Original article:

Correlation of birth weight with other anthropometric measurements of newborns.

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ABSTRACT

Introduction: Birth weight is an important indicator of child survival. Appropriate and timely care of a newborn specially if they are born with low birth weight is important but this is difficult in developing countries since most of deliveries are conducted at home where adequate facilities to weight a newborn does not exist. The main objective is to find out appropriate proxy indices for low birth weight, correlation between birth weight and other anthropometric measurements of newborns.

Methods: One hundred fifty newborns examined within 48 hours of their birthin the Department of Obstetrics and Gynecology/Pediatrics at Guru Gobind Singh Medical College and Hospital, Faridkot. They were weighed naked on electronic weighing scale to the nearest of 5 grams and all anthropometric measurements taken by a fiber glass measuring tape to the nearest of 0.1 cm.

Results: All parameters were significantly ($p<0.001$) correlated to each other. With regard to birth weight, the chest circumference (CC) showed the highest correlation ($r=0.948$) as compared to other anthropometric parameters.CC is best surrogate to predict low birth weight and cutoff point of CC is 29.45 cm at highest sensitivity and specificity of 89.9%. When there is chest deformity use mid-calf circumference(MCC) as an alternative to CC and cutoff point for MCC is 10.75 cm at best sensitivity and specificity.

Conclusion: Measurement of Chest circumference being simple, easy, cheap and reliable method for identification of low birth weight.

Keywords: Low birth weight, Anthropometric measurements

INTRODUCTION

Birth weight is the most sensitive and reliable indicator of the health in a community. It is universally acknowledged that size at birth is an important indicator of foetal and neonatal health in the context of both individual and population. Birth weight in particular is strongly associated with foetal, neonatal and post-neonatal mortality and with infant and child morbidity [1]. It is the most important determinant of children's chance of survival, healthy growth and development in future [2].

Of the approximately four million global neonatal deaths that occur annually, 98% occur in developing countries, where most newborns die at home while they are being cared by mothers, relatives, and traditional birth attendants (dais) [3]. About 38% of total under-five mortality occurs during the neonatal period and nearly three quarters of these deaths occurs during the first week of life [4]. Globally, about one-sixth of all newborns are low birth weight (LBW, <2500 grams), which is single most important underlying risk factor for neonatal deaths [3,5]. Only about half of the newborns are weighed at birth and further for a smaller proportion of them the gestational age is known [6]. An estimated 18 million babies are born with LBW [7]. They account for 60 - 80% of neonatal deaths.

The neonatal period is a highly vulnerable time for an infant. The high neonatal morbidity and mortality rates attest to the fragility of life during this period. In the United States, of all the deaths occurring in the first year, two thirds are in the neonatal period [8].

LBW babies who survive the critical neonatal period may suffer impaired physical and mental growth. 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% [9].

Thus, continued efforts are required to describe optimal methods for identifying these high-risk infants in the community. In India, 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 LBW newborns soon after birth [10-11]. One such method may be the use of anthropometric surrogates to identify LBW babies [12-13].So a proxy indicator, in absence of facility based delivery care in India, which can be used in a field situation is needed. The present study is planned to find out the most suitable anthropometric measure to indicate LBW.

A meta-analysis of total 69 studies in 2011 has concluded that chest and arm circumference are equally accurate, although not confirmative, in predicting LBW and a review of the literature reveals that there is no consensus on anthropometric parameter which can best be used as a surrogate to birth weight in identification of LBW babies.[14] Hence, this study was planned to identify an anthropometric measurement which can best replace recording the birth weight to identify newborns needing level I, II or III neonatal care.

MATERIAL AND METHODS

The study was conducted in the Department of Obstetrics and Gynecology/ Pediatrics at Guru Gobind Singh Medical College and Hospital, Faridkot. One hundred fifty newborns were examined within 48 hours of their birth in this hospital during May-December 2012. A random sampling technique was adopted to recruit the study subjects. The study included both term and pre-term newborns. Gestational age was calculated as total duration of pregnancy in weeks from first date of the last normal menstrual period (LMP) to the time of delivery. Gestational ages of these newborns ranged from 31 to 44 weeks.

Procedure:

- Babies were weighed naked on electronic weighing scale to the nearest 5 gm.
- Mid upper arm circumference (MUAC) was measured at the mid-point of the left upper arm between the tip of acromion process and olecranon process with a fiber glass measuring tape to the nearest 0.1 cm.
- Head circumference (HC) was measured with the help of a fiber glass measuring tape to the nearest 0.1 cm. Maximum

occipitofrontal circumference of head was recorded.

