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SIZE AT BIRTH OF SRI LANKANS

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Summary: The weight, crown-heel length (CHL), crown-rump length (CRL), circumference of head, chest and mid-upper arm, skinfold thickness at 4 sites, triceps, biceps, subscapular and suprailiac, and biacromial diameter, of 230 neonates have been measured within 24 hours of birth. These anthropometric characteristics have been related to the height, post - partum weight and body mass index (BMI) of the mother. The population studied included all babies born in the Professorial Unit of the Teaching Hospital in Colombo, other than those managed in the Special Care Baby Unit.

The mean (and SD) were 2.94 kg (0.45) for weight, 50.33 cm (2.631) for CHL, 32.60 cm (1.701) for CRL and 32.79 cm (1.996) and 30.80 cm (1.910) for head and chest circumferences, respectively. Mother's weight exerts a significant influence on birth weight and length and on head and chest circumferences, subcutaneous fat and shoulder width of the neonate. Mother's height also bears a significant influence on the parameters studied. The BMI of the mother bears no significant relationship to the anthropometry of neonate, with the exception of chest circumference.

Key words: Birth weight, crown-heel length, crown-rump length, head circumference, chest circumference, subcutaneous fat, BMI, relationship to maternal anthropometry.

INTRODUCTION

Since the pioneering study of Nicholls is 1939 (1) there have been several reports on the weight at birth of Sri Lankans. Birth weight has been shown to be influenced by the socio-economic status of the mother (1, 2, 3, 4, 5), by parity (2, 3, 4), by maternal height and weight (2, 3, 5), by the educational level of the mother (5), by weight gain during pregnancy (5) and by intrauterine infection (6, 7, 8). Only 3 reports (9, 10, 11) on other anthropometric characteristics of the neonate have been published, and in each of these, only one characteristic has been studied.

Accordingly, a study has been carried out where several anthropometric characteristics have been measured, and related to the height, weight and body mass index of the mother.

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STUDY POPULATION AND METHODS

The study was conducted at the Professorial Unit of the De Soysa Hospital for Women (non-paying wards 3 and 15), from May to June 1988. Approximately 75% of the admissions to the Unit are from within the Municipal limits of Colombo and suburbs, the remainder being from the rest of the Western Province. All babies born consecutively were included, other than the neonates admitted to the Special Care Baby Unit. Premature babies, those with birth weights inappropriate for gestational age as well as neonates with other complications which needed special care, were thus excluded. The study population numbered 230.

Birth weight, crown-heel length (CHL), crown-rump length (CRL), head, chest and mid-upper-arm circumferences, biacromial diameter (BAD) and skin-fold thicknesses over 4 sites, the triceps and biceps, subscapular and suprailiac, were measured. All measurements were taken within 24 hours of birth.

The weight of the neonate was measured in the nude on a baby scale to the nearest 10g. The scale was regularly standardised using reference weights.

The length was measured to the nearest 0.1 cm using a portable measuring board. The mother held the crown of the head against the head board so that the external auditory meatus and lower orbital margin were at right angles to the board. The knees were pressed down and the foot board brought up to touch the heels, which were held at right angles to the legs. The infant was gently stretched to ensure maximum length. The crown-rump length was measured with the lower limbs held perpendicular to the trunk while the trunk was pressed down and gently stretched.

A flexible steel tape was used to measure arm lengths and the circumferences. When measuring the head circumference (HC) the tape was made to cross the frontal bone superior to the supra-orbital regions and posteriorly round the occiput, so that the maximum circumference was measured, to the nearest 0.1cm. Chest circumference was measured at the level of the nipples. Mid-upper arm circumference (MAC) was measured at the plane mid-way between the tip of the acromion and the tip of the olecranon. The distance between the acromion and olecranon was taken as the upper arm length and that between the olecranon and the tip of the styloid process of the ulna as the lower arm length.

