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Comparison of Different Anthropometric Measurements as Predictors of Low Birth Weight

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Abstract

Introduction: *Birth weight is a sensitive and reliable predictor of health in newborn babies. Determining the birth weight is extremely important because that can help in identifying babies who need emergency or special care after birth. According to WHO, a birth weight of <2.5kg is considered low birth weight for babies. But it is not always possible to measure the weight after birth, as, in many developing countries including ours, most childbirths happen at home, by the hands of traditional birth attendants, who don't always have weighing scales with them. Also in many tertiary hospitals, babies are not regularly weighed because of the lack of weighing scales. Because of this, anthropometric measurements are used to determine the LBW babies with very few tools that can be found almost everywhere. The present study was conducted to see different types of anthropometric measurements and their use in determining birth weight.*

Aim of the study: *The aim of the study was to determine substitute methods for identifying low birth weight babies where weighing scales are not readily available.*

Methods: *This was a cross-sectional study conducted at the Dhaka Shishu Hospital during the period of July 2013 to December 2013 with a sample size of 306. Anthropometric measurements including weight, mid upper arm circumference, chest circumference, Occipitofrontal circumference, foot length and crown heel length were taken within 24 hours of life. Correlation coefficient was used to assess the association between birth weight and other anthropometric measurements. ROC and linear regression was used. A p-value <0.05 was considered statistically significant.*

Result: *This study was conducted with 306 neonates aged under 24 hours. The male-female ratio was 1.73:1.56.9% of the neonates were aged between 7-12 hours. A total of 126 were preterm, and 180 were term neonates. Total low birth weight neonates were 48.4% and mean birth weight was 2.405±0.613 kg. All anthropometric measurements were significantly correlated with weight. Simple regression equation used for prediction of birth weight from different anthropometric measurements. Highest ROC value was 0.998 for CC. Mid upper arm circumference (MUAC) had highest correlation (r=0.936) after that Chest circumference (CC) correlation(r=0.922). Cut off value for MUAC, CC, OFC, FL and CHL was 9.5 cm, 29.9 cm, 32.6 cm, 7.2 cm, and 47.0 cm respectively. The accuracy was 94.6%, 98.7%, 88.8%, 92.3%, and 94.7% respectively, for MUAC, CC, OFC, FL, and CHL.*

Conclusion: *The result of the present study showed that the mean birth weight was 2.404 kg and the incidence of low birth weight was 48.4%. All anthropometric measurements had significant correlation with birth weight. Among them mid upper arm circumference and chest circumference had best correlation. Mid-upper arm circumference and chest circumference can be used for identifying low birth babies at the community level, where weighing scales are not easily available*

Keywords: *Anthropometric, Measurements, low Birth Weight, Chest Circumference, MUAC*

