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A Study of Relationship between Birthweight and Various Anthropometric Parameters in Neonates

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Abstract:
Back Ground: *Low birth weight (LBW) is the most important determinant of infant mortality rate. In India, 80% of births occur in the rural areas, only about half of the newborns are weighed at birth and for a smaller proportion of them gestational age is known. Hence there is a constant search for newer methods to detect low birth weight babies. One such method may be the use of anthropometric surrogates to identify LBW babies.*
Aims And Objectives Of The Study: *To record various anthropometric parameters of neonates so as to find out their relationship between birth weights, in order to identify a reliable surrogate for birth weight.*
Study Design: *Hospital based cross-sectional, observational study.*
Methods: *This observational study includes a total no. of 500 consecutive live singleton infants admitted in the neonatology department of Niloufer hospital, Hyderabad between 34 to 42 weeks gestation in a period of 6 months. Anthropometric parameters such as birth weight, crown heel length, Crown rump length, mid arm circumference, head circumference, chest circumference, thigh circumference and calf circumference were recorded.*
Results: *It was observed that CFC of < 9.7 & 8.8 cms had better sensitivity, specificity and predictive value for identifying infants weighing ≤2,500 gms and ≤2,000gms respectively.*
Conclusions: *Calf circumference can be used as a surrogate parameter of birth weight for early detection and prompt referral of low birth weight babies especially at the community level where there are no facilities for weighing babies.*
Key Words: *Anthropometric parameters, Birth weight, predictive value, relation, sensitivity, specificity, neonates*

I. Introduction

Low birthweight (LBW) is the most important determinant of infant mortality rate (IMR)[1]. The current Infant Mortality Rate (IMR) of India, as per the Sample Registration System (SRS) 2013, is 40 per 1,000 live births**.** To reduce the IMR, early identification, prompt referral and management of low birthweight babies is essential. In India, 80% to90% of the roughly 20 million births in rural areas, occur at home and are conducted by illiterate and often untrained traditional birth attendants(TBAs). Provision of valid weighing scales at domiciliary level poses logistic (carryingaheavyscale), as well as, operational problems (inability ofTBAs to read). Also,because of socio cultural reasons, parents are reluctant to get their children weighed immediately after birth.

About 38% of total under-five mortality occurs during the first 28 days of life and nearly three quarters of these deaths occur during the first week of life [3]. Globally, about one-sixth of all newborns are low birthweight (LBW, <2500 grams), which is the single most important underlying risk factor for neonatal deaths [2-4]. Only about half of the newborns are weighed at birth and for a smaller proportion of them gestational age is known [5]. An estimated 18 million babies are born with LBW and half of them are born in south Asia [6]. Although these LBW babies account for 14% of the children born, they account for 60–80% of neonatal deaths [7]. Moreover, LBW babies who survive the critical neonatal period may suffer impaired physical and mental growth.

Appropriate and timely care of a newborn specially if he is born with low birth weight is important but this is difficult in developing countries since most of the deliveries are conducted at home where adequate facilities to weigh a new born does not exist. In our country where almost 70- 80% births take place at home and peripheral hospitals, taking accurate birth weight is a problem due to unavailability of weighing scale and trained personnel. Hence there is a constant search for newer methods to detect low birth weight babies so that early intervention can be instituted.

