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Determination of Low Birth Weight using Mid Upper Arm Circumference and Chest Circumference

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Abstract **Original Research Article**

Introduction: Birth weight is a sensitive and reliable predictor of health in newborn babies. Determining the birth weight is extremely important because it 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 health care centers, 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 recognizing 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, and chest circumference were taken within 24 hours of life. The correlation coefficient was used to assess the association between birth weight and other anthropometric measurements. ROC was used. A p-value <0.05 was considered statistically significant. ***Result:*** This study was conducted with 306 neonates aged within 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. Mid-upper arm circumference (r=0.936) and Chest circumference (r=0.922) had a significant correlation with birth weight. The optimal cut-off point for mid-upper arm circumference and chest circumference was determined as 9.5 cm and 29.9cm. Mid-upper arm circumference detected 93.7% of low-birth-weight babies, and 98.0% of normal-weight babies, Chest circumference detected 99.3% of low-birth-weight babies and 98.1% of normal-weight babies. Chest circumference was a very high predictor of low birth weight followed by mid-upper arm circumference. ***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%. Mid-upper arm circumference and chest circumference correlated with birth weight and 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.

INTRODUCTION

Perinatal and neonatal morbidity is one of the increasingly important public health issues faced all around the world, but this is even more apparent in developing countries. To determine the health of a newborn, birth weight is recognized as the most sensible and reliable indicator for both individuals and the population as a whole. It is strongly associated with fetal, neonatal, and post-neonatal mortality and with infant and child morbidity [1]. According to the World Health Organization, birth weight less than 2.5 Kg is considered as LBW, which is a major health problem in many developing countries, where over 16% of infants are from the LBW category [2]. Low birth weight contributes to about half of perinatal and a third of infant death, and in general, contributes to high mortality and morbidity [3]. Among all the LBW cases occurring globally each year, 95% of them are in developing countries [4]. In developing countries, LBW accounts for about 60%-80% of all neonatal mortalities [5]. Most neonatal deaths occur at home, under the care of traditional birth attendants, relatives, or parents. This happens because of a lack of knowledge regarding the proper methods of caring for LBW children, as well as being unable to determine the birth weight properly. LBW is globally recognized as the single most important risk factor for neonatal deaths, as one-sixth of all newborns is of low birth weight [5]. Although the prevalence of low birth weight over 15% of cases indicates a public health problem, the prevalence rate is extremely high in our country, varying between 23% to 60% [6]. A study by UNICEF revealed that the incidence of low birth weight in Bangladesh was 30% [7]. Low birth weight causes many problems in newborns, including an increased risk of bacterial infection [8]. Preterm LBW baby are also vulnerable to develop respiratory distress syndromes, chronic lung disease, septicemia, and various other disabilities [9]. Although medical advancements have allowed the neonatal mortality rate to decrease greatly, even the recent UN survey of 2019 showed a neonatal mortality rate of 19.1% [10]. Another survey conducted in 2019 showed that the prevalence of LBW was 13.6% [11]. Low birth weight can also lead to long-term physical and mental growth impairments in the babies who survived the critical neonatal period. Because of such reasons, extra essential care for low birth newborn babies is necessary to decrease neonatal mortality [12]. Although rapid urbanization is decreasing the number of home delivery cases, most deliveries still take place at home and are mostly attended by relatives and traditional birth attendants. The importance of weight recording at birth is not common knowledge among these people, and even those who know of the importance don't necessarily have a weighing scale on hand. Even in many health complexes, baby weight is not recorded regularly because of the scarcity of weighing scales at the centers [8]. 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 can be performed by the midwife or other traditional birth attendants with minimal training and can be performed by birth length, birth weight, mid-upper arm circumference, chest circumference, head circumference, and foot length [13]. Because of such reasons, the present study was conducted to determine the validity of MUAC (Mid-Upper Arm circumference) and CC (Chest circumference) as a substitute anthropometric method to determine LBW neonates.