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1. Introduction

Birth weight is a very sensitive and reliable indicator of health in communities. Size at birth is an important indicator of fetal and neonatal health in both individuals and overall society. Birth weight, in particular, is strongly associated with fetal, neonatal, and post-neonatal mortality and with infant and child morbidity[1]. According to the World Health Organization, a birth weight less than 2.5kg is labeled as low birth weight. LBW is a major health problem especially in developing countries where 16 percent of infants, weigh less than 2500grams at birth.[2] Low birth weight contributes to high mortality and morbidity, and about half of all perinatal mortality can be attributed to it[3]. About 95% of all low-weight births per year are from developing countries[4]. Low birth weight accounts for 60% -80% of neonatal deaths in such countries[5]. Approximately 98% of all annual global neonatal deaths occur in developing countries, where most newborns die at home while they are being cared for by mothers, relatives, and traditional birth attendants.[5] Globally, about one-sixth of all newborns are of low birth weight, recognized as the single most important underlying risk factor for neonatal deaths.[5] In Bangladesh, the prevalence of low birth weight has been recorded at 60% of the children, which was unacceptably high and more than twice the 15% threshold that indicates a public-health problem[6]. A study by UNICEF reveals that the incidence of low birth weight in Bangladesh is 30%[7]. Low birth weight affects about 2 to 3 million children in Bangladesh every year. Here the average birth weight is 2.48 to 2.53Kg. The study of the birth weight status of a newborn has become essential as low birth weight babies are very prone to various types of ailments.[4] Apart from the obstetric risk factors, prematurity, and low birth weight are associated with increased bacterial infection rates[8]. The incidence of neonatal sepsis is 1 to 10 cases per 1000 live births and 1 per 250 live premature births[9]. Premature very low birth weight (VLBW) neonates are vulnerable to develop respiratory distress syndrome (RDS), intraventricular hemorrhage (IVH), and long-term sequelae such as chronic lung diseases (CLD) and developmental disability.[10] Moreover, low birth weight babies who survive the critical neonatal period may suffer impaired physical and mental growth. Therefore, early identification and prompt referral of low-birth-weight newborns is vital in preventing neonatal death. So extra essential newborn care for low-birth-weight babies can reduce the number of neonatal mortalities[11]. In Bangladesh, most deliveries take place at home and are mostly attended by traditional birth attendants. Most of the traditional attendants are not aware of the importance of weight recording at birth, and even the trained traditional birth attendants don't always have a weighing scale in their delivery kits. Also, in most health complexes, babies are not weighed routinely due to the scarcity of suitable weighing scales at the center.[8] To overcome this problem, a number of alternative anthropometric measurements have been proposed as a surrogate for birth weight.[8,13] Anthropometric measurements of newborn assessment techniques are quite simple and easy to perform by the attending midwife with very little training[12]. Because of this, knowledge regarding alternative anthropometric measurements needs to be widespread as a surrogate of birth weight to determine the health of the neonate and proper ways of treatments. Anthropometric measurements are a series of quantitative measurements that are used to assess the overall composition of the body. There are multiple methods used as anthropometric measurements. Among them, height, weight, BMI, body circumference, and skin thickness are the commonly used ones. Anthropometric measurements are important because of their ability to diagnose obesity and nutritional status of children and pregnant women, and can also be used as a baseline for physical fitness. Limited health facility, high delivery rate, a rapid turnover rate of newborn care and limited staff of perinatal ward in developing countries has resulted in the low coverage of babies weighed at birth. Because of such reasons, the present study was conducted to determine the validity of anthropometric measurements as a substitute anthropometric method to determine LBW neonates.

2. Objective

General Objective

- To measure the anthropometric surrogate for identification of LBW babies.

Specific Objectives

- To find out an alternate practicable measure for identification of LBW babies.
- To assess the correlation of birth weight with different anthropometric measurements

3. Methods

This was a hospital-based cross-sectional study, carried out in Dhaka Shishu (Children) Hospital from July 2013 to December 2013. All term and preterm neonates who were admitted to this hospital within 24 hours of life during the study period were enrolled in the study. Any newborns with major congenital anomalies or newborns with <26 weeks of gestation or > 42 weeks of gestation were excluded from the study. Complications of the mother or multiple pregnancy cases were also excluded from the study. For each baby, detailed history of gestational age, sex, place, and mode of delivery was recorded using a questionnaire. Measurement of Weight, Crown heel length (CHL), Occipitofrontal circumference (OFC), Mid upper arm circumference (MUAC), Mid chest circumference (MCC), Foot length (FL) was recorded for all participating neonates. The equipments used during this study were flexible, non-stretchable measuring tape, and a digital weighing machine. Birth weight was obtained by the digital weight machine. Head circumference (HC) was obtained by placing the tape along the largest occipitofrontal diameter along over the occiput and eyebrow. The chest circumference (CC) was measured by placing measuring tape along with the point of the nipple. The mid-arm circumference (MUAC) was obtained from the left arm with the elbow at the midpoint between acromion and olecranon process. Foot length (FL) was measured from the tip of the big toe to the back of the heel on the right foot. HC, CC, MUAC, FL was measured by Flexible, non-extendable plastic measuring tape to the nearest of 0.1 cm. The crown-heel length (CHL) was measured to the nearest of 0.1 cm on an infantometer with the baby in supine position with full extension of knee and soles of feet held firmly against the footboard and head touching the fixed board. A total of three consecutive measurements were taken for each variable and the mean value was recorded. Informed written consent was taken from the parents during data collection. The ethical clearance was taken from the ethical review committee of the respected hospital. Written approval was taken from the concerned authority and department with due procedure. Data was entered and checking properly. Then data were analyzedby using SPSS version-17. The correlation coefficient was used to assess the association between birth weight and other anthropometric measurements. ROC curve was used to evaluate the accuracy of different anthropometric measurements to predict LBW. Sensitivity and specificity were calculated at all cut-points for any anthropometric measurement and the optimum cut-point was chosen with the highest accuracy [(sensitivity+specificity)/2] ratio. Linear regression was used for the estimation of birth weight by anthropometric measurement. A p-value <0.05 was considered statistically significant.