Therefore, an early identification and prompt referral of LBW newborns is vital in preventing neonatal deaths. Available evidence from resource-poor settings shows that extra essential newborn care for LBW babies can reduce the number of neonatal deaths by 20–40% [8]. Research has also shown that this extra essential newborn care may be delivered by health workers or family members if they are suitably trained [9].In resource-poor settings, a large proportion of deliveries take place at home and birth-weight is most often not recorded. Therefore, there is a need to develop simple, inexpensive and practical methods to identify low birth weightnewborns soon after birth [10]. One such method may be the use of anthropometric surrogates to identify LBW babies. Several researchers have attempted to identify suitable anthropometric surrogates which are simple and reliable to identify LBW babies. Recent hospital-based studies from India, Bangladesh and other developing countries have suggested different anthropometric surrogates to identify LBW babies and have also recommended various cut-off values for identification of LBW babies [11-20]. Available evidence suggests that there is a lack of consensus about most reliable anthropometric surrogate and a fixed cut-off point. In our country where almost 70-80% births take place at home and peripheral hospitals, taking accurate birth weight is a problem due to unavailability of weighing scale and trained personnel[21-23]. Hence there a constant search for newer methods to detect LBW babies so that early intervention can be instituted. Various authors have used different surrogate anthropometric measurements from different parts of our country[24-29].

This study was conducted to find out a surrogate who could efficiently be used for detecting low birth weight babies at birth when no weighing machine is around.

II. Research Questions

1. Which anthropometric parameter is correlating highly with birth weight?
2. Can we use this parameter as a screening test for predicting birth weight?
3. What is the role of calf circumference in predicting birth weight?
4. What are the cut-off values?

III. Materials And Methods

Study Design

Hospital based cross-sectional study**.**

Birth weight is used as a measure of LBW because of its correlation with gestation and ease of recording in hospital setting.The present study was conducted with an aim to find an alternate, cheap and reliable predictor of LBW babies that can be used by a trained or untrained person.It also aims to study the relationship between birth weight and the other anthropometric parameters so that, a parameter that correlates best with the birth weight can be identified.

Study Population

The study population consisted of 500 consecutive newborns admitted between 34 and 42 weeks of gestational age, who were born between July 1st, 2014 and December, 31st 2014 at Niloufer hospital (tertiary care hospital in South India)

Data Collection

All the anthropometric measurements were carried out by a single observer within 24 hours of birth and were taken with the newborn lying down.

Proforma

Name of the baby: sex of the baby: M/F
Post natal age (in hours): Mode of delivery:
Birth weight (in grams):
Post natal age at which birth weight was recorded:

Anthropometric Parameters

(To the nearest 0.1 cms)
1. Crown Rump length (CRL)
2. Crown Heel length (CHL)
3. Head circumference (HC)
4. Chest circumference (CHC)
5. Mid arm circumference (MAC)
6. Thigh Circumference (TC)
7. Calf circumference (CFC)

Equipments Used

Equipments used during the study were a flexible, non-stretchable measuring tape , a pediatric weighing machine, an infantometer capacity of measuring upto 0.1 cm, 50 gm 0.1 cm respectively .The methodology employed in respect of these anthropometric measurements was as per standardized recommended procedures, described by Jelliffe.

Fig 1

Equipments used in this study: beam type weighing machine, infantometer, non-strechable measuring tape.
ANTHROPOMETRIC PARAMETERS:Anthropometric measurements studied in respect to newborns were:
1. Birth weight (BW)
2. Crown Rump length (CRL)
3. Crown Heel length (CHL)
4. Head circumference (HC)
5. Chest circumference (CHC)
6. Mid arm circumference (MAC)
7. Thigh circumference (TC)
8. Calf circumference (CFC)

Birth Weight: Birth weight was recorded using a beam type weighing machine. Birth weight was recorded to the nearest of log.(50g)The scale was periodically checked using a set of standard weights. Babies were weighed naked. Low birth weight was defined as birth weight less than 2500 g.
Crown Heel Length: The baby's supine crown-heel length was recorded by placing him in an infantometer, with knees fully extended and soles of feet held firmly against the foot board.
Crown Rump Length: Crown-rump length is recorded from the crown of the head to the prominence of the buttocks. With regard to low birth weight babies, their crown rump length is usually less than 47 cms.
Head Circumference: The head circumference was measured by placing a flexible non-stretchable tape anteriorly at the glabella, posteriorly along the most prominent points.
Chest Circumference: The chest circumference was measured at the level of xiphoid cartilage.
Mid-Arm Circumference: The mid-arm circumference was measured in the left arm at the point midway between tip of the acromian process and the olecranon process of ulna.
Thigh Circumference: The thigh circumference was measured in supine position, at the level of lowest furrow in the gluteal region; the tape was placed perpendicular to the long axis of lower limb.
Calf Circumference: The calf circumference was measured at the most prominent point in semi flexed position of the leg. All measurements of length were to the nearest 0.1 cm.

