Birth weight centiles were calculated for each week of gestation from 29-43 weeks for four categories based on sex of the infant and birth order (first born or later born). Smoothing of centiles was done using a three point weighted moving average. Each centile was weighted by the square root of the number of observations on which it was based(7).

Smoothed gestation specific birth weight centiles were then calculated for all infants born between 37 and 41 weeks, without adjustment for sex or birth order. Data for births between 37 and 41 weeks were reanalyzed using these non-adjusted birth weight centiles and birth weight centiles adjusted for sex and birth order to determine misclassification of data. The statistical significance of misclassification errors was calculated on a 10% random sub-sample using the z-test(8).

Maternal height to the nearest cm was recorded in the last 1803 consecutive births. Birth weight was regressed against birth order, sex of the infant, gestation at birth and its square, and maternal height in this group. Data from this group of mothers and their infants were compared with those from the remaining 9839 births where maternal height had not been recorded. The two groups were comparable for gravidity of the mother, gestation at delivery, sex of the infant and birth weight.

Results

The distribution of the 11, 645 births by birth order and sex is shown in *Table I.* Of these, 3, 346 (28.7%) were first born infants and 5777 (49.6%) were boys. Since the numbers of births at gestational ages below 31 weeks were small, data from these births were excluded from calculation of smoothed birth weight centiles. Further, data from births at 31 weeks and 43 weeks were excluded because of smoothing. *Figs. 1-4* show smoothed gestation specific birthweight centiles between 32 and 42 weeks.

There was significant misclassification of infants based on birth weight alone ($p < 0.001$) *(Table II).* Use of non-adjusted centiles resulted in more first born infants

TABLE I— *Distribution of Births According to Sex of Infant and Birth Order*

Gestation (weeks)	Males		Females	
	First born n= 1695	Later born n= 4082	First born n= 1651	Later born n= 4217
29	2	3	4	4
30	5	7	1	7
31	7	9	4	8
32	4	12	4	12
33	22	31	10	23
34	17	48	8	35
35	27	65	20	61
36	63	132	54	139
37	164	366	119	323
38	324	775	254	755
39	475	1095	474	1184
40	413	947	467	1081
41	147	487	202	488
42	19	82	24	79
43	6	23	6	18

and more girls being wrongly labeled as lighter than the 10th centile for gestation. On the other hand, more male infants and latter born infants were wrongly considered to be heavier than the 90th centile for gestation.

The mean (SD) maternal height in the last 1803 births was 153.9 (0.16) cm. The mean (SD) birth weight of infants born to women whose height was in the interquartile range (150-158 cm) was 2945 (516) g. The mean (SD) birth weight of infants born to women shorter than 150 cm was 2847 (480) g while that of infants born to women taller than 158 cm was 3036 (524) g. These differences were statistically significant ($p < 0.0001$).

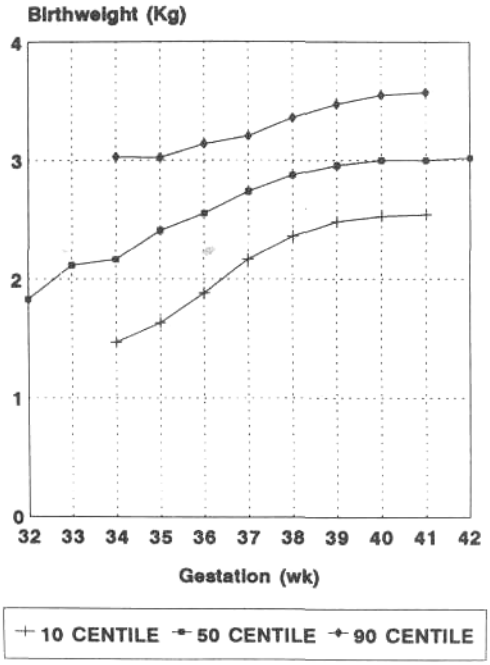

Fig. 1. Gestation specific birthweight centiles-first born male infants.