4. Results

This study was conducted with 306 neonates aged under 24 hours. Among the neonates, 37% were female and the remaining 63% were male. The majority of the neonates (56.9%) were aged between 7-12 hours. 15% were aged less than 7 hours and the remaining 28.1% were aged between 13 to 24 hours. A total of 126 were preterm, and 180 were term neonates. Among the Preterm neonates, 15.9% were underweight for their gestational age and 84.1% were appropriate for gestational age. Among the term neonates, 12.2% were underweight for gestational age, and 87.8% were of the appropriate weight. Total low birth weight neonates were 48.4% and mean birth weight was 2.405±0.613 kg. Highest ROC value was 0.998 for CC. OFC had a cut- off value of 32.6 cm and 88.8% accuracy. MUAC had a cut-off value of 9.5 cm and 94.6% accuracy. Cut off value for CC, FL and CHL was 29.9 cm, 7.2 cm, and 47.0 cm respectively. The accuracy was 99.3%, 96.9%, and 96.4% respectively, for CC, FL, and CHL.

Table-I: Age distribution of the studied neonates (n=306)

Age in hours	Frequency	Percentage (%)
1-6 hours	46	15
7-12 hours	174	56.9
>12 hours	86	28.1
Total	306	100

Table 1 shows the age group distribution of the neonates, where the majority (46.9%) were from the 7-12 hours of age group, 46 (15%) were from the 1-6 hours of age group, and 86 (28.1%) were >12 hours of age group. The mean age was 11.15 (±4.62), ranging from 2-22 hours.

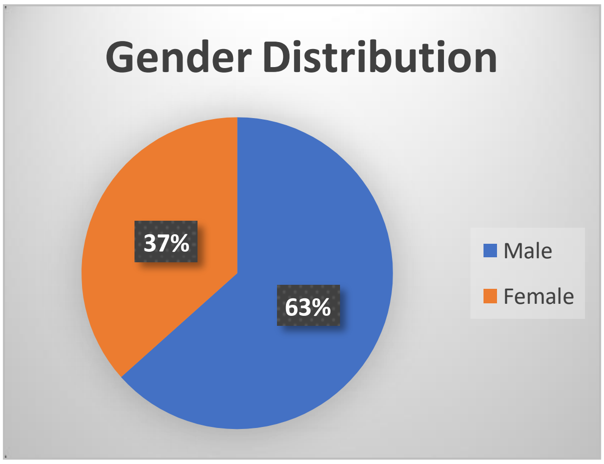

Figure I: Sex distribution of the study population

Figure I showed the Gender distribution of the participants. Majority (63.4%) were male and 112 (36.6%) were female. The Male: female ratio was 1.73:1.

Table-II: Gestational age distribution of the study population

Gestational age (Weeks)	Number	%
<29	3	1
29-33	43	14.1
34-36	80	26.1
37-40	180	58.8
Total	306	100

Table II shows the gestational age distribution of the study population. Among them, 1% had gestational age less than 29 weeks, 43 (14.1%) had a gestational age between 29-33 weeks, 80 (26.1%) were between 34-36 weeks and 180 (58.8%) neonates were between 37-40 gestational weeks. Mean gestational age was 36.6±2.7 weeks ranging from 28 weeks to 40 weeks.

