Original Research Article

Utility of anthropometric measurements to predict low birth weight newborns

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Abstract

Introduction: Birth weight is an important indicator of survival, future growth and overall development of the child. Timely care of a low birth weight newborn (LBW) is important but it's difficult in developing countries since many are home deliveries with inadequate facilities to weigh the newborn. Hence this study was conducted to find out the relationship between birth weight and different anthropometric measurements from which LBW babies could be identified reliably and managed accordingly. **Methods:** The study samples of 500 live newborns were selected by random sampling technique born at Mysore Medical College and Research Institute (MMCRI), Mysore between 1st December 2006 to 30th November 2007. The following anthropometric measurements were recorded within 24 hours of birth: Weight, Head circumference (HC), Chest circumference (CC), Mid arm circumference (MAC), Calf circumference (CaC), Crown heel length (CHL), Foot length (FL) and Thigh circumference (TC). Comparison between these measurements was done to find out the most suitable birth weight substitute in identification of LBW babies. **Results:** For determining LBW <2.5 kg, the critical limits for HC, CC, MAC,TC, CaC, FL, CHL were 33.82cm, 31.5cm, 9.99cm, 15.47cm, 10.25cm, 7.67cm and 48.45cm respectively. For determining a birth weight ≤2kg the critical limits for HC, CC, MAC,TC, CaC, FL, CHL were 31.93cm, 29.75cm, 9.03cm, 13.62cm, 9.5cm, 6.93cm and 44.8cm respectively. MAC of ≤9.99cm and ≤9.03cm for detection of birth weight <2.5kg and <2kg respectively have higher measures of validity. **Conclusions:** MAC is a simple, quick and reliable indicator for predicting LBW. Hence a simple tricolored tape for early detection of at risk newborn can be introduced in community for their timely management.

Keywords: Anthropometry, Low birth weight, Mid arm circumference, Newborn screening tape

Introduction

Birth weight is the single most important indicator of survival, future growth and overall development of the child. LBW is associated with high neonatal morbidity and mortality due to susceptibility to adverse environmental influences, predilection to infections and under nutrition [1]. LBW is also associated with post neonatal mortality, infant and childhood morbidity. It also accounts for about 70% of perinatal and 50% of infant deaths in India [2,3]. In developing countries like India, majority of births are still conducted at home by the traditional birth attendants (TBA) where the estimation of birth weight is not done because of lack of weighing machines.

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Practically it is not possible to provide expensive weighing scales to the community members. Therefore it is essential to find out an alternative method for the estimation of birth weight.

A number of studies have been done in finding suitable birth weight substitute anthropometric measurements [4-19].

Such anthropometric measurements must identify LBW babies reliably and be easily measurable using a simple and robust measuring instrument. Many of the birth weight substitutes that have been proposed are anthropometric measurements such as arm circumference, foot length, chest circumference, thigh circumference and calf circumference.

Aim and objectives of the study

An attempt has been made through study to find out the relationship between birth weight and different anthropometric measurements from which LBW babies could be identified reliably and managed accordingly.

Materials and Methodology

Source of data- The study sample of 500 live term newborns were selected by random sampling technique born at Cheluvamba hospital, MMCRI, a tertiary care centre, Mysore, between 1st December 2006 to 30th November 2007 after acquiring approval from the institutional ethical committee.

Inclusion criteria-Live newborns of term gestation

Exclusion criteria

- Sick newborns who are under intensive care in the first 24 hours of birth
- Preterm babies

The data was collected in a predesigned and pretested proforma after obtaining informed and written consent from the parents of the babies. Relevant antenatal histories with following anthropometric measurements were recorded in warm environment using standard technique and instruments.