Multiple regression analyses of data from these 1803 births showed that gestational age and its square, sex of the infant, birth order and maternal height contributed significantly to birth weight *(Table III).* This quadratic equation explained 18% of variation in birth weight.

Discussion

The important determinants of birth weight include sex of the infant and birth order(9-ll). We have adjusted birth weight centiles for birth order and sex of the infant. This is in contrast to other reports from India(3-6) where birth order and sex of the infant have not been studied. Singh *et al.(2)* reported mean birth weight for gestation for north Indian babies for both sexes. However birth weight centile graphs in that report were constructed based on combined data from both sexes. More recently, Kumar(12) reported birth weight

TABLE II—*Misclassification of Infants Based on Only Birthweight for Gestation (37-41 weeks)*

A. All infants (10,540)

		Adjusted centiles		
		<10th	10-90th	>90th
Non adjusted centiles	<10th	757	91	0
	10-90th	176	8277	81
	>90th	0	210	948

B. All male infants (5193)

		Adjusted centiles		
		<10th	10-90th	>90th
Non adjusted centiles	<10th	307	16	0
	10-90th	149	3983	4
	>90th	0	210	524

C. All female infants (5347)

		Adjusted centiles		
		<10th	10-90th	>90th
Non adjusted centiles	<10th	450	75	0
	10-90th	27	4294	77
	>90th	0	0	424

D. All first born infants (3039)

		Adjusted centiles		
		<10th	10-90th	>90th
Non adjusted centiles	<10th	239	58	0
	10-90th	24	2416	80
	>90th	0	2	220

E. All later born infants (7501)

		Adjusted centiles		
		<10th	10-90th	>90th
Non adjusted centiles	<10th	518	33	0
	10-90th	152	5861	1
	>90th	0	208	728

TABLE III—*Factors Influencing Birthweight*

Variable	Coefficeint	SE	Significance (P)
Gestation (weeks)	−123.75	28.8	<0.0001
Gestation^2	2.82	0.4	<0.0001
Sex (male=1; female=2)	−112.85	44.6	0.0117
Birth order (first born=1; later born=2)	130.23	45.8	0.0047
Maternal height (cm) (<150 cm=1; 150-158 cm=2; >158 cm=3)	81.1	33.8	0.0169
Constant	3230.02	499.9	<0.0001

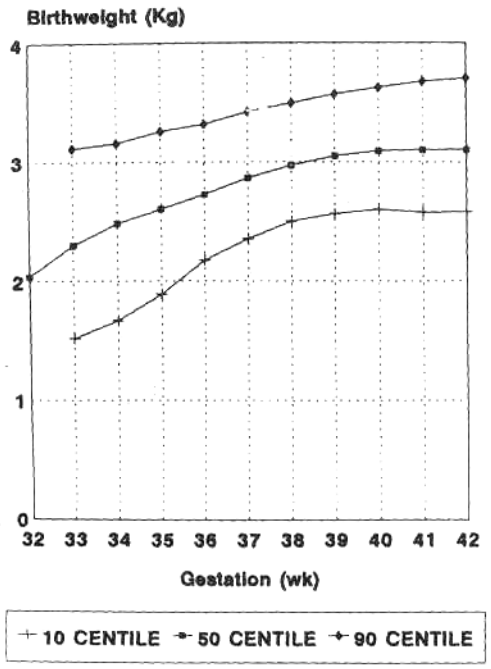

Fig. 2. Gestation specific birthweight centiles-later born male infants.