Exclusion Criteria:
1. Babies with major congenital malformations.
2. Babies whose anthropometric measurements were not recorded due to unidentified reasons.
3. Pre term babies less than 32 weeks of gestation.

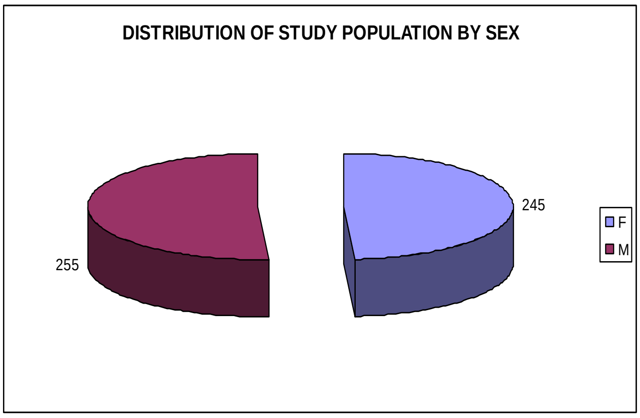
Statistical Analysis

Data was entered into Microsoft excel sheets. Descriptive data was calculated initially(mean, minimum & maximum values, standard deviation).Later on, 2 x 2 tables were made and Standard statistical methods of correlation, sensitivity, specificity, predictive value, regression calculated using the statistical package SPSS 15. Cut off values (critical limits) were calculated for each anthropometric parametric and they were compared with birth weight to find out a surrogate for birth weight. Receiver operated curves were also made to calculate area under the curve once again to find out the best surrogate marker for birth weight.

IV. Results

Total no. of newborns studied = 500
No. of babies excluded as per the exclusion criteria = 36
Babies whose birth weight was less than 2500g = 191
Therefore, the PREVALENCE OF LOW BIRTH WEIGHT IN THIS STUDY= 38.2%
Babies whose birth weight was less than 2000g = **44**
AVERAGE BIRTH WEIGHT IN THIS STUDY = 2636 g.

Graph 1: Sex Distribution Of The Study Population



The study population was distributed almost equally among both sexes(M=51%;F=49%)

Table 1: Effect Of Sex Of The Baby On Birth Weight(<2500G)

SEX	WEIGHT < 2500 GMS	WEIGHT > 2500GMS
MALE	95	160
FEMALE	96	149
TOTAL	191	309

Chi Square = 0.7998 (<3.8 hence insignificant) p value = 0.50 (insignificant). Since the chi square value is insignificant , we infer that the sex of the baby has NO OBVIOUS EFFECT on the BIRTH WEIGHT(wt< 2500g).

Table 2: Effect Of Sex Of The Baby On Birth Weight(<2000G)

SEX	WEIGHT < 2000GMS	WEIGHT > 2000GMS
MALE	16	239
FEMALE	28	217
TOTAL	44	456

Chi Square = 4.103 (significant)P value = 0.05(significant).Since the chi square value is significant, (>3.84) we infer that the sex of the baby has obvious effect on babies weighing < 2000 g only. FEMALE sex being a risk factor for low birth weight(< 2000 g).