Harpenden calipers were used for measring skin-fold thicknesses. The calipers had a surface small enough to be used on neonates. The reading was taken between 30 and 60 seconds after application of the calipers, because falsely high estimates of subcutaneous fat are obtained at shorter (15 seconds) time intervals (12,13). Triceps and biceps folds were measured in the long axis of the arm in the same plane as the MAC. The subscapular fold was picked up below the lower angle of the scapula in the axis of the skin crease, and the suprailiac fold immediately above the iliac crest in the midaxillary line. The gestational age of the neonates was obtained from hospital records.

The mother's height and weight, mid-upper-arm circumference and triceps skinfolds were measured on the second day post-partum. Her mid-pregnancy weight was obtained from hospital ante-natal records.

All measurements were taken by the same investigator (A.R).

RESULTS

The maternal data, relating to the height, weight and duration of the pregnancy, are given in Table I.

Table 1, Mid-pregnancy weight (MPW), post-partum weight (PPW), height and length of gestation of the mothers in the study,

	Mean	SD	Range
MPW,kg	51.60	8.00	30.0-82.0
PPW,kg	48.00	8.03	31.5-78.0
Height,cm	153.53	4.61	145.0-172.0
Gestation,wk	38.91	1.48	33-43

Table 2 shows the birth weight of neonates of different gestational age. On the average, boys weigh about 130 g more than girls. When boys and girls are considered together, birth weight is found to increase gradually, from 2.56 kg at 36 weeks to 3.08 kg at term. The rate of increase falls from 200g per week in the 37th week to 140 g in the 38th, 130 g per week in the 39th wk and 10 g in the 40th week. Fourteen percent were of low birth weight (LBW), $\leq$ 2.5 kg.

In Table 3 the changes with gestational age of crown-heel length (CHL), crown-rump length (CRL) and the ratio CRL/CHL are shown. The foetus reaches a length of about 50 cm by the 37 the week, with little change

Table 2. Variation of birth weight with gestational age

Gestational Age wks	Birth weight in kg Males			Females			Total		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
33	1	2.71	0				1	2.71	
34				1	1.90		1	1.90	
35	1	3.35					1	3.35	
36	4	2.45	0.22	1	3.00		5	2.56	0.30
37	14	2.70	0.36	15	2.82	0.49	29	2.76	0.44
38	26	3.05	0.47	24	2.75	0.46	50	2.90	0.49
39	36	3.04	0.41	28	2.83	0.26	64	2.95	0.37
40	23	3.20	0.47	28	2.98	0.34	51	3.08	0.42
41	10	2.96	0.47	9	3.23	0.44	19	3.09	0.47
42	4	2.90	0.40	4	2.81	0.62	8	2.85	0.53
43	1	3.25					1	3.25	
Total	120	3.00	0.46	110	2.87	0.43	230	2.90	0.45

Table 3. Change with gestational age of crown–heel length (CHL) and crown–rump length (CRL) in cm, and the ratio CRL/CHL

Gestational Age	N	CHL		CRL		CRL/CHL	
		Mean	SD	Mean	SD	Mean	SD
33	1	48.0	—	32.0	—	0.67	—
34	1	44.0	—	32.0	—	0.73	—
35	1	52.0	—	34.0	—	0.65	—
36	5	47.8	1.72	31.8	1.33	0.67	0.03
37	29	50.5	2.69	31.9	2.13	0.63	0.04
38	49	49.9	2.69	33.4	1.34	0.66	0.03
39	65	50.4	2.69	32.5	1.63	0.65	0.04
40	51	51.2	2.16	32.8	1.77	0 64	0.04
41	19	49.8	2.58	33.1	1.67	0.67	0.03
42	8	49.8	2.06	31.9	1.17	0.64	0.02
43	1	51.8	—	33.0	—	0.64	—
Total							
Male	120	50.35	2.61	32.61	1.71	0.65	0.04
Female	110	50.1	2.66	32.46	1.77	0.64	0.03
All	230	50.3	2.63	32.6	1.7	0.66	0.04

thereafter. The CRL is greater than leg length (CHL-CRL) in all foetuses, and the ratio CRL/CHL remains constant at about 0.65 between the 37th and 40 th weeks. The differences in these measurements between males and females are not significant.

