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Comparison of Two Anthropometric Measurements in Determining Low Birth Weight: Chest Circumference and Foot Length

Fardush T[1*], Shirin M[2], Ahmed F[3]

[1]Registrar (in-charge), MBBS, FCPS (Paediatrics), Department of Adolescent Female; Dhaka Shishu (Children) Hospital, Dhaka, Bangladesh
[2]Associate Professor; MBBS, FCPS (Paediatrics), Department of Neonatology, Dhaka Shishu (Children) Hospital, Dhaka, Bangladesh
[3]Residential Medical Officer; MBBS, FCPS (Paediatrics), Department of Paediatrics Cardiology: Dhaka Shishu (Children) Hospital, Dhaka, Bangladesh

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***Corresponding author:** Dr. Tania Fardush

Abstract **Original Research Article**

Introduction: Birth weight is a sensitive and reliable predictor of health in newborn babies, especially because many neonates are not able to handle any tests to determine their health. 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 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, chest circumference, and foot length 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 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. Cut off value for Chest circumference (CC) was 29.9 cm, and for foot length (FL) it was 7.2 cm. Chest circumference (r=0.922) and foot length (r=0.870) had a significant correlation with birth weight. The optimal cut-off point for chest circumference and foot length was determined as 29.9cm and 7.2 cm. The accuracy was 98.7% for chest circumference and 92.3% for foot length. Chest circumference detected 99.3% of low birth weight babies and 98.1% of normal-weight babies and foot length detect 96.9% low birth babies and 89.0% normal birth weight babies. Chest circumference was a very high predictor of low birth weight. ***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%. Chest circumference correlated highly with birth weight compared to foot length, 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, Foot Length.

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. It is important to identify babies with low birth weight and administer proper care for them to decrease the neonatal and perinatal mortality and morbidity rates. At the beginning of 21st century, there were 7.5 million annual perinatal deaths, and 5.1 million annual neonatal deaths globally [1]. This was even higher in developing countries like Bangladesh, where there were 75 perinatal deaths per 1000 births and 38 neonatal deaths per 1000 [2]. This has been changing gradually, as the global neonatal death count has declined from 5 million in 1990 to 2.4 million in 2019, but the rate of this decline is still slow, considering the substantial medical progress worldwide [3]. This slow progress might be because of the lack of proper medical equipment in many parts of the world, as well as patients relying on traditional method of birth, rather than going to a clinic. In such places where intricate testing and care are not readily available, determining the birth weight can greatly help in recognizing neonates who are in need of extra care, and is a reliable indicator for health in community. A child's health can be mostly determined by size and weight at birth, but birth weight is specially associated with fetal, neonatal and post-neonatal mortality and morbidity rates [4]. According to WHO guidelines, a birth weight less than 2.5 kg is considered LBW, which is a major health problem in the developing countries, where 16% of infants are of low birth weight [5]. LBW accounts for approximately 60% to 80% of neonatal deaths in developing countries, and the global neonatal death toll, 98% occur in the developing countries [6]. This is primarily caused by lack of proper knowledge regarding an infant health needs, as majority of these deaths happen at home while being cared for by relatives and traditional birth attendants. Low birth weight is the single most important underlying risk factor for neonatal deaths globally, which is not a common knowledge among traditional birth attendants [6]. The prevalence of LBW is unacceptably high in Bangladesh, as annually 2 to 3 million children are affected by it [7, 8]. The survival rate of LBW babies is extremely low, and moreover, LBW babies who survive the critical neonatal period may suffer from impaired physical and mental growth. Therefore, an early identification and prompt referral of low-birth-weight newborns is vital in preventing neonatal death, as extra essential newborn care for low-birth-weight babies can reduce the number of neonatal deaths [9]. But because of lack of training and knowledge among traditional attendants, as well as scarcity of proper equipment, it is not always possible to measure the weight of a newborn. Anthropometric measurements are used as a surrogate for determining LBW babies [10]. 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 [11]. This study was undertaken to focus on two different anthropometric measurement method and to determine the most suitable one among them.

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 chest circumference measurements
- To assess the correlation of birth weight with foot length measurements

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 chest circumference (MCC), and 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. The chest circumference (CC) was measured by placing measuring tape along with the point of the nipple. Foot length (FL) was measured from the tip of the big toe to the back of the heel on the right foot. The measurements were taken by 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-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.