A. Birth weight: The naked birth weight of the babies was measured in the spring scale to the nearest 25g.
B. Head circumference(HC) : It was measured using flexible non -stretchable measuring tape placed over the supra-orbital ridges in front and the maximum occipito-frontal circumference was recorded to the nearest 0.1cm.[20]
C. Chest circumference (CC) : It was measured to the nearest 0.1cm at the level of nipple/4th costosternal joint [6,21].
D. Mid arm circumference(MAC) : It was measured at the midpoint between the tip of acromion and the olecranon process in the left upper arm with the measuring tape to the nearest 0.1cm [1,6,22,23,24].
E. Thigh circumference (TC): In supine position the thigh circumference was measured to the nearest 0.1cm at the level of the lowest gluteal furrow of left thigh, the tape being placed perpendicular to the long axis of the left lower limb [7].
F. Calf circumference (CaC): It was measured at the most prominent point in semi-flexed position of the left leg with the measuring tape to the nearest 0.1cm [8].
G. Foot length (FL) : A 15cm long sliding gauge with divisions up to .05cm was prepared. Heel was stabilized against the fixed vertical end of the gauge and sliding end was adjusted against the tip of big toe after straightening the foot and foot length measurement was recorded to the nearest 0.1cm.[25,26].
H. Crown heel length (CHL) : CHL was recorded to the nearest 0.1cm on an infantometer with the baby being supine, knees fully extended and soles of feet held firmly against the foot board and head touching fixed board. Gestational age assessment was done by New Ballard Score as described by Ballard J.L et al.

The statistical calculations include

1. Mean with standard deviation (SD) and standard error of mean (SEM) for individual anthropometric measurements.
2. Correlation Coefficient (r) of individual anthropometric measurements with respect to birth weight and the probability value (p-value) with statistical significance.
3. Regression equations to predict birth weight based on other anthropometric measurements.
4. Validity indicators of cut-off values of individual anthropometric measurements in the prediction of birth weight of <2500g and ≤2000g.

Results

Among the total 500 newborns, 492 were singleton births and 8 twins. The birth weight and sex distribution is depicted in Table 1 below.

Table-1: Birth weight and sex distribution of newborn infants.

Birth weight (kg)	Male		Female		Total	
	Number	%	Number	%	Number	%
≤ 2 kg	83	16.6	41	8.2	124	24.8
2.01-2.49	39	7.8	49	9.8	88	17.6
> 2.5	164	32.8	124	24.8	288	57.6
Total	**286**	**57.2**	**214**	**42.8**	**500**	**100**

Table-2: Mean, standard deviation (SD) and standard error of mean (SEM) of individual anthropometric measurements (n = 500).

Sl. No.	Measurements	Mean	SEM	SD
1	Weight (kg)	2.5924	2.637	0.5897
2	Crown-heel length (cm)	46.454	0.1545	3.4537
3	Head circumference (cm)	32.79	7.59	1.6971
4	Mid arm circumference (cm)	9.4682	4.858	1.0862
5	Thigh circumference (cm)	14.466	0.1089	2.4353
6	Chest circumference (cm)	30.53	8.111	1.8137
7	Foot length (cm)	7.2700	2.253	0.5039
8	Calf circumference (cm)	9.7433	4.58	1.025

Table-3: Correlation matrix between anthropometric parameters.

Factors	Birth weight (kg)	Crown heel length (cm)	Head circumference (cm)	Mid arm circumference (cm)	Thigh circumference (cm)	Chest circumference (cm)	Foot length (cm)	Calf circumference (cm)
Birth weight (kg)		0.627 (S)	0.665 (S)	0.799 (S)	0.857 (S)	0.736 (S)	0.504 (S)	0.809 (S)
Crown-heel length (cm)			0.562 (S)	0.499 (S)	0.498 (S)	0.610 (S)	0.476 (S)	0.576 (S)
Head circumference (cm)				0.597 (S)	0.470 (S)	0.869 (S)	0.561 (S)	0.656 (S)
Mid arm circumference (cm)					0.659 (S)	0.665 (S)	0.531 (S)	0.814 (S)
Thigh circumference (cm)						0.570 (S)	0.288 (S)	0.689 (S)
Chest circumference (cm)							0.590 (S)	0.700 (S)
Foot length (cm)								0.578 (S)

S – Significant; $p < 0.001$

Comparison of correlation coefficients of individual anthropometric measurements with respect to birth weight

From the table 3, it can be observed that correlation coefficients of all the parameters are highly positive and are statistically significant ($p < 0.001$). Maximum positive correlation was observed in case of thigh circumference ($r = 0.857$). The arrangement of anthropometric measurements in the descending order of "r" value is given below.