Body mass index (weight x 100/CHL^2) and MAC reached values of 11.6 and 10.1 cm, respectively by the 38th week and showed no change thereafter. The differences between genders were not significant (Table 4).

Table 4. Changes in body mass index (BMI) and mid-arm circumference (MAC) with gestational age

Gestational age (wks)	N	BMI Mean	BMI SD	MAC Mean cm	MAC SD
33	1	11.8	–	9.5	–
34	1	9.8	–	8.0	–
35	1	12.4	–	10.5	–
36	5	11.2	0.14	10.0	0.45
37	29	10.9	1.70	10.1	0.89
38	49	11.6	1.40	10.1	1.04
39	65	11.7	1.50	10.4	0.90
40	51	11.7	1.10	10.3	0.87
41	19	12.6	2.60	10.4	0.75
42	8	11.5	–	10.3	1.00
43	1	12.3	–	10.0	–
Male		11.6	1.6	10.25	0.92
Female		11.5	1.7	10.16	0.93
Total	230	11.59	1.62	10.0	0.92

The skinfolds on both sides of the body were measured. The values on one side were not significantly different from those of the other side. The mean of the readings were taken when computing "arm fat" and "trunk fat". The sum of the triceps and biceps skinfolds was taken to represent arm fat and the sum of the subscapular and suprailiac folds to represent trunk fat. All skinfolds increased slightly (though not significantly) between the 37 th and 40 th week. The mean values are shown in Table 5.

Table 5. The mean and SD of biceps, triceps, subscapular and suprailiac skinfolds (in mm), arm fat, truuk fat and the ratio arm fat/trunk fat.

	Mean	SD
biceps, L	3.70	1.09
biceps, R	3.70	1.12
triceps ,L	4.50	1.37
triceps, R	4.10	1.11
subscapular L	4.27	1.18
subscapular R	4.20	1.17
suprailiac ,L	3.37	1.24
suprailiac, R	4.40	1.25
arm fat	8.16	2.67
trunk fat	8.70	2.28
arm fat/trunk fat	0.95	0.26

The skinfold thicknesses of Sri Lankan nesnates compare well with values reported from the USA (14). England (15) and from Guatemala (16) the triceps fold in these countries varying from 4.0 mm in the USA to 4.7 mm in England, and the subscapular fold from 3.8 mm in the USA to 5.2 mm in England.

As in the case of skinfolds and MAC, the upper arm length (UAL) and biacromial diameter (BAD) reached values at the 37 week that did not increase significantly thereafter. The ratios UAL/CHL, BAD/CHL and BAD/CRL remained constant after the 36 th week, indicating that the slight increase in body length is accompanied by a proportionate increase in other parameters. The mean valus are given in Table 6.

Table 6. The ratios, biacromial diameter/crown heel length, upper arm length/crown heel length, and biacromial diameter/crown–rump length (mean and SD).

	Mean	SD
BAD/CHL	0.19	0.03
UAL/CHL	0.20	0.18
BAD/CRL	0.29	0.04

Head circumference (HC) increased from 31.9 cm in the 36th week to 33.1 cm the 40th week, the difference being highly signifcant ($p=0.001$). Similary, the chest circumference showed a significant increase, from 29.5 cm in the 36th week to 31.1 cm in the 40th week. However, the ratio HC/CC remained coastant during the same period. Table 7 and 8 indicate the 5th 25th. 50th, 75th, and 90th centiles and range of values obtained for each anthropometric characteristic between the 33rd and 43rd week of gestation.

Table 7. The 5th, 25th, 50th, 75th and 90th centiles of anthropometric characteristics.

