Original Article

An institutional study of anthropometric surrogates for birth weight

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ABSTRACT

Background: Various anthropometric parameters have been studied so far to find the best possible surrogate of birth weight. Material & **Methods:** The present study was done among 430 babies with a normal birth weight and 430 babies with a low birth weight born at IGGMC, Nagpur during June 2007 to December 2009.

Result: Mean birth weight of all newborns was 2.49 kg (±0.37) while their mean length was 45.62 cms (±3.32), mean head circumference (HC) was 33.79 cms (±1.63), mean mid arm circumference (MAC) was 9.91 cms (±0.96), mean chest circumference (CC) was 31.30 cms (±1.49), mean thigh circumference (TC) was 14.92 cms(±1.53) and mean calf circumference (CaC) was 9.98 cms (±0.88). Highest degree of correlation was found between birth weight & length (r=0.95) followed by HC (r=0.94). The cut off value for identifying LBW was 45.7 cm, 33.8 cm, 9.9 cm, 31.3 cm, 14.9 cm & 10 cm for length, HC, MAC, ChC, TC &CaC respectively. CaC with a cut off value of 10 cm was found to be the best suitable parameter for predicting LBW with 95.58% sensitivity & 92.32% specificity. HC on the other hand, though have a sensitivity of 96.74% for predicting LBW but its specificity of 83.25% was too low to make it best suitable anthropometric surrogate of low birth weight. Conclusion: Calf circumference with 10 cms of cutoff was found to be the most valid anthropometric surrogate for predicting low birth weight.

Key words: Low birth weight (LBW), Normal birth weight (NBW), Anthropometric surrogates like length, head circumference (HC), mid arm circumference (MAC), chest circumference (CC), thigh circumference (TC), calf circumference (CaC) etc.)

Introduction:

Birth weight of a newborn is one of the most important determinants of the chances of the newborn to survive and to experience healthy growth and development. However in our country more than 60% of deliveries are still conducted at home where recording of weight immediately after birth is hardly possible[1]. Even for the deliveries which are conducted at hospitals weighing facilities are not always available or are not always reliable. According to NFHS-3 survey (2005-06) only 34% of births were weighed at birth and 22% of them were of low birth weight (less than 2.5 kgs)[1]. This undermines the importance of finding an alternate, cheap and reliable anthropometrics surrogate of low birth weight (LBW) that can be used by a trained or untrained person.

So the present study was aimed to find the correlation of various anthropometric surrogates with birth weight of the newborn and to predict the most valid anthropometric surrogate for identification of low birth weight.

Material & Methods:

Type of study: The present study was a cross sectional comparative study.

Site of study: The study was carried out at post natal care (PNC) wards of Indira Gandhi Government Medical College & Hospital, Nagpur.

Duration of study: The study was conducted from June 2007 to December 2009.

Study population: The study population was all babies born at the IGGMC, Nagpur during the study period.

Case definition: A Low Birth Weight (LBW) was defined as birth weight of <2500 grams and a Normal Birth Weight (NBW) was defined as birth weight of 2500 grams or more. These cases and controls were matched for maternal age, parity and completed weeks of gestational age at the time of birth by using 1:1 paired matching.

Inclusion criteria: babies born out of a singleton pregnancy through a normal vaginal delivery at the above mentioned center during the specified period.

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Exclusion criteria: multiple births, babies delivered by Caesarean Section, babies seriously ill or kept in the intensive care unit.

Methods:
Approval from Institutional Ethical Committee & from University Ethical Committee of MUHS, Nashik was taken before commencing the study. Data collection was done by using predesigned & pretested proforma. A written informed consent of mother of the newborn baby was taken before starting the interview. A pilot study was done on 100 LBW & 100 NBW to check the feasibility of the proforma. Sample size was also calculated based on the findings of the pilot study. Relative risk (or Odds Ratio) of 0.08-3.02 were calculated for various risk factors for LBW; accordingly a relative risk of 1.60 was taken to calculate the sample size after considering the feasibility of the study. Formula for sample size was $n=[(2pq)(Z_{\alpha}+Z_{\beta})]/(p_1-p_0)^2$. A sample size of 430 each was estimated for LBW & NBW for present study.
Examination of newborn along with recording of anthropometric measurements was done within 24 hours of delivery.