Anthropometric measurement	'r' value
Thigh circumference	0.857
Calf circumference	0.809
Mid arm circumference	0.799
Chest circumference	0.736
Head circumference	0.665
Crown-heel length	0.627
Foot length	0.504

Table-4: Validity indicators of cut-off values of different anthropometric measurements in the detection of birth weight < 2.5 kg.

Factors		<2.5 kg	≥2.5 kg	Sensitivity	Specificity	Predictive value of positive test	Predictive value of negative test	% of false negative	% of false positive
Head circumference (cm)	≤33.82	173	148	81.6	48.6	53.89	78.21	18.39	48.61
	>33.82	39	140						
Chest circumference (cm)	≤31.50	173	161	81.6	44.09	51.79	76.5	18.39	44.09
	>31.50	39	127						
Mid arm circumference (cm)	≤9.99	202	88	95.28	69.44	69.65	95.23	4.7	69.44
	>9.99	10	200						
Thigh circumference (cm)	≤15.47	208	98	98.11	65.97	67.97	97.93	1.88	65.97
	>15.47	4	190						
Foot length (cm)	≤7.67	161	261	75.94	9.37	38.15	34.61	24.05	9.3
	>7.67	51	27						
Calf circumference (cm)	≤10.25	212	167	100	42	55.93	100	0	42
	>10.25	-	121						
Crown-heel length (cm)	≤48.45	163	159	76.88	44.79	50.62	72.47	23.11	44.79
	>48.45	49	129						

From the table 4, it can be observed that mid-arm circumference with a cut-off value of ≤ 9.99 cm has maximum sensitivity (95.28%), specificity (69.44%) and positive predictive value (69.65%).

Thigh circumference, calf circumference with cut-off values of ≤ 15.4 cm and ≤ 10.25 cm respectively also have high values of sensitivity but lower specificity and positive predictive values.

Inference- Mid-arm circumference with cut-off value of ≤ 9.99 cm has high measures of validity in the detection of birth weight of < 2.5 kg in comparison to other anthropometric measurements.

From the table 5 it can be observed that mid-arm circumference with a cut-off value of ≤ 9.03 cm has maximum sensitivity (100%) and specificity (71.22%).

Although foot length has maximum specificity (95.12%) and positive predictive value (54.34%). But the sensitivity is appreciably low (36.23%).

Thigh circumference, calf circumference also has high sensitivity of 98.55% and 100% respectively. But lower specificity and positive predictive value as compared to that of mid-arm circumference.

Inference-Mid-arm circumference with a cut-off value of ≤ 9.03 cm has high measures of validity in the detection of birth weight < 2 kg.

Table-5: Validity indicators of cut-off values of different anthropometric measurements in the detection of birth weight < 2 kg/.

Factors		<2 kg	>2 kg	Sensitivity	Specificity	Predictive value of positive test	Predictive value of negative test	% of false negative	% of false positive
Head circumference (cm)	≤31.93	25	100	36.23	76.79	20	88.26	63.76	76.79
	>31.93	44	331						
Chest circumference (cm)	≤29.75	27	108	39.13	74.94	20	88.49	60.86	74.94
	>29.75	42	323						
Mid arm circumference (cm)	≤9.03	69	124	100	71.22	35.75	100	0	71.22
	>9.03	-	307						
Thigh circumference (cm)	≤13.62	68	126	98.55	70.76	35.05	99.67	1.44	70.76
	>13.62	1	305						
Calf circumference (cm)	≤9.51	69	139	100	67.74	33.17	100	0	67.74
	>9.51	-	292						
Foot length (cm)	≤6.93	25	21	36.23	95.12	54.34	90.3	63.76	95.12
	>6.93	44	410						
Crown-heel length (cm)	≤44.80	57	106	82.6	75.4	34.96	96.43	17.39	75.4
	>44.80	12	325						

Table-6: Regression equations of birth weight in relation to individual anthropometric measurements.