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 anthropometric variables like MUAC and CC.

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, Mid upper arm circumference (MUAC) and Mid chest circumference (MCC) were recorded for all participating neonates. The equipments used during this study were a flexible, non-stretchable measuring tape, and a digital weighing machine. Gestational age was calculated as the total duration of pregnancy in weeks from the 1st date of the last menstrual period to the birth of the baby. Birth weight was obtained by the digital weight machine (DETECTO MB 130, capacity10/20 kg d=5/10 gm). Before taking weight, zero calibration of the scale was done, the baby was placed in the middle of the scale without clothes and weight was taken after the baby lay still. The chest circumference (CC) was measured by placing measuring tape along the point of nipple. The mid-upper arm circumference (MUAC) was obtained from the right or left arm at the midpoint of the arm. The measurements were done by using a Flexible, non-extendable plastic measuring tape to the nearest of 0.1 cm. 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 analyzed by 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-off 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 of <0.05 was considered statistically significant.

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 small for gestational age and 84.1% were appropriate for gestational age. Among the term neonates, 12.2% were small for gestational age, and 87.8% were of appropriate birth weight. Total low birth weight neonates were 48.4% and mean birth weight was 2.405±0.613 kg. The highest average value of MUAC was 94.6%, so the best cut-off point for mid-upper arm circumference was determined as 9.5cm. The highest average value of CC was 98.7%, so the best cut-off point for chest circumference was determined as 29.9 cm. Mid-upper arm circumference detected 93.7% of low-birth-weight babies, and 98.0% of normal-weight babies, Chest circumference detected 99.3% of low-birth-weight babies and 98.1% of normal-weight babies. Chest circumference was a very high predictor of low birth weight followed by mid-upper arm circumference.

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.

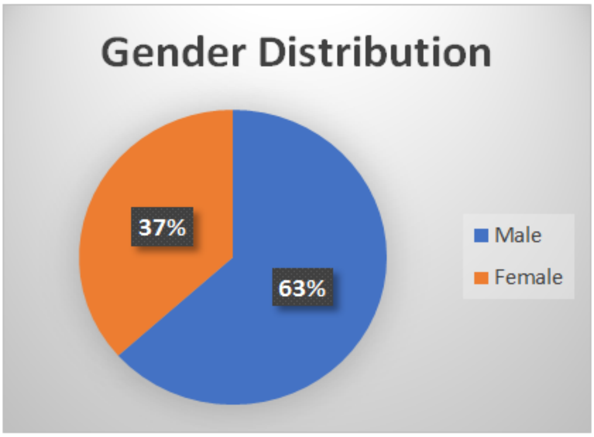

Fig-I: Sex distribution of the study population

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.

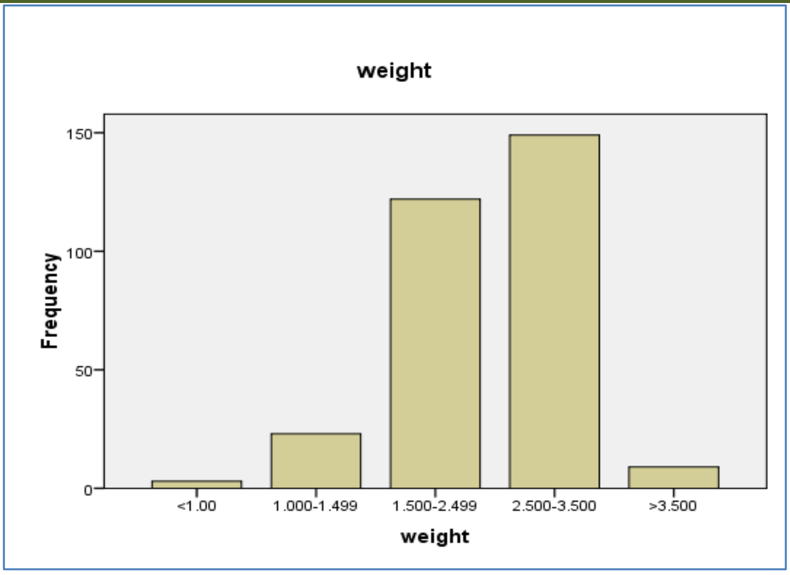

Fig-II: Distribution of birth weight

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: Correlation Matrix of Birth weight, MUAC, and CC