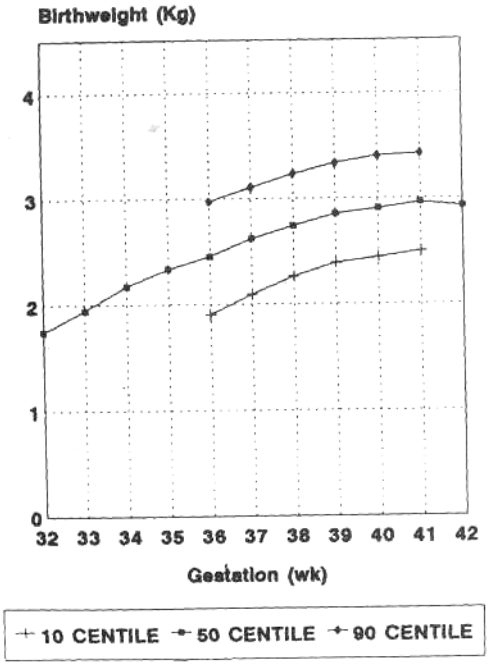

Fig. 3. Gestation specific birthweight centiles-first born female infants.

curves adjusted for maternal weight, parity and sex of the infant based on data from 575 live births.

In our study, girls were on the average 113 g (95% CI 26-200 g) lighter than boys. Similarly first born infants were on the average 130 g (95% CI 40-220 g) lighter than later born infants. It is important to consider these differences as otherwise infants may be inappropriately classified as being light for dates, heavy for dates or appropriate for dates. While it would be much simpler to use non-adjusted birth weight centiles, misclassification of infants using non adjusted birth weight centiles may lead to unnecessary intervention and anxiety on the part of care givers and parents. Use of non-adjusted birth weight centiles in the present study resulted in statistically significant misclassifications *(Table II).*

One in every five babies whose birth weights were less than the adjusted 10th centile for gestation was missed using non-adjusted centiles. Further more girls and first born infants were inappropriately considered lighter than the 10th centile for gestation, while more boys and later born infants were considered heavier than the 90th centile for gestation.

Socioeconomic factors, maternal nutrition, active and passive maternal smoking(13,14) may influence birth weight but these are extrinsic factors which affect fetal growth. Maternal age is an intrinsic factor which can influence birth weight(14) but this cannot be always accurately determined in our country. Hence maternal age was not considered in the present analysis.

As a categorical variable, maternal height contributed significantly to

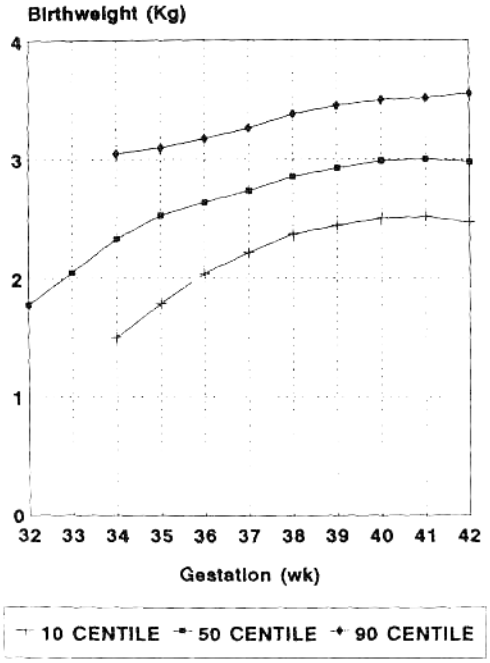

Fig. 4. Gestation specific birthweight centiles-later born female infants.

Birth weight. Thomson, *et al.(9)* recommended adjustments of birth weight for maternal height and weight. Kapur *et al*.(15) and Bhargava *et al.*(16) also found birthweight to correlate with maternal height. However Kumar(12) did not find maternal height to be a significant variable in determining birth weight. Although maternal height was available only in 1803 births, data from these births were comparable to those from the remainder and therefore this information may be used for adjusting birth weight for maternal height. If maternal height is below 150 cm, 81 g should be added to the birth weight before using the graphs to determine the centile rank. If the mother is over 158 cm tall, a similar amount should be subtracted from the birth weight before determining the adjusted birth weight centile.

Comparison of the present data with those from the same institution in 1968(15) shows secular changes in birth weight and maternal height. Mean birth weight at term increased by 74 g while mean maternal height increased by 4.4 cm. A similar increase in birth weight has been reported from community based studies in and around Vellore (17). However mean parity and preterm delivery rate have decreased over the same time period (18). When adjustments were made for changes in parity and gestation at delivery, the increase in mean birth weight over one generation was 137 g(18).