Table 3: Descriptive Statistics Of Birth Weight And Other Anthropometric Measurements

	N	Minimum	Maximum	Mean	Std. Deviation
BIRTHWT	500	1.45	4.00	2.6369	0.49494
CRL	500	18.00	51.00	31.1130	3.85454
CHL	500	19.00	57.00	47.2820	4.17341
HC	500	25.00	38.00	32.7190	1.71972
CHC	500	22.50	36.00	30.6792	2.26094
CFC	500	7.00	12.00	9.9338	1.02892
TC	500	7.00	19.00	14.5040	2.07523
MAC	500	6.00	13.00	9.4564	1.20859
Valid N (listwise)	500				

The average BIRTH WEIGHT obtained in this study = 2.6369 kg.

Table 4: Correlation Between Birth Weight & Various Anthropometric Parameters

Anthropometric parameter	Correlation coefficient (R)	CUT OFF VALUE(Wt< 2500 g) cms	CUT OFF VALUE(Wt< 2000 g) cms
CRL	0.311823	30.8	30
CHL	0.432375	46.8	45
HC	0.64893	32.4	33
CC	0.70347	27.8	26
CFC	0.860296	9.7	8.8
TC	0.474372	14.2	13.2
MAC	0.573816	9.3	8.6

Correlation: The relationship or association between two quantitatively measured or continuous variables is called correlation. Correlation Coefficient (r/R): The extent or degree of relationship between two sets of figures is measured in terms of another parameter called correlation coefficient. The extent of correlation varies between -1 and +1 (-1=perfect negative correlation; +1= perfect positive correlation)
Inference: Calf circumference(R=0.860296) correlates the greatest with birth weight followed by Chest circumference(R=0.70347).

Table 5: Zero-Order Correlation Matrix And Pearson's Correlation Coefficients.
Cut off values were calculated using regression equation (Slop, Y intercept).

	BIRTH WEIGHT	HC	CHC	MAC	TC	CC	CRL	CHL
BIRTH WEIGHT	1.000	0.64893	0.70347	0.573816	0.474372	0.860296	0.311823	0.432375
HC	-	1.000	0.660408	0.43569	0.526693	0.526693	0.065944	0.472827
CHC	-	-	1.000	0.638488	0.577797	0.653652	0.306361	0.428979
MAC	-	-	-	1.000	0.783818	0.638488	0.319455	0.393176
TC	-	-	-	-	1.000	0.783818	0.225358	0.491165
CC	-	-	-	-	-	1.000	0.382024	0.427433
CRL	-	-	-	-	-	-	1.000	-0.15618
CHL	-	-	-	-	-	-		1.000

Table 6: Validity Indexes Of Various Anthropometric Parameters At Their Serial Cut Off Values For Babies Weighing < 2500 Gms

PARAMETER	CRITICAL LIMIT(cut off value)	SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE
CRL	30.8	64.9%	78.3%	64.9%	78.3%
CHL	46.8	62.9%	72.4%	49.7%	81.8%
HC	32.4	67%	80.3%	67%	79.2%
CHC	27.8	83.8%	67.7%	24%	98.4%
CFC	9.7	86.2%	88.3%	65.4%	82.6%
TC	14.2	67%	49.2%	53.9%	65.6%
MAC	9.3	49.2%	72%	55%	71.8%

Inference: A parameter has to be both sensitive & specific to be able to be used as a screening test. From the above table we can infer that both CFC & CHC could be used as good screening devices for identification of babies weighing <2500g(LBW babies).Sensitivity is the proportion of true positives that are correctlyidentified by the test.Specificity is the proportion of true negatives that are correctlyidentified by the test

Table 7: Validity Indexes Of Various Anthropometric Parameters At Their Serial Cut Off Values For Babies Weighing < 2000 G

Parameter	Critical Limit	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
CRL	30	37%	89.4%	85.4%	84.4%
CHL	45	35%	97.5%	77.3%	86%
HC	33	42.1%	89%	90.9%	87.9%
CHC	26	63%	94.2%	38.6%	97.8%
CFC	8.8	80%	98.4%	84%	96.4%
TC	13.2	22.2%	96.8%	75%	74.7%
MAC	8.6	38%	89.4%	95.4%	85%

From the above table we can infer that both CFC & CHC have the greatest sensitivity & specificities.Therefore they could be used as good screening parameters for identification of babies weighing < 2500g as is evidenced by the better sensitivity, specificity patterns when compared to babies weighing< 2000g.