- Chest circumference (CC) was measured at the level of nipple by a fiber glass measuring tape to the nearest 0.1 cm at the end phase of expiration.
- Crown heel length (CHL) was recorded to the nearest 0.1 cm on an infantometer with the baby supine, knees fully extended and soles of feet held firmly against the foot board and head touching the fixed board.
- Mid calf circumference(MCC) was measured with the help of a fiber glass measuring tape to the nearest 0.1 cm at the level of the greatest posterior protrusion of calf in semi flexed position of leg.

OBSERVATIONS AND RESULTS

The observations in the present study reveal that out of one hundred fifty newborns, seventy three (48.7%) were of low birth weight. Females (52.7%) outnumbered males (47.3%). The birth weight of one hundred fifty newborns studied ranged from 920 to 3500g, with a mean of 2398g and a standard deviation of 560gm. The mean CHL, HC, CC, MUAC and MCC were 46.1±3.3 cm, 32.5±2.2 cm, 29.2±2.6 cm, 9.3±1.1 cm and 10.5±1.2 cm respectively. There is no significant difference in anthropometric measurements of male and female newborns.(Table 1).

Maximum numbers of newborns (38%) were in the birth weight range of 2500-2999 gm. However in newborns weighing < 2500 gm, maximum number (26% of total) was in 2000-2499 gm group. This group of newborns needs only level-I care which can be given at home/PHC level by mother under guidance of AWW, ASHA worker, ANM or LHW. Only 10 newborns (6.6% of total) fell in the category of weight < 1500 gm, (1.3% were ELBW & 5.3% were VLBW).

Table-1 Anthropometric measurements of newborns categorized by sex

Anthropometry	Mean(male)	SD	Mean(female)	SD	Mean(both sexes)	SD
BW(gm)	2375	566	2419	558	2398	560
CHL(cm)	46.2	3.4	46.13	3.3	46.1	3.3
HC(cm)	32.68	2.3	32.4	2.0	32.5	2.2
CC(cm)	29.04	2.7	29.3	2.4	29.2	2.6
MUAC(cm)	9.2	1.1	9.3	1.1	9.3	1.1
MCC(cm)	10.5	1.2	10.6	1.2	10.5	1.2

SD=Standard deviation, BW=Birth-Weight, CHL=Crown heel length,
HC=Head circumference, CC=Chest circumference, MUAC=Mid upper arm circumference,
MCC=Mid calf circumference

Table-2 Relationship between birth weight and other anthropometric measurements of newborns

Variable (cm)	Total no. of cases	Mean BW(gm)	SD	F(p value)
CHL				
<40	8	1186	247	
40-44.9	35	1798	239	
45-47.9	60	2473	201	221(.000)
48-50.9	39	2889	205	
51-52.9	8	3276	180	
HC				
<27	4	985	85	
27-29.9	14	1550	224	
30-32.9	49	2155	354	81.8(.000)
33-35.9	79	2727	311	
36-37	4	3260	189	
CC				
<26	19	1391	252	
26-29.9	59	2202	307	
30-31.9	54	2707	196	145(.000)
32-33.9	16	3167	208	
34-38	2	3176	201	
MUAC				
<7	2	920	.000	
7-8.9	54	1874	386	121(.000)
9-10.9	80	2646	254	
11-12	14	3215	169	
MCC				
<8	5	1231	285	
8-9.9	34	1706	304	
10-10.9	43	2385	218	166(.000)
11-13	68	2838	279	

SD=Standard Deviation, BW=Birth-Weight, CHL=Crown heel length, HC=Head circumference, CC=Chest circumference, MUAC=Mid upper arm circumference, MCC=Mid calf circumference

Table 2 represents the mean birth weight of newborns in relation to different categorized values of CHL, HC, CC, MUAC, MCC. The mean birth weight significantly increased with increasing values of all the anthropometric measurements.

Table-3 Matrix of zero-order correlation-coefficients between birth weight and other anthropometric measurements of newborns

Anthropometry	WT	CHL	HC	CC	MUAC	MCC
WT	1	0.945	0.901	0.948	0.926	0.946
CHL		1	0.904	0.910	0.869	0.875
HC			1	0.893	0.832	0.853
CC				1	0.890	0.911
MUAC					1	0.938
MCC						1

p=0.001 for all variables, BW=Birth-Weight, CHL=Crown heel length, HC=Head circumference, CC=Chest circumference, MUAC=Mid upper arm circumference, MCC=Mid calf circumference

Matrix of zero-order correlation-coefficients between birth weight and other anthropometric measurements of newborns at birth showed that all measurements significantly correlated with each other (Table 3). So we can predict the birth weight by using any one of these measurements. The correlation was highest with the CC (0.948) and lowest with the HC (0.901).