1. Birth weight = -6.4285 + (0.264 x Head circumference) kg
2. Birth weight = -6.3497 + (0.2809 x Chest circumference) kg
3. Birth weight = -2.7467 + (0.5254 x Mid-arm circumference) kg
4. Birth weight = -1.6672 + (0.2693 x Thigh circumference) kg
5. Birth weight = -3.0309 + (0.5397 x Calf circumference) kg
6. Birth weight = -2.6910 + (2.5 x Foot length) kg
7. Birth weight = -4.1427 + (0.1371 x Crown heel length) kg

Table-7:Cut-off values of different anthropometric measurements corresponding to birth weight of < 2.5 kg and < 2 kg (The cut-off values are derived from the regression equations).

Sl. No.	Anthropometric measurement	Birth weight	
		< 2.5 kg	< 2 kg
1	Head circumference (cm)	≤ 33.82 cm	≤ 31.93 cm
2	Chest circumference (cm)	≤ 31.5 cm	≤ 29.75 cm
3	Mid-arm circumference (cm)	≤ 9.99 cm	≤ 9.03 cm
4	Thigh circumference (cm)	≤ 15.47 cm	≤ 13.62 cm
5	Calf circumference (cm)	≤ 10.25 cm	≤ 9.51 cm
6	Foot length (cm)	≤ 7.67 cm	≤ 6.93 cm
7	Crown-heel length (cm)	≤ 48.45 cm	≤ 44.8 cm

Discussion

The early identification of low birth weight babies is an important pre-requisite of any initiative to reduce mortality. In many developing countries including India, widespread accurate measurement of birth weight is not practicable; easily measurable substitutes for birth weight are therefore needed.

1. Male to female ratio- Male to female ratio in our study was1.33:1. It is .96:1 in a study done by Huque F et al [1], It varies from 1.04 to 1.14 :1 in other studies. [18,19,23,27]

2. Mean birth weight- Mean birth weight of present study was 2.592 kg. It is comparable to the study by Diamond I et al [10]. New Delhi (B)), Kamaladoss J [28] and Huque F et al [1]**.** Mean birth weight ranges from 2.8 to 3 kg in other studies done by Dhar B et al [15**]**, Sreeramreddy, [19] and Alves JGB et al [29].

3. Prevalence of low birth weight- A. At a cut-off value of < 2.5 kg the prevalence of LBW was 42.4% in the present study. It is comparable to studies by Huque F et al [1], Sharma JN et al [22] and Bhargava SK et al.(**6)** It is slightly high in a study done by Taksande A et al [18]. However it is very low of 12% in brazil study by **Alves** J G B et al [29] Kamaladoss [28] and Rittenbaugh [30] found it to be 24.6%.

B. At a cut-off value of < 2 kg the prevalence of low birth weight was 24.8% in the present study. It was low in other studies by Huque F et al (**1**) of 2.3%, Parmar V R et al [31**]** of 9.1%, Singh P A et al [32] of 6.3% and 18.9% in Ramji et al [7].

4. Comparison of correlation coefficients of various anthropometric measurements in relation to birth weight of the present study with other studies.

Among all anthropometric measurements higher correlations was found with thigh circumference, calf circumference and mid-arm circumference with r = 0.857, 0.809 and 0.799 respectively. Mid-arm circumference 'r' value is comparable to studies by Alves JGB et al [28), Bhargava SK et al., [6], Neela J et al [8] Ahmed FU et al [13] and Samal GC et al [14] (Table 8)

Table-8: Comparison of present study with other studies by correlation coefficients.