Birth weight: Nude weight of the baby was taken to the nearest of 50 gms by infant weighing machine within 15-30 minutes of birth. The machine was standardized from time to time with the help of known weights.

Length: The baby's supine crown to heel length was measured by an infantometer, with knees fully extended & soles of feet held firmly against the foot board.

Head circumference (HC): HC was measured by placing measuring tape anteriorly at glabella & posteriorly along the most prominent point.

Mid arm circumference (MAC): MAC was measured midway between tip of the acromian process & olecranon process of ulna.

Chest circumference (ChC): ChC was measured at the level of xiphoid cartilage during quite respiration.

Thigh circumference (TC): TC was measured in supine position at the level of lowest furrow in gluteal region; the tape was placed perpendicular to the long axis of lower limb.

Calf circumference (CaC): CaC was measured at the most prominent point in semiflexed position of leg.
All measurements of newborn were taken nearest to 0.1 cm by flexible, non-stretchable measuring tape with a hope that it will fit all circumferences snugly & thus ensures the better accuracy.

Statistical analysis: chi square test, Z test and correlation co-efficient were used for data analysis.

Results:

A total of 430 LBW and 430 NBW babies were studied. LBW and NBW were matched for maternal age, parity & completed weeks of gestation at the time of birth by 1:1 paired matching. Maximum 280 (65.12%) matched pairs of mothers were in the age group of 20-24 years, 261 (60.70%) matched pairs of mothers were primipara and 216 (50.24%) matched pairs of mothers delivered at 39-40 completed weeks of gestation.

67.56% mothers were Hindus, 46.51% had secondary education, 91.63% were housewives and 90.93% were involved in light physical activity during pregnancy, 66.04% had 8-10 hours of sleep per day and 53.02% were married between the age of 18-20 years. All these factors were having insignificant difference between LBW and NBW group. But a birth interval of less than 2 years (30% v/s 20%) and rural area of residence (45% v/s 29%) were significantly different between LBW and NBW group.

Table 1 shows the distribution of LBW and NBW as per the sex of newborn. Sex of the newborn was not significantly different among LBW and NBW groups as there were 47.67% females in LBW group as compared to 45.12% females in NBW group. This difference in the proportions was found to be statistically insignificant ($c^2=0.56$, df=1, $p>0.05$).

Table 2 shows that mean birth weight of all newborns was 2.49 kg with a standard deviation of 0.41 kg. Their mean length was 45.62 cms, mean HC was 33.79 cms, mean MAC was 9.91 cms, mean ChC was 31.30 cms, mean TC was 14.92 cms and mean CaC was 9.98 cms Table 2 also shows differences in various anthropometric parameters among LBW and NBW babies. The mean weight of LBW babies was 2.2 kgs with S.D. of 0.19 kg and mean weight of NBW babies was 2.79 kgs with S.D. of 0.27 kg. Other anthropometric parameters like

length (43.37 v/s 47.88 cms), head circumference (32.54 v/s 35.04 cms), mid arm circumference (9.1 v/s 10.73 cms), chest circumference (30.25 v/s 32.35 cms), thigh circumference (13.82 v/s 16.02 cms) and calf circumference (9.26 v/s 10.70 cms) were also different among LBW and NBW groups.

The difference in the birth weight between male & female babies was found to be insignificant ['z'value (male vs female) = 0.79, p>0.05]. Like-wise for all other anthropometric parameters (length, HC, MAC, ChC, TC, CaC), the difference in mean anthropometric parameter for male & female babies was found to be statistically insignificant.