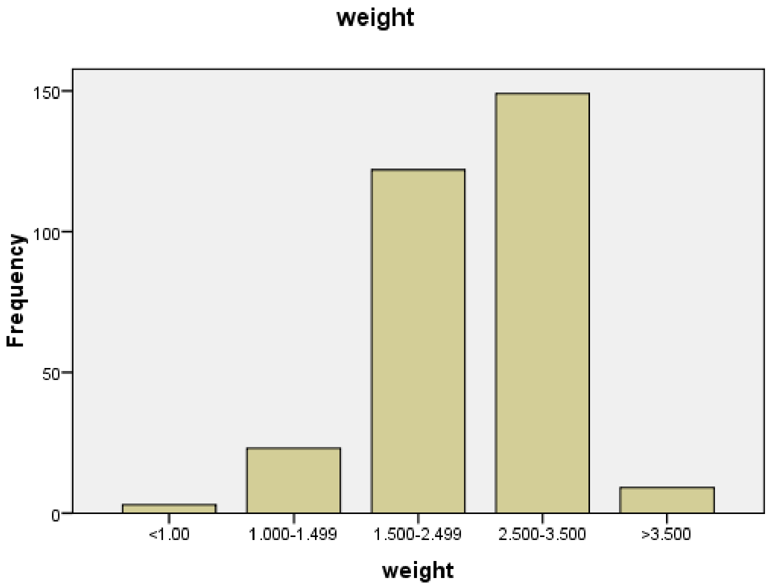

Figure II: Distribution of birth weight

Figure II shows the birth weight of the neonates. <1.000kg of weight was present in 3 (1%), 23 (7.5%) neonates weighed between 1.00-1.499 kg, 122 (39.9%) weighed between 1.500-2.499 kg, 149 (48.7%) weighed between 2.500-3.500 kg, and 9 (2.9%) had weight above 3.500 kg. Total low birth weight babies were 148 (48.4%) and mean birth weight was 2.405±0.613 kg.

Table-III: Matrix of zero-order correlation-coefficients between birth-weight and other anthropometric parameters

Anthropometry	Weight	OFC	MUAC	CC	FL	CHL
Weight	1	0.883	0.936	0.922	0.870	0.885
OFC		1	0.837	0.927	0.892	0.932
MUAC			1	0.879	0.821	0.819
CC				1	0.897	0.905
FL					1	0.932
CHL						1
P= <0.001 for all variables						

Table III shows matrix of zero-order correlation-coefficients between birth weight and other anthropometric measurements of newborns within 24 hours of life showed that all measurements significantly correlated with each other. So we can predict the birth weight by using any one of these measurements. The correlation was highest with the MUAC (0.936) then chest (0.922) and lowest with the FL (0.870).

Table-IV: Area under the curve values for ROC curves of various anthropometric measurements.

Methods	Area Under Curve	P Value	95% CI	
			Lower Bound	Upper Bound
OFC	0.965	0.00	0.948	0.984
MUAC	0.976	0.00	0.946	0.985
CC	0.998	0.00	0.991	1.000
FL	0.967	0.00	0.949	0.985
CHL	0.98	0.00	0.971	0.993

Table IV shows the area under curve value for the ROC curve of different anthropometric values. The highest area under curve value was present in cc, at 0.998. CHL had a value of 0.98, MUAC had a value of 0.976, FL had the value

Table-V: Simple regression equations for estimating birth weight

Anthropometry	Regression equation	Adjusted R^2	ANOVA F value	P value
MUAC	WT= -1.302+0.397×MUAC	0.875	2144.27	0.000
CC	WT= -3.282+0.195×CC	0.850	1735.73	0.000
FL	WT= -3.032+0.774×FL	0.756	943.557	0.000
CHL	WT= -3.888+0.137×0.137	0.782	1095.284	0.000
OFC	WT= -4.849+0.227×OFC	0.779	1075.46	0.000

MUAC= mid-upper arm circumference, CC= chest circumference, FL= foot length, CHL= Crown-heel length, OFC= occipitofrontal circumference

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

Table-VI: Cut-off value and its predictive ability with normal and low birth weight babies

Variable	Cut-off value	Sensitivity (%)	Specificity (%)	Accuracy (%)	Positive predictive value (%)	Negative predictive value (%)
OFC	32.6 cm	89.1	88.6	88.8	88.0	89.7
MUAC	9.5 cm	97.9	93.7	94.6	99.0	98.0
CC	29.9 cm	98.0	99.4	98.7	99.3	98.1
FL	7.2 cm	87.2	97.5	92.3	96.9	89.0
CHL	47.0cm	92.6	96.8	94.7	96.4	93.2

Table VI shows the statistical indices sensitivity (Birth weight <2.5 kg), specificity (birth weight ≥2.5kg), a predictive positive value (< cut-off value), and predictive negative value (≥ cut-off value) for all anthropometric parameters in newborns. OFC had a cut-off value of 32.6 cm and 88.8% accuracy. MUAC had a cut-off value of 9.5 cm and 94.6% accuracy. Cut off value for CC, FL and CHL was 29.9 cm, 7.2 cm, and 47.0 cm respectively. The accuracy was 98.7%, 92.3%, and 94.7% respectively, for CC, FL, and CHL.