Sl. No.	Study	"r" value of birth weight with respect to							
		Sample (n)	Head circum-ference (cm)	Chest circum-ference (cm)	Crown-heel length (cm)	Mid-arm circum-ference (cm)	Thigh circum-ference (cm)	Calf circum-ference (cm)	Foot length (cm)
1	Sharma JN et al [22]	1000	0.7257	0.8678	0.8081	0.8912	-	-	-
2	Gohil JR et al [26]	353	-	-	-	-	-	-	0.699
3	Hossain MM et [23] (Egypt)	148	-	-	-	0.6188	-	-	-
4	Ramji S et al [7]	216	-	-	-	0.8292	0.9180	-	-
5	Huque F et al [1] (Bangaldesh)	217	-	0.867	-	0.8420	0.8450	-	-
6	Alves JGB [29] (Brazil)	1024	-	-	-	0.7900	-	-	-
7	Bhargava SK et al [6]	520	0.7264	0.8696	0.8023	0.8110	-	-	-
8	Neela J et al [8]	256	0.6800	0.8000	0.7200	0.8100	-	0.8300	-
9	Samal GC et al [14]	1580	0.6200	0.6000	0.5700	0.7200	0.7500	0.7800	-
10	Ahmed FU et al [13]	1676	-	-	-	0.7920	-	-	-
11	Das JC et al [17]	560	-	-	-	0.9560	-	0.9460	-
12	Present study (Mysore)	500	0.6650	0.7360	0.6270	0.7990	0.8570	0.8090	0.5040

5. Comparison of cut-off values of chest circumference in the detection of birth weights < 2.5 kg and < 2 kg

Table-9: Comparison of cut-off values of chest circumference in the detection of birth weights < 2.5 kg and <2 kg

	Study	Sample (n)	Birth weight < 2.5 kg			Birth weight < 2 kg		
			Cut-off value (cm)	Sensitivity	Specificity	Cut-off value (cm)	Sensitivity	Specificity
1	Bhargava SK et al [6]	520	≤ 30	82.88%	83.89%	≤ 27.5	73.68%	98.55%
2	Huque F et al [1]	217	≤30.14	89.78%	93.75%	≤28.34	100%	29.41%
3	Samal G et al [14]	1580	≤ 31.8	79.8%	69.6%	-	-	-
4	Dhar B et al [15]	316	≤ 30.5	83.3%	83.6%	-	-	-
5	Present study (Mysore)	500	≤ 31.5	81.6%	44.09%	≤29.75	39.13%	74.94%

The cut-off value of chest circumference of ≤ 31.5 cm in the detection of birth weight < 2.5 kg is comparable to study by Samal GC et al [14].

The cut-of value of chest circumference of ≤ 29.75 in the detection of birth weight < 2 kg is comparable to value obtained in the study by Huque F et al.[**1**]

6. Comparison of cut-off values of mid-arm circumference in the detection of birth weights of < 2.5 kg and < 2 kg

Table-10: Comparison of cut-off values of mid-arm circumference in the detection of birth weights of <2.5 kg and <2 kg

Sl. No.	Study	Sample (n)	Birth weight < 2.5 kg			Birth weight < 2 kg		
			Cut-off value (cm)	Sensitivity	Specificity	Cut-off value (cm)	Sensitivity	Specificity
1	Alves JGB et al [29]	1024	≤ 9.0	84.5%	94.9%	-	-	-
2	Bhargava SK et al [6]	520	≤ 8.7	77.92%	83.85%	≤ 7.57	71.05%	98.55%
3	Neela J et al [8]	256	≤ 9.3	82.84%	82.84%	-	-	-
4	Ramji S et al [7]	216	≤ 8.4	75.6%	96.4%	≤ 8.0	75.6%	96.4%
5	Huque F et al [1]	217	≤ 8.9	50%	84%	≤ 7.9	72.3%	97%
6	Hossain MM et al [23]	148	≤ 9.5	50%	84%	-	-	-
7	Sauerbor et al [24]	973	≤ 9.5	91%	83%	-	-	-
8	Samal GC et al [14]	1580	≤ 8.3	72.9%	82.2%	-	-	-
9	Present study (Mysore)	500	≤ 9.99	95.28%	69.44%	≤ 9.03	100%	71.22%