Graph 2: Receiver Operated Curve: (COMPARING CFC, MAC, CC, HC)

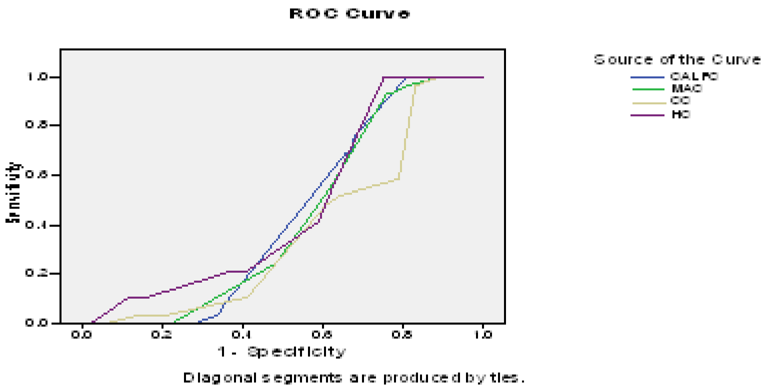


Table 8: Area Under The Curve:

Test Result Variable(s)	Area
CALFC	0.438
MAC	0.426
CC	0.374
HC	0.470

The test result variable(s): CALFC, MAC, CC, HC has at least one tie between the positive actual state group and the negative actual stategroup. Statistics may be biased.

V. Discussion

Since identification of LBW babies in rural community is of highest priority to provide effective minimal perinatal care to decrease mortality, there is a constant search for a simple and inexpensive method for screening such newborns.

Therefore this study was done at a tertiary care centre in south India (Andhra Pradesh) to find out the prevalence of low birth weight, and to find out that particular anthropometric parameter which correlates best with birth weight so that it could be used as a surrogate in the periphery (community level) to identify low birth weight babies so that they are given specialized care and referral to higher centers. There has been only one study from Andhra Pradesh in the past (1992) comparing Calf, thigh & arm circumferences in identifying low birth weight babies.

The average birth weight obtained in this study is 2636 g as compared to the national average of 2800-3000g. This may be because, of the large no. of low socio economic strata mothers who attend the antenatal outpatient dept. and delivery room. Majority of them are under nourished and anaemic. There were also a good no. of high risk pregnancies (PIH, IUGR, Bad obstetric history, twins, preterm delivery) being delivered in our hospital.

A WHO multicenter study reported that the average birth weight was 2630, 2780 and 3840 for newborns in India, Nepal and Sri Lanka respectively[29]. The proportion of LBW was high (38.2%) in our study which is similar to studies reported earlier where the proportion of LBW varied from 10% to 46%[29]. The prevalence of LBW in india is around 33%.

We have compared 7 anthropometric parameters with birth weight. There are several other studies done previously. Our study showed that CFC correlated best with birth weight followed by CHC, which is in accordance with several other studies as shown below.

Therefore The Role Of Cfc In Identification Of Low Birth Weight Babies Is Vital

Hence our hypothesis is being met. The reason for choosing CFC is that the calf being prominent and easily identifiable even by untrained TBA or CHW with minimal training. There is no need to expose the rest of the body which in a newborn can lead to hypothermia.

Our study population was distributed equally amongst both the sexes. There was no statistically significant effect of sex of the baby to the birth weight or any of the anthropometric parameters. Therefore the cut off values were generalized for both the sexes.

Many researchers have attempted to identify a suitable anthropometric surrogate to identify LBW babies which is reliable, simple, and logistically feasible in field conditions. As we can see in the above table, some studies (Bhargava et. al., WHO Collaborative Study in India) have recommended that CHC may be used as anthropometric surrogates to identify LBW babies .Some other studies have recommended MAC (B.D.