The data presented here are birth weight centiles and not intrauterine growth curves, as these are often called(2-6). Fetal growth may be assessed in longitudinal studies, clinically or through ultrasound scans. Birth weights and estimated intrauterine fetal weights are not always comparable especially at earlier periods of gestation. Infants that are born preterm are usually growth retarded. Hence data from birth weights should not be used to calculate intrautering growth rate.

REFERENCES

1. Lubchenco LO, Hansman C, Dressier M, Boyd E. Intrauterine growth as estimated from live-born birth weight data at 24-42 weeks of gestation. Pediatrics 1963, 32: 793-799.
2. Singh M, Giri SK, Ramachandran K. Intrauterine growth curves of live born single babies. Indian Pediatr 1974, 11: 475-479.
3. Ghosh S, Bhargava SK, Madhavan S, Taskar AD, Bhargava V, Nigam SK. IIntrauterine growth of north Indian babies. Pediatrics 1971, 47: 826-832.
4. Bhatia BD, Bhargava V, Chatterjee M, Kota VLN, Singh LI, Jain NP. Studies on fetal growth patterns: Intrauterine

growth percentiles for singleton live born babies. Indian Pediatr 1981, 18: 647-653.

5. Mittal SK, Singh PA, Gupta RC. Intrauterine growth and low birth weight criteria in Punjabi infants. Indian Pediatr 1976,13: 679-682.

6. Mohan M, Shiv Prasad SR, Chellani HK, Kapani V. Intrauterine growth curves in north Indian babies: weight, length, head circumference and ponderal index. Indian Pediatr 1990, 27: 43-51.

7. Hayes A, Daly L, O'Brien NG, MacDonald D. Antropometric standards for Irish newborn. Irish Med J 1983, 76: 60-70.

8. Fleiss JL. Statistical methods for rates and proportions, 2nd edn. New York, John Wiley & Sons, 1981, pp 201-204.

9. Thomson AM, Billewicz WZ, Hytten FE. The assessment of fetal growth.J Obstet Gynaecol Brit Commonw 1968, 75: 903-916.

10. Datta Banik ND, Krishna R, Mane SIS, Raj L, Taskar AD. The influence of maternal factors on birth-weight of the newborn. Indian J Pediatr 1969, 36: 278-282.

11. Mukherjee DK, Sethna NJ. Birth weight and its relation with certain maternal factors. Indian J Pediatr 1970, 37: 460-464.

12. Kumar R. Prenatal growth curves corrected for certain genetic and environmental factors. J Trop Pediatr 1992, 38: 256-261.

13. Mathai M, Skinner A, Lawton K, Weindling AM. Maternal smoking, urinary cotinine levels and birth-weight. Aust NZ J Obstet Gynaecol 1990, 30: 33-36.

14. Mathai M, Vijayasri R, Babu S, Jeyaseelan L. Passive maternal smoking and birthweight in a south Indian population. Brit J Obstet Gynaecol 1992, 99: 342-343.

15. Kapur S, Kumar G, Mammen KC, Jesudian G. Height and weight of south Indian women of child bearing age and their effect on birth weight and length of the baby. Indian J Med Res 1971, 59:1480-1488.

16. Bhargava V, Chatterjee M, Prakash A, Bhatia B, Mishra A. Fetal growth-I. Influence of maternal size and nutrition on identification of fetal growth retardation. Indian Pediatr 1983, 20: 549-559.

17. Rao PSS, Antonisamy B, Richard J. Trends in intra-uterine growth of single live borns during 1969-73 and 1989-93 among rural and urban communities of North Arcot Ambedkar District of Tamil Nadu, India. Monograph No. 21 from "Longitudinal Studies in Child Growth and Development", Department of Biostatistics, Christian Medical College, Vellore.

18. Mathai M. Changes in health status and birthweight in Vellore over 25 years (1969-1994). Occasional Papers, Centre for Science for Environment (SUM), Oslo (in press).