5. Discussion

In many developing countries, because of social customs, many childbirths take place at the home, at the hands of untrained or semi-trained birth attendants.[8] Most traditional birth attendants don't have any weighing scale available, and even in many health complexes, babies are not weighed regularly because of a lack of a suitable weighing scale. But determining birth weight immediately after birth can be of great help when selecting appropriate methods to take care of the neonate. Because of this, some anthropometric measures have been proposed that can help determine the baby's weight without the need for any special equipment. [1,11,14,15,16,17] The goal of the present study was to determine the best surrogate parameters to identify low birth weight babies. These indicators should have a good correlation with the birth weight, be highly sensitive and accurate so that a greater portion of at-risk babies can be identified and referred for better treatment. Good specificity is also a requirement, to not send unnecessary referrals to other centers. In the present study, 48.8% of the total sample size was of Low Birth Weight (LBW). A weight of less than 2.5 kg or 2500 grams measured during the neonatal period was determined to be LBW. The Mean±SD birth weight was 2.405±0.613 kg in our study, which was similar to some other studies, where the ratio of LBW neonates was also similar to our study.[1,18] The prevalence of LBW was much lower in some other studies by Mutihir, Mohsen, Sajjadian where the Mean±SD birth weight was 3.1±0.8 kg, 3.123±0.641 kg, and 3.195±3.99 kg respectively.[5,10,12] This difference was observed because the mentioned studies were conducted in maternity hospitals, whereas our study was conducted at the tertiary hospital, where only the referred neonates were available. A good correlation between birth weight and anthropometric measurements was observed in many studies worldwide.[1,10-14,17] The present study found the highest correlation of birth weight with CC, followed by MUAC. This was somewhat different from other studies where MUAC showed a slightly higher correlation than CC.[10,12,17] In the present study, 126 neonates were preterm babies, and 180 were term babies with a gestational age of 37-40 weeks. Among the preterm babies, 84.1% had appropriate birth weight for their age, and 15.9% had less weight than estimated compared to their age. Among the term babies, 87.8% had appropriate birth weight, and 12.2% were small for their gestational age. After observing the overall weight distribution of the birth weight in the neonates, 1% were found to have weighed less than 1 kg, 7.5% were between the weight range of 1.000-1.499 kg, and 39.9% were from the weight group of 1.500-2.499 kg. For the estimation of low birth weight by observing different anthropometric measurements, cut-off values were determined based on the average sensitivity and specificity of different measurements of each type of measurement method and their correlation with the original weight. The average score was highest in MUAC measurement <9.5 criteria, so the cut-off point was determined as 9.5 cm. This was similar to the study by Gozel, where the cut-off value was determined to be ≤9.5 cm to predict low birth weight.[13] Some studies showed significantly different mean weight and cut- off values, but those can be explained by their sample size consisting only of full-term neonates[5,10] Similarly, different cut-off values were selected for OFC, FL, and CHL measurements. The present study found a good correlation between birth weight and chest circumference, which was similar to many other studies.[1,5,8,10,11] Different regression equations were used to determine the weight of neonates based on anthropometric measurements. After the equation, the comparison of both digital machine weight and weight from anthropometric measurements were made to determine the accuracy of the weight, and CC had the highest accuracy among all the measurements, and MUAC was the second highest with 94.6% accuracy. CHL had an accuracy score of 94.3%, foot length had an accuracy of 92.3%, and OFC had the lowest accuracy of 88.0%. The difference between the accuracy of CC, MUAC, and CHL was very slim, CC and MUAC are easily measurable with just a measuring tape. Because of this, Mid-upper arm circumference and chest circumference are the most suitable anthropometric methods to determine LBW babies in absence of a digital weighing machine.

Limitations of the Study

Only referral patients were taken. So, sample size was small, which may not reflect the scenarios of the whole country.

6. Conclusion

The result of the present study showed that the mean birth weight was 2.404 kg and the incidence of low birth weight was 48.4%. All anthropometric measurements had significant correlation with birth weight. Among them mid upper arm circumference and chest circumference had best correlation. Mid-upper arm circumference and chest circumference can be used for identifying low birth babies at the community level, where weighing scales are not easily available

7. Recommendation

Further studies with a large population are needed to cross-validate this result.

Conflict of interest: None Declared.

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