Table 3 shows the correlation of various anthropometric parameters with birth weight of new born. Birth weight correlated significantly with all anthropometric measurements. Highest degree of correlation was found with length (r=0.95), followed by head circumference (r=0.94). Equal degree of correlation (r=0.93) was found with mid arm circumference & calf circumference. Least degree of correlation was found between birth weight & chest circumference (r=0.83).

Table 4 shows the sensitivity, specificity, positive & negative predictive values, false positive values and false negative values of various anthropometric parameters for predicting birth weight. The cut off value for predicting low birth weight was 45.7 cms for length, 33.8 cms for HC, 9.9 cms for MAC, 31.3 cms for ChC, 14.9 cms for TC and 10.0 cms for CaC.

The sensitivity of HC was maximum (96.74%) with 85% positive predictive value followed by CaC (95.58%) with 92.57% positive predictive value. Specificity on the other hand was maximum for CaC (92.32%) with 95.43% negative predictive value followed by for MAC (89.77%) with 93.46% negative predictive value. The false positive value was maximum for length (31.86%) while it was minimum for CaC (7.67%). On the other hand false negative value was highest for TC (20.23%) and was lowest for HC (3.25%). It is evident from table 4 that calf circumference (CaC) with 10 cm of cut off limit had the best sensitivity (95.58%) and specificity (92.32%) for predicting the low birth weight.

Table: 1- Distribution of LBW and NBW as per sex of newborn

Sex of newborn	LBW		NBW	
	No.	%	No.	%
Female	205	47.67	194	45.12
Male	225	52.33	236	54.88
Total	430	100.00	430	100.00

χ^2=0.56, df=1, p>0.05

Table 2: Anthropometric Measurements of Newborns

Anthropometric measurements		Newborns <2.5kg (N=430)		Newborns >2.5kg (N=430)		All newborns (N=860)	
		Mean	SD	Mean	SD	Mean	SD
Birth weight (kg)	Combined	2.2	0.19	2.79	0.27	2.49	0.37
	Male	2.18	0.20	2.82	0.29	2.50	0.41
	Female	2.22	0.17	2.75	0.22	2.48	0.33
	Z value (male vs female)	0.79, p>0.05					
Length (cm)	Combined	43.37	1.96	47.88	2.83	45.62	3.32
	Male	43.17	2.05	48.15	3.04	45.72	3.60
	Female	43.59	1.84	47.55	2.51	45.51	2.95
	Z value (male vs female)	0.94, p>0.05					
HC (cm)	Combined	32.54	0.85	35.04	1.20	33.79	1.63
	Male	32.49	0.87	35.11	1.25	33.83	1.70
	Female	32.59	0.83	34.94	1.14	33.73	1.54
	Z value (male vs female)	0.90, p>0.05					
MAC (cm)	Combined	9.1	0.53	10.73	0.49	9.91	0.96
	Male	9.07	0.53	10.77	0.49	9.94	0.99
	Female	9.13	0.53	10.68	0.47	9.89	0.92
	Z value (male vs female)	0.77, p>0.05					
ChC (cm)	Combined	30.25	1.01	32.35	1.10	31.30	1.49
	Male	30.23	1.03	32.41	1.16	31.34	1.55
	Female	30.27	0.98	32.3	1.03	31.25	1.42
	Z value (male vs female)	0.89, p>0.05					
TC (cm)	Combined	13.82	1.38	16.02	0.58	14.92	1.53
	Male	13.74	1.39	16.04	0.60	14.92	1.56
	Female	13.91	1.36	16.00	0.56	14.93	1.49
	Z value (male vs female)	0.10, p>0.05					
CaC (cm)	Combined	9.26	0.54	10.70	0.48	9.98	0.88
	Male	9.24	0.54	10.76	0.52	10.02	0.92
	Female	9.29	0.53	10.64	0.43	9.94	0.82
	Z value (male vs female)	1.35, p>0.05					