Fig 1 Correlation of birth weight with chest circumference

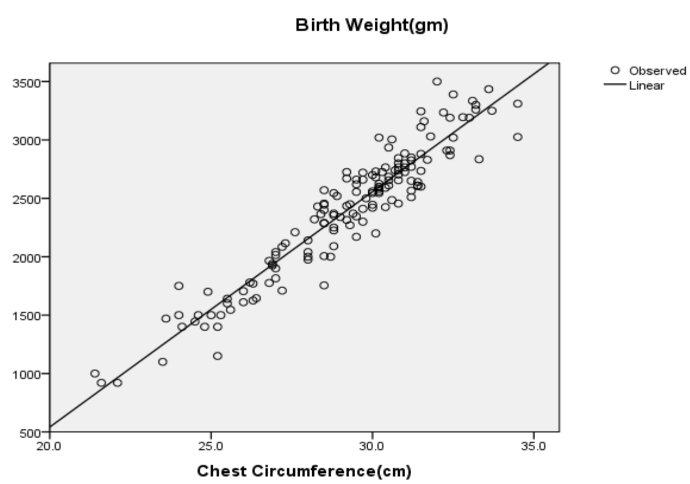

Table 4 Estimation of low birth weight by chest circumference of newborns

Chest circumference (cm)	Sensitivity (%)	Specificity (%)	Average(%) (sensitivity+specificity/2)
<29.45	86.3	93.5	89.9
<29.60	89	89.6	89.3
<29.75	91.8	87	89.4
<29.90	91.1	85.7	88.4

CI 95% = 94-98.9, P Value = .000

Area under ROC curve is .965. Highest average value is 89.9% so best cut off point for chest circumference is 29.45 cm.

Fig 2 ROC Curve for chest circumference to choose optimal surrogate for birth weight

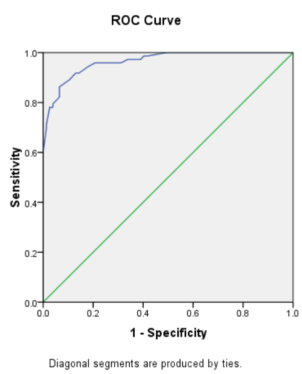

Table-5Simple regression equations for estimating birth weight

Anthropometry	Regression equation	sp value	Adjusted R^2
CHL(cm)	WT=-4836.558+156.727CHL	.000	.893
HC(cm)	WT=-5062.841+229.218HC	.000	.811
CC(cm)	WT=-3490.021+201.574CC	.000	.897
MUAC(cm)	WT=-1859.087+456.123MUAC	.000	.856
MCC(cm)	WT=-2160.357+431.588MCC	.000	.894
BW=Birth-Weight, CHL=Crown heel length, HC=Head circumference, CC=Chest circumference, MUAC=Mid upper arm circumference, MCC=Mid calf circumference			

Table 5 shows the simple regression equations for prediction of birth weight of newborns from different anthropometric measurements. By using these equations we can predict the birth weight of a newborn.

DISCUSSION

In developed countries, ultrasonic measurement techniques are used to measure foetal weight, but we live in a region where only a few expectant mothers can get the services of a maternity and child health programme which are far behind the services available in developed countries. Most of Indian population lives in rural areas. Even in cities, few people go to hospitals and clinics. Although government established primary health centers are present in the rural areas with maternal and child health components, not all of them have even a weighing machine. This fact reveals that only a small fraction of the population of India and other developing countries have a chance to get their babies weighed after birth as most of them are born at home at the hand of untrained or semi-trained birth attandent, relatives or neighbors [3].

In our study we found that the birth weight ranged from 920 to 3500 grams with a mean of 2398±560 gm. A study in Indiashowed 2678±454 gm[16]. One study in Bangladeshshowed mean birth weight of 2889±468 gm [18]. Which is higher than our study, but recently a study in Jansi (UP) showed a mean birth weight of 2348±505 gm[23]. This matches to our study.There is slight preponderance of females over males in this study comprising 52.7% females and 43.3% males. It was observed in the study that the difference in the mean birth weight between male and female newborns is not significant ($p>0.05$). This is in conformity with studies by Kadam[21].