Correlations				
		Weight	**MUAC**	**CC**
Weight	Pearson Correlation	1	.936**	.922**
	Sig. (2-tailed)		.000	.000
	N	306	306	306
MUAC	Pearson Correlation	.936**	1	.879**
	Sig. (2-tailed)	.000		.000
	N	306	306	306
CC	Pearson Correlation	.922**	.879**	1
	Sig. (2-tailed)	.000	.000	
	N	306	306	306
**. Correlation is significant at the 0.01 level (2-tailed).				

The table shows the correlation and significance between weight, MUAC and CC. MUAC had a 0.936 correlation with birth weight and a 0.879 correlation with CC. CC had a 0.922 correlation with birth weight.

Table-IV: Estimation of low birth weight by mid-upper arm circumference

MUAC (cm)	**Sensitivity %**	**Specificity %**	**Average % (Sensitivity+Specificity)/2**
<9.4	94.6	93.0	93.8
<9.5	97.9	91.3	94.6
<9.6	97.3	89.9	93.6
<9.7	98.1	74.1	86.0

MUAC=mid-upper arm circumference

Table IV shows the highest average value of MUAC was 94.6%, so the best cut-off point for mid-upper arm circumference was determined as 9.5cm.

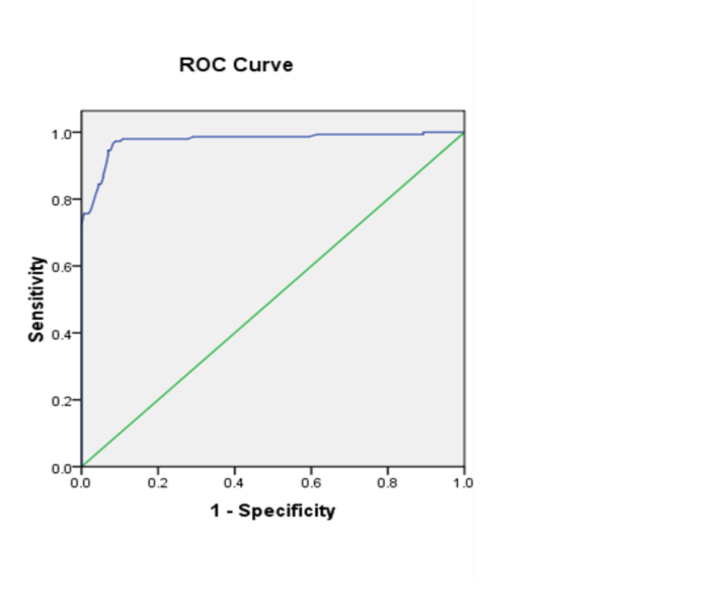

Fig-III: ROC Curve of MUAC measurements

Figure 3 describes the receiver operating characteristics (ROC) curve of MUAC measurements, based on the false positive, true positive, true negative, and false negative cases of MUAC. Area under ROC is 0.976 and P=0.000.

Table-V: Estimation of low birth weight by chest circumference of newborns

CC	Sensitivity %	Specificity %	Average % (Sensitivity+Specificity)/2
29.8	97.3	99.4	98.3
29.9	98.0	99.4	98.7
30.0	98.0	97.5	98.3
30.1	98.0	92.4	95.1

CC= chest circumference

Table V shows the highest average value of CC was 98.7%, so the best cut-off point for chest circumference was determined as 29.9 cm.