	5th	25th	50th	75th	90th
Weight, kg	2.24	2.61	2.90	3.25	3.50
Length, cm	46.0	49.0	50.0	52.0	54.0
Crown–rump length,cm	30.0	32.0	32.0	33.0	35.0
Upper arm length, cm	8.5	9.5	10.0	11.0	11.5
Lower arm length, cm	7.0	7.5	8.0	8.5	9.0
Mid-arm cir cumference, cm	9.0	9.5	10.0	11.0	11.5
Head circum ference, cm	30.0	32.0	33.0	34.0	35.0
Chest circum ference, cm	28.0	29.7	30.5	32.0	33.0
Biacromial diameter. cm	8.0	9.0	9.5	10.0	11.0
Skin–folds					
Biceps, mm	2.0	3.0	3.8	4.4	5.0
Triceps, mm	3.0	4.0	4.2	5.0	5.4
Subscapular, mm	2.8	3.2	4.2	5.0	5.4
Suprailiac, mm	2.8	3·5	4.2	5.0	6.0
BMI	9.20	10.6	11.6	12.4	13.5

Table 8. The mean, staudard deviation and range of anthropometric characteristics of neonates in the study.

	Mean	SD	Range
Birth weight, kg	2.94	0.450	1.90–4.40
Crown-heel length, cm	50.53	2.631	41.00–58.00
Crown-rump length, cm	32.60	1.701	23.00–37.00
BMI kg x $100/m^2$	11.62	1.609	7.77–20.82
Upper arm length, cm	10.24	0.966	7.00–12.50
Lower arm length, cm	8.02	0.756	6.00–10.00
Mid arm circumference, cm	10.24	0.926	7.50–13.00
Head circumference, cm	32.79	1.996	20.00–36.50
Chest circumference, cm	30.80	1.910	21.50–38.00
Biacromial diameter, cm	9.5	1.215	7.00–14.50

In Table 9, the mothers have been divided into 3 groups, those with a post-partum weight less than 45 kg, those with a weight between 45.0 and 49.9 kg and those weighing 50 kg or more. and some anthropometric characteristics of the neonates born to mothers in each group are compared. Birth weight (BW) increases significantly with increase in maternal weight. The increase in birth length (CHL) is significant only when maternal weight increases from 45 kg to 50 kg, but not for the intermediate group. The same is true for HC, CC. BAD and sum of the 4 skinfold measurements. The change in BMI is not statistically significant.

When the mothers are grouped according to their heights, birth length is found to increase significantly with the height of the mother (Table 10). The increase in BW is significant only when the mother is 155 cm or taller. The other characteristics do not show a significant change with maternal height. When babies born to mothers less than 153.5 cm in height (the mean height of the mothers in the study) are compared with the rest, the differences between the mean BWs become highly significant.

Table 11 shows the relationship of these parameters to the BMI of the mother. Although each parameter shows an increase with maternal BMI, only the increase in chest circumference is significant. Therefore, in this series the mother's weight has a stronger influence on size at birth than mother's height The mother's BMI has little influence on the weight and length of her offspring.

DISCUSSION

The population studied may be consldered to be a select group. Although all babies measured were born in the same institution during a period of 2 months, those who needed management in the Special Care Baby Uuit having been excluded. Those included therefore represent healthy babies born in a non-paying delivery room at a teaching hospital in Colombo. The mean birth weight (BW) of 2.94 kg is very similat to the value obtained by Abhayaratne & de Fonseka (17) who also studied BW of the babies born after the 28 th wk of a normal pregnancy. The percentage of low birth weight (LBW) babies in the present study was 14. Abhayaratne and de Fonseka obtained values of 17.92% and 13.91% for males and females respectively. These values are low when compared with figures of 20 to 25% reported for all babies born at this same hospital and at other major hospitals in the provinces. Therefore, reducing factors such as maternal malnutrition and infection which reduce birth size necessitating special management of the neonate, could considerably lower the incidence of LBW babies.