Bhatia and Tyagi et al, M.L.Kulkarni M. Rehman et al) may be used as a good surrogate . CFC is being supported by some studies (R.K. Sachar R.K. Soni et. al., V.S.Virdi et. al.)

It is argued that measurement of HC may not be accurate due to moulding of head during birth especially during prolonged and obstructed labor [30].Previous studies have suggested that CHC was a better surrogate for birth weight [36-38].

In our study CFC was identified as a suitable surrogate to identify LBW babies, as is suggested by the highest correlation coefficient (R=0.862) followed by CHC (R=0.703). This is in accordance to studies done by Ramji S, Marwahet[43], R.K. Sachar R.K. Soni et. Al[40]. V.S.Virdi et. al,Bhat IA; Dhar GM et al[15.]

Table 9: Validity Of Calf Circumference For Birth Weight Less Than 2500g (Comparability Of Studies)

	Our Study	L.Raman et al ('92)	V.Gupta et al ('96)	V.S.Virdi et al ('01)
Sensitivity (%)	86.2	94	98.4	70.7
specificity (%)	88.3	84.3	90	92.4
Positive pred value	65.4	----	----	94.2
Negative pred. value	86.2	----	----	64.4

The table given above compares the sensitivity & specificity patterns of a few studies. The sensitivity & specificity of CFC were 86.2 & 88.3 respectively; this is in comparison to other studies as shown below. Greater sample size may be required to get better sensitivity,specificity patterns. CFC is useful for identifying both LBW babies(sensitivity : 86%; specificity : 88.4%)& babies weighing less than 2000g(sensitivity : 80% ; specificity 98.4%).Therefore CFC is more specific for babies < 2000g .Health workers may be trained to identify LBW babies by measuring CFC. It has been suggested that measuring CHC is simpler because identification of nipple line is relatively easier than other measurements [38.]

The cut-off points we obtained by ROC curve analysis are relatively higher than those suggested by previous studies [34-37]. The sensitivity and predictive accuracies of CFC for identifying LBW newborns widely varied across different study samples for different cut-offs i.e. 8, 9, 10 centimeters . The decision on choice of a cut-off point may depend on the resources available to manage the LBW (high risk) newborns in the community. It is suggested that the family members or health workers who usually attend the deliveries at home may be given cut-off rules with lesser precision (0.5 centimeter) [39].

There is a need for further studies to validate our results and to define optimum cut-offs for the appropriate surrogates to identify LBW newborns.

VI. Conclusions

On evaluation of the validity of these cut off values if was observed that CFC of < 9.7 & 8.8 cms had better sensitivity, specificity and predictive value for identifying infants weighing ≤2,500 gms and ≤2,000gms respectively.

A three color coded tape similar to Shakir's tape which is used to identify the children with under nutrition may be suggested to overcome the problems of illiteracy.

We suggest that clean home delivery kits which are currently manufactured and promoted in India may contain a color coded measuring tape. We anticipate that the presence of a skilled attendant and use of CHDK (Clean Home Delivery Kit) may improve during home delivery. Therefore it is necessary to define the optimal cut-offs and validate the use of such device by lesser trained health workers or family members in home setting.

Tapes with different colored risk zones could be devised and tested for reliability so that they can be used in community by traditional birth attendants and multipurpose health workers.

VII. Recommendations

1. CALF CIRCUMFERENCE and CHEST CIRCUMFERENCE can be used as surrogate parameters of birth weight for early detection and prompt referral of low birth weight babies especially at the community level where there are no facilities for weighing babies.
2. Tapes with different colored risk zones could be devised and tested for reliability so that they can be used in community by traditional birth attendants and multipurpose health workers.
3. It is preferable that this color coded tape be included in the clean delivery kit issued for the traditional birth attendants so that LBW babies can be identified and referred to higher centers at the earliest.

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