The cut-off value of MAC of ≤9.99 in the detection of birth weight<2.5 kg is comparable to study by Sauerborn et al [24]

7. Comparison of cut-off values of thigh circumference in the detection of birth weights < 2.5 kg and < 2 kg

Table-11: Comparison of cut-off values of thigh circumference in the detection of birth weights<2.5 kg and < 2 kg.

Sl. No.	Study	Sample (n)	Birth weight < 2.5 kg			Birth weight < 2 kg		
			Cut-off value (cm)	Sensitivity	Specificity	Cut-off value (cm)	Sensitivity	Specificity
1	Ramji S et al [7]	216	≤ 14.7	81.8%	92.1%	≤ 13.9	100%	93.71%
2	Huque F et al [1]	217	≤14.56	85.07%	83.13%	≤13.06	100%	27.72%
3	Samal GC et al [14]	1580	≤ 13.9	83.3%	83.9%	-	-	-
4	Present study (Mysore)	500	≤15.47	98.1%	65.9%	≤13.62	98.5%	70.7%

The cut-off value of ≤ 15.47 cm of the present study is marginally higher than the values obtained in the study by Ramji S et al [7] and Huque F et al (**1**). However the sensitivity is higher than that of the other studies.

The cut-off value of ≤ 13.62 cm in the detection of birth weight < 2 kg is comparable to study by Ramji S et al (**7**). Sensitivity is comparable to both studies done by Ramji S et al [7] and Huque F et al [1].

8. Comparison of cut-off values of calf circumference in detection of birth weights < 2.5 kg and < 2 kg.

Table 12: Comparison of cut-off values of calf circumference in the detection of birth weights < 2.5 kg and < 2 kg.

Sl. No.	Study	Sample (n)	Birth weight < 2.5 kg			Birth weight < 2 kg		
			Cut-off value (cm)	Sensitivity	Specificity	Cut-off value (cm)	Sensitivity	Specificity
1	Neela J et al.[8]	256	≤ 10	95.7%	79.7%	-	-	-
2	Samal G et al.[14]	1580	≤ 9.9	85.9%	82.9%	-	-	-
3	Present study (Mysore)	500	≤10.25	100%	42%	≤ 9.51	100%	67.74%

The cut-off value of ≤ 10.25 and its sensitivity in the detection of birth weight < 2.5 kg is comparable to study by Neela J et al [15]

Data for comparison of cut-off value of calf circumference for detection of birth weight < 2 kg is not available.

9. Comparison of cut-off values of crown-heel length in the detection of birth weights < 2.5 kg and < 2 kg.

Table 13: Comparison of cut-off values of crown-heel length in the detection of birth weights < 2.5 kg and < 2 kg.

Sl. No.	Study	Sample (n)	Birth weight < 2.5 kg			Birth weight < 2 kg		
			Cut-off value (cm)	Sensitivity	Specificity	Cut-off value (cm)	Sensitivity	Specificity
1	Neela J et al.[8]	256	≤ 47.7	72.5%	82.9%	-	-	-
2	Samal GC et al[14]	1580	≤ 44.6	75.9%	79.6%	-	-	-
3	Present study (Mysore)	500	≤48.45	76.88%	44.79%	≤ 44.8	82.6%	75.4%

The cut-off value of crown-heel length of ≤ 48.45 cm is marginally higher than the value (≤ 47.7 cm) obtained in the study by Neela J et al [8]. Sensitivity is comparable to both studies by Neela J et al (8) and Samal GC et al.(14). The cut-

off values of crown-heel length in the present study for detection of birth weight < 2 kg is ≤ 44.8 cm with a sensitivity of 82.6% and specificity of 75.4%. (Data for comparison is not available.)