Out of one hundred fifty newborns seventy three (48.7%) were LBW. In a study in Bangladesh incidence of LBW newborns was 41% [12]. Kumar in 2012 reported in their study 55.27% incidence ofLBW[23], hence data is near about same. But a study in 2003 from Lagos showed LBWincidence was 17.56% [20]. This showed that incidence of LBW still high in developing countries than developed countries. The means of anthropometric measurements were in close proximity with studies by Huque[13] Mehta et al [17].As anthropometric measure increased the mean birth weight increased. This is in conformity study done by Dhar et al[18].

Many studies have been done to find out a relationship between the birth weight and anthropometric parameters to predict birth weights that were normal or otherwise [12-13, 15-16]. In this study, all parameters were significantly ($p<0.001$) correlated to each other. With regard to birth weight, the CC showed the highest correlation($r=0.948$) as compared to other anthropometric parameters. This finding is in conformity with Bhargava SK [10],Haque[12],Dhar B et al [18],Naik et al[19], Sajjadian[22]. Sharma JN et aland Kaur and Bansalhad found highest correlation of birth weight with MUAC followed by CC [11, 24]. GuptaV et al had found highest correlation of birth weight with MCC [15]. Ezeaka VC et al in their study concluded that highest correlation of birth weight was with HC [20]. Kadam YR observed that thigh circumference had a relatively higher correlation value than the other anthropometric measurements [21].

In our study after CC highest correlation of birth weight was with MCC followed by CHL and MUAC and least correlation was with HC.All the anthropometric measurements are significantly correlated with each other so for estimation of birth weight there is no need to take all the parameters &only one is sufficient. So we consider only CC for detection of birth weight.

Most studies used cut-off points of 30, 30.14, 29.5, 28.5 and 31.25 cm for CC for a proxy indicator for birth-weights [18, 19, 22]. A comparative analysis using these and cut-off values of 29.45, 29.60, 29.75 and 29.90 cm for this study is shown in Table 4. Highest average value for sensitivity and specificity is 89.9% so best cut off point for CC is 29.45 cm.

Results of studies in India also showed a CC of <30 cm or 30.16cm have the best sensitivity and specificity for identifying LBW infants [10, 21]. In Egypt, two cutoff points of 29 to <30 and <29 cm were selected for CC to identify 'at-risk' and 'high-risk' infants respectively [13].

It is estimated that, in India, about 80-90% of deliveries take place either at home or in the community till today. The results of the present study showed that CC can be used for identifying LBWbabies at the community level, where weighing scales are not easily available. Since LBW is highly predictive of neonatal mortality, and CC can identify infants with LBW with a fair degree of accuracy, it would be logical to assume that this substitute measurement would be useful in predicting neonatal outcome. Furthermore, in the community, where taboos exist regarding weighing of newborns, this measurement can be used without any obstruction from the community to identify LBW newborns.

Here, we would like to raise one issue that whether we will choose all the anthropometric measurements for identifying LBW babies or choose only one single parameter. The findings of the present study revealed that, of five anthropometric measurements, CC is the best one to identify low-birth-weight infants. Multiple regression equation also showed that CC alone explained the variation of birth-weight by 90%, and the additional use of MUAC and HC did not significantly improve the prediction of birth-weight. Moreover, CC is more replicable than that of MUAC. In most cases, measurement of HC at birth could not be accurate due to moulding of head, particularly in cases of prolonged and obstructed labour. The use of chest rather than arm circumference as a surrogate for birth weight is recommended for two reasons; firstly it is simpler to measure as identification of the nipple line is easier making measurement more operationally feasible than that of mid-arm circumference. Secondly, the findings suggest that measurement of both MUAC and CC is of little additional value in predicting LBW babies. We also suggest that if there is chest deformity measure MCC as an alternative to CC so here we are giving cut off point of MCC that is 10.75 cm at best specificity and sensitivity.

Trained birth attendants and health and family planning workers residing at the community can easily be provided with a measuring tape. Since it is a simple tool to measure babies and also to detect LBW babies, grassroots-level health and family-planning workers and trained birth attendants can play a significant role in identifying LBW babies and in giving proper advice to mothers and other caretakers. Even at the Upazila Health Complexes and District Hospitals, physicians can also identify 'at-risk' babies by measuring chest circumference.

CONCLUSION

Chest circumference is best surrogate to predict LBW and cutoff point of CC is 29.45 cm at highest sensitivity and specificity of 89.9%. When there is chest deformity use MCC as an alternative to CC and cutoff point for MCC is 10.75 cm at best sensitivity and specificity.

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