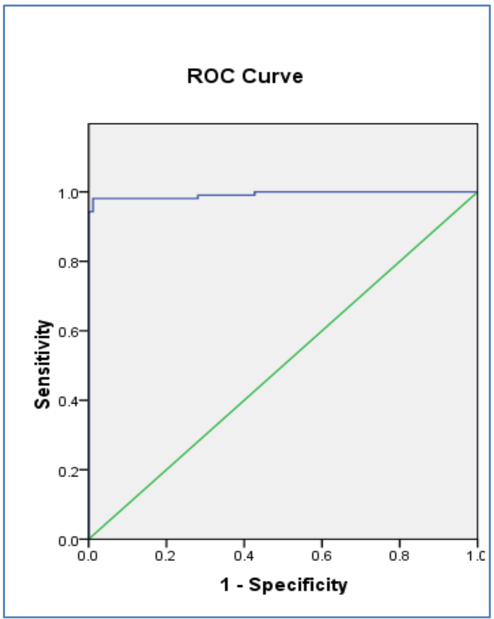

Fig-IV: ROC Curve of CC measurements

Figure 3 describes the receiver operating characteristics (ROC) curve of CC measurements based on the false positive, true positive, true negative, and false negative cases of CC. Area under ROC is 0.998 and P=0.000

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

Variable	Cut-off value	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
MUAC	9.5 cm	97.9	93.7	99.0	98.0
CC	29.9 cm	98.0	99.4	99.3	98.1

Table VI shows the statistical indices sensitivity (Birth weight <2.5 kg), specificity (birth weight ≥2.5kg), a predictive positive value (< cut-off value), predictive negative value (≥ cut-off value) for both anthropometric parameters in all newborns. Mid-upper arm circumference detected 99.0% of low-birth-weight babies, and 98.0% of normal weight babies, Chest circumference detected 99.3% of low-birth-weight babies and 98.1% of normal-weight babies. Chest circumference was a very high predictor of low birth weight followed by mid-upper arm circumference.

Table-VII: 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

MUAC= mid-upper arm circumference, CC= chest circumference.

Table VII shows the simple regression equations for the prediction of birth weight of newborns from MUAC and CC measurements. By using these equations, we can predict the birth weight of a newborn.

DISCUSSION

In many developing countries, because of social customs, much childbirth 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, 12-16]. The goal of the 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, so as 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, 17]. 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, 12, 13]. 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, 12-16, 18]. 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 [12, 14, 19]. 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% was 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 Mid-Upper Arm Circumference, a cut-off value was determined based on the average of sensitivity and specificity of different measurements of the MUAC and their correlation with the original weight. MUAC measurements of <9.4 cm had an average of 93.8, <9.5 cm had 94.6% average score, <9.6 cm had 93.6%

average score and <9.7 cm had an average score of 86.0. 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 [20]. The cut-off value was determined to be <9.6 cm in the study by Ahmed, which was almost similar to our studies [21]. 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, 12]. The present study found a good correlation between birth weight and chest circumference, which was similar to many other studies [1, 5, 8, 12, 14]. In the present study, the highest average point was 98.7% at 29.9 cm measurement, so the cut-off point was determined as 29.9 cm. This was quite similar to other studies, with a small margin of difference at ±0.1 cm [22, 23]. But a study in Indonesia had a slightly lower cut-off point of 29.4 cm [20]. Two different regression equations were used to determine the weight of neonates based on MUAC and CC. After the equation, the comparison of both digital machine weight and weight from anthropometric measurements were made to determine the sensitivity and specificity, and CC had slightly higher sensitivity compared to MUAC (±0.1), but a larger difference was found in specificity between the two, with 93.7% in MUAC measurements and 99.4% in CC measurements. Positive and negative predictive values were also higher in CC measurements, but overall, both CC and MUAC were able to identify baby weight with a very low margin of error.

Limitations of the Study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

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%. Mid-upper arm circumference and chest circumference correlated with birth weight and can be used for identifying low birth babies at the community level, where weighing scales are not easily available

Recommendation

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

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