Table 3: Correlation between Birth Weight and Anthropometric Measurements

Anthropometric measurement	Correlation coefficient (r)
Length	0.95
HC	0.94
MAC	0.93
ChC	0.83
TC	0.85
CaC	0.93

Table 4: Validity of cut off values of various anthropometric measurements for predicting birth Weight

Anthropometric measurements	Cut off values (in cms)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	False +ve (%)	False -ve (%)
Length	45.7	84.88	68.14	72.71	81.84	31.86	15.12
HC	33.8	96.74	83.25	85.24	96.24	16.74	3.25
MAC	9.9	93.72	89.77	90.16	93.46	10.23	6.28
ChC	31.3	91.86	78.14	80.78	90.57	21.86	8.14
TC	14.9	79.77	84.42	83.66	80.66	15.58	20.23
CaC	10.0	95.58	92.32	92.57	95.43	7.67	4.42

APPENDIX:

Identification of LBW Babies by Anthropometric Measurements

Anthropometric measurement	Birth weight	
	<2.5 kgs	=2.5 kgs
Length		
<45.7 cms	365	137
=45.7 cms	65	293
Head circumference		
<33.8 cms	416	72
=33.8 cms	14	358
Mid arm circumference		
<9.9 cms	403	44
=9.9 cms	27	386
Chest circumference		
<31.3 cms	395	94
=31.3 cms	35	336
Thigh circumference		
<14.9 cms	343	67
=14.9 cms	87	363
Calf circumference		
<10 cms	411	33
=10 cms	19	397

Discussion:

Various authors had studied correlation of different anthropometric parameters with birth weight.

Among 11 such studies reviewed by us only 1 had compared all six anthropometric surrogates while 2 had compared 5 surrogates, 3 had studied 3 surrogates and 5 had studied 2 surrogates.

Among 5 studies which had compared Calf circumference, 4 had found it to be the most useful of all anthropometric surrogates for birth weight.

Correlation coefficient of birth weight	Length	HC	MAC	ChC	TC	CaC
Present study	0.95	0.94	0.93	0.83	0.85	0.93
Y.R.Kadam et al (2005)[2]	---	0.827	0.814	0.843	0.864	0.819
G.C.Samal et al (2001)[3]	0.57	0.62	0.72	0.60	0.75	0.78
V.Gupta et al (1996)[4]	---	---	-–	0.86	0.93	0.98
L.Raman et al (1992)[5]	---	---	0.689	---	0.754	0.772
J.Neela et al (1991)[6]	0.72	0.68	0.81	0.80	-–	0.83
FazlulHuque et al (1991)[7]	---	---	0.842	0.867	0.845	---
J.N.Sharma et al (1989)[8]	---	0.725	-–	---	0.920	---
S.Ramji et al (1986)[9]	---	---	0.8292	---	0.918	---
WHO Study in Delhi-A (1993)[10]	---	---	0.83	0.87	-–	---
WHO Study in Delhi-B (1993)[10]	---	---	0.77	0.94	-–	---
WHO Study in India (Chandigarh) (1993)[10]	---	---	0.95	0.95	-–	---

Conclusions and Recommendations:

The difference in mean birth weight between male (2.50±0.41kg) and female (2.48±0.33kg) was not significant statistically. Also, there was no statistically significant difference in all the anthropometric measurements of all male & female newborns. Highest degree of correlation was found between birth weight & length (r=0.95), followed by HC (r=0.94). The cut off value for identifying LBW baby was 45.7cm, 33.8cm, 9.9cm, 31.3cm, 14.9cm & 10cm for length, HC, MAC, ChC, TC &CaC respectively. CaC of 10cm was found to be the best suitable parameter for predicting LBW neonate with 95.58% sensitivity & 92.32% specificity. In conclusion, calf circumference with 10 cms of cutoff was found to be the most valid anthropometric surrogate for predicting LBW neonate while MAC was second best paremeter.

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