Table 9 Relationship between weight of mother post-partum and anthropometric characteristics of neonate

Anthropometric characteristics of neonate	Post partum weight of mother in kg					
	Group 1 weight ≤ 45.0 N= 88		Group 2 weight 45.0–49.9 N= 52		Group 3 weight => 50.0 N= 89	
	Mean	SD	Mean	SD	Mean	SD
Birth weight, kg	2.81[a,b]	0.41	3.00[a]	0.48	3.02[b]	0.43
Birth length, cm	49.7[c]	2.29	50.51	2.82	50.7[c]	2.72
BMI, kg x 100/m^2	11.36	1.35	11.77	1.69	11.74	1 77
Head circumference, cm	32.49[d]	2.01	32.53	2.61	33.18[d]	1.4
Chest circumference, cm	30.47[e]	1.74	30.78	2.12	31.04[e]	1.88
Biacromial diameter, cm	9.27[f]	1.1	9.61	1.41	9.74[f]	1.16
Sum of 4 skinfolds, mm	16.29[g]	3.28	16.79	5.35	17.41[g]	3.55

a p=0.026 Group 1/Group 2
b p=0.001 Group 1/Group 3
c p=0.005 Group 1/Group 3
d p=0.009 Group 1/Group 3
e p=0.02 Group 1/Group 3
f p=0.003 Group 1/Group 3

Table 10. Relationship between height of mother and anthropometric characteristics of neonate .

Anthropometric characteristics of neonate	Height of mother in cm					
	Group 1 Height < 148.0 N=23		Group 2 Height 148.0 - 154.99 N=130		Group 3 Height => 155.0 N=77	
	Mean	SD	Mean	SD	Mean	SD
Birth weight, kg	2.82[a]	0.5	2.90[c]	0.43	3.03 [a,c]	0 46
Birth length, cm	49.39[b]	2.74	49.98[d]	2.4	51.19[b, d]	2.76
BMI, kg x 100, m^2	11.52	1.5	11.62	1.46	11.63	1.87
Head circumference, cm	32.7	2.66	32.6	1.9	32.9	1.77
Chest circumference cm	30.65	1.84	30.64	1.74	31.1	2.16
Biacromial diameter, cm	9.32	1.66	9.47	1.17	9.7	1.12
Sum of 4 skinfolda, mm	17.41	3.24	16.44	4.09	17.4	3.87

a $p = 0.052$ Group 1/ Group 3 b $p < 0.01$ Group 1/ Group 3
c $p < 0.05$ Group 2/ Group 3 d $p = 0.001$ Group 2/ Group 3

Table 11. Relationship between post-partum BMI of mother and anthropometric characteristics of neonate.

Anthropometric characteristic of neonate	Body Mass Index of mother: Group 1 BMI < 17.0 N = 26 Mean	SD	Group 2 BMI 17–18.39 N = 25 Mean	SD	Group 3 BMI => 18.4 N = 178 Mean	SD
Birth weight, kg	2.82	0.35	2.94	0.45	2.95	0.4
Birth length, cm	50.19	2.47	50.1	1.92	50.36	2.7
BMI, kg × 100/m²	11.2	1.27	11.7	1.56	11.65	1.65
Head circumference, cm	32.25	1.27	32.29	2.1	32.77	2.04
Chest circumference, cm	30.6	1.61	30.09[b]	2.4	30.91[b]	1.85
Biacromial diameter, cm	9.2	0.9	9.76	1.14	9.55	1.26
Sum of 4 skinfolds, mm	15.97	3.81	16.37	2.79	17.03	4.1

b $p < 0.05$ Group 2/ Group 3

Foetal weight (as judged by BW) increased very rapidly in early pregnancy, and the weight velocity decreases from 200 g / wk in the 37 th week to 10g / wk in the 41 st week. These velocities are in agreement with values reported by Lubchenco et al (18) in Colorado, namely 125 g / wk between 34 & 36 week and 25 g / wk between the 38th and 40th week