10. Cut-off values of foot length in the detection of birth weights < 2.5 kg and < 2 kg

The cut-off value of foot length ≤ 7.67cm in detection of <2.5 kg has sensitivity and specificity of 75.94% and 93.7% respectively.

The cut-off value of foot length ≤ 6.93cm has sensitivity and specificity of 36.23% and 95.12 % respectively. Data for comparison is not available.

11. Cut-off values of head circumference in the detection of birth weights < 2.5 kg and < 2 kg

The cut-off value of head circumference of ≤ 33.82 cm is slightly lower than the value (≤ 33.9 cm) obtained in the study by Samal GC et al [14].

The measure of validity that is sensitivity is same in both studies but specificity is lower (48.6%) that of study done by Samal GC et al [14] (81.2%).

The cut-off value of head circumference of ≤ 31.93 in detection of birth weight < 2 kg has higher specificity of 76.79% with lower sensitivity 36.23%. Data for comparison is not available.

12. Comparison of present study with other studies by regression equations.

Table-14: Comparison of present study with other studies by regression equations.

Sl. No.	Study	Sample (n)	Regression equations to predict birth weight based on						
			HC (cm)	CC (cm)	CHL (cm)	MAC(cm)	TC(cm)	CaC (cm)	FL (cm)
1	Sharma JN et al [22]	1000	-	-	-	451.011 x MAC – 1039.9219	-	-	-
2	Hossain MM et al [23]	148	-	-	-	361.5282 x MAC – 257.0258	-	-	-
3	Huque F et al [1]	217	-	277.777 x CC – 5873.777	-	500 x MAC – 1951	333.333 x TC – 2354.333	-	-
4	Bhargava SK et al [6]	520	-	199.2987 x CC – 3440.2403	-	414.0524 x MAC – 1042.6658	-	409.4 x CaC – 1495.5	-
5	Present study (Mysore)	500	-6.4285 + 0.264 x HC	-6.3497 + 0.2809 x CC	-4.1427 + 0.1371 x CHL	-2.7467 + 0.5254 x MAC	-1.6672 + 0.2693 x TC	-3.0309 + 0.5397 x CaC	-2.6910 + 2.5 x FL

Conclusion

It was observed that all the anthropometric measurements studied had positive correlation with birth weight with statistical significance ($p < 0.001$).

Thigh circumference ($r = 0.857$) and calf circumference ($r = 0.809$) have higher correlation coefficient values and higher sensitivity than that of mid-arm circumference ($r = 0.799$), but specificity and positive predictive values are lower. Hence overall mid-arm circumference has higher measures of validity. Mid-arm circumference of ≤ 9.99 cm and ≤ 9.03 cm have higher measures of validity in the detection of birth weight < 2.5 kg and < 2 kg respectively than any other anthropometric measurement.

Measurement of mid-arm circumference can substitute for actual recording of birth weight. Mid arm circumference is a simple, quick and reliable indicator for predicting low birth weight. It can be easily measured by medical practitioners and traditional birth attendants in the community.

For this purpose a special measuring tape may be introduced for identifying infants of low birth weight. The device should be flat, flexible, non-stretchable and suitably coloured in red, yellow and green, so that these can be used and understood easily by the illiterate Traditional Birth Attendants (TBA).

1. If the MAC reading falls in the red zone the weight of the baby will be ≤ 2 kg.

2. If the MAC reading falls in the yellow zone the weight of the baby will be 2.1-2.49 kg.

3. If the MAC reading falls in the green zone the weight of the baby will be > 2.5 kg.

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