According to Briend (19). in all populations perinatal mortality is related to BW by a U-shaped curve, with high values for very small babies and for large neonates, and a minimum in the median range of BW. The BW associated with the lowest level of perinatal mortality is considered the optimal BW, suggestiug that "mean" foetal growth results in lower than optimal BW. Briend finds that the optimal BW varies from one ethnic group to another, between 3.8 and 4.0 kg for white Americans, about 2.95 kg in the poorest social class and 3.38 kg in the middle social class in India and 3.05 kg in Ghana. As precise data on optimal BW depends on reliable data on neonatal mortality, no assessment can yet made of the optimal BW for Sri Lankans.

In 1935 Gomes (10) reported a mean crown - heel length (CHL) of 48.2 cm in a series of 100 full - term babies born at the DMH, which is less than the figure of 50.3 cm in the present study. Although, in this study, no significant difference is evident in CHL of males and females, Keen and Pearse (20) found significant differences between the genders in a large series in Sheffield, England. Their values of 58.7 cm and 52.0 cm for CHL of full-term boys and girls respectively, are larger than the values in Table 3.

Before the 36th week, crown - rump length (CRL) accounts for more than two - thirds of the CHL of foetus. The ratio CRL/CHL falls to about 0 64 due to a more rapid growth in length of the legs (at about 0.6 cm / wk) than of the trunk. This is in agreement with results of a study reported by Usher and Mclean (21).

Body mass index (BMI) and the mid upper - arm circumference (MAC) are both dependent upon the amount of soft tissue laid down around the bones. After the 36th week of gestation both these parameters remain constant, indicating that the soft tissues are being deposited in proportion to the length.

The change in arm fat (sum of biceps and triceps skinfolds thicknesses) and in trunk fat (subscapular skinfold+ suprailiac skinfold) with gestational age is slight after the 36th week, and less regular than that of MAC, which represents the diameter of the humerus and muscles round it, in addition to sub - cutaneous fat. The ratio, arm fat to trunk fat remains around 0.95 during the last 4 weeks of gestation,

indicating that a little more fat is being deposited around the trunk than around the upper arm. The results of the present study do not illustrate a definite trend in the amount of fat laid down with advancing gestation, in contrast to results obtained by Brans et al (12), who found that, in normally grown, both mature and premature neonates, the amount of subcutaneous fat (as indicated by mid - tricipital and subscapular skin folds) is affected by gestational age.

The mean head circumference (HC) of 31.9 cm is lower than the value of 33.5 cm obtained by Amarasinghe (11) for 813 babies born in the non-paying delivery room of the General Hospital, Kandy. The Sri Lankan children have lower HC and show a smaller increase between the 36 and 42 weeks, when compared with values obtained by Keen & Pearse (10). Chest circumference (CC) also increases slightly with gestational age, being always less than HC, making the ratio HC/CC greater than one.

The biacromial diameter increases with gestational age but the ratios, BAD/CHL and BAD/CRL remain constant, showing that, as the length increases, the shoulder width also increases in proportion. This is also illustrated by the ratio arm length/CHL which remains constant, indicating a proportionate increase in the length of upper limb bones with increase in CHL.

Table 9, 10 and 11, show that the mother's weight exerts a significant influence on birth weight and length as well as on head and chest circumference, subcutaneous fat and the shoulder width of the neonate. Mother's height is also important in determining birth weight and length but has little influence on the other parameters. On the other hand the BMI of the mother bears no significant relationship to the anthropometry of the neonate, with the exception of chest circumference. Women who gain more fat during pregnancy may not have bigger babies (22).

Therefore, every effort should be made to increase maternal weight and height. Special attention should be paid to the nutrition of the girl child, which should be maintained at a satisfactory level throughout the period of growth, to enable her to reach her full genetic potential as regards height. During pregnancy her weight should be charted and, where necessary, food supplements provided, to ensure a pregnancy weight gain of at least 10 kg.

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