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 the appropriate weight. Total low birth weight neonates were 48.4% and mean birth weight was 2.405±0.613 kg. Cut off value for CC was 29.9 cm, and for FL it was 7.2 cm. The accuracy was 98.7% for chest circumference and 92.3% for foot length. Chest circumference detected 99.3% of low birth weight babies and 98.1% of normal-weight babies and foot length detect 96.9% low birth babies and 89.0% normal birth weight babies.

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.

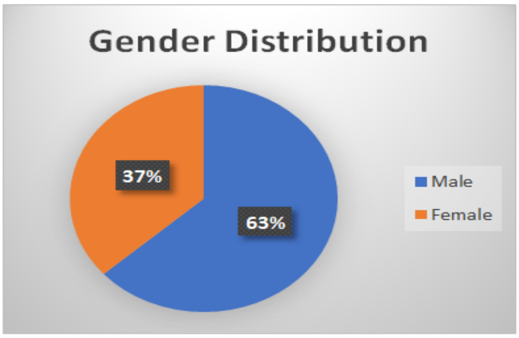

Figure I: Sex distribution of the study population

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.

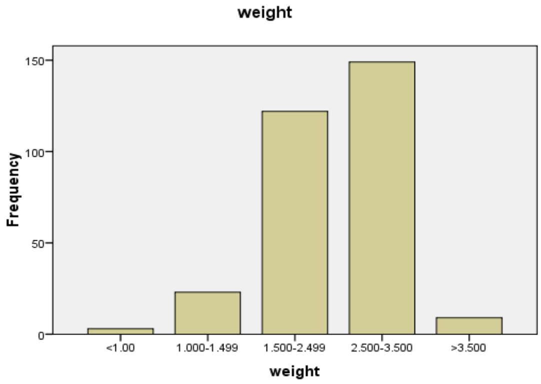

Figure II: Distribution of birth weight

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 Correlation Matrix of birth weight, CC, and FL

Correlations				
		weight	CC	FL
Weight	Pearson Correlation	1	.922**	.870**
	Sig. (2-tailed)		0	0
	N	306	306	306
CC	Pearson Correlation	.922**	1	.897**
	Sig. (2-tailed)	0		0
	N	306	306	306
FL	Pearson Correlation	.870**	.897**	1
	Sig. (2-tailed)	0	0	
	N	306	306	306
**. Correlation is significant at the 0.01 level (2-tailed).				

Weight had a correlation of 0.922 with CC and 0.870 with FL. CC had a correlation of 0.897 with FL.

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

CC (cm)	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 IV 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.

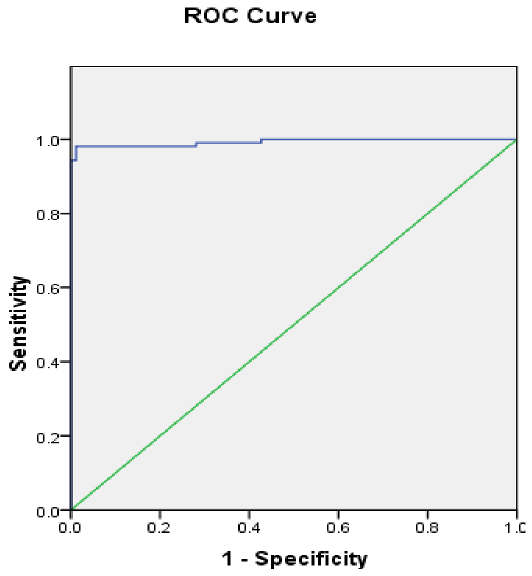

Figure-III: Receiver operating characteristic curve (ROC) of CC measurements.

Figure III 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

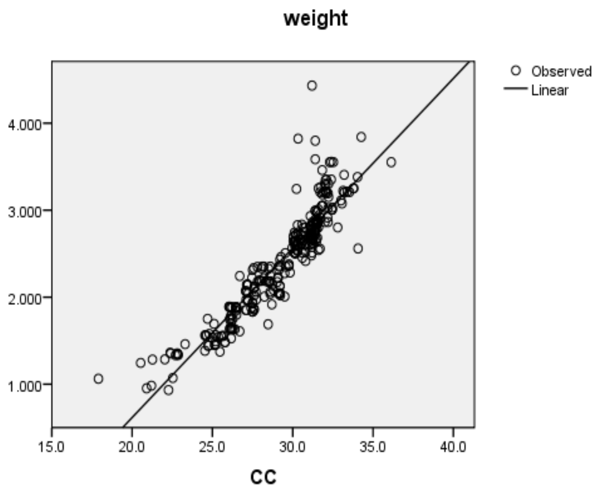

Figure-IV: Correlation of birth weight with chest circumference (CC)

Figure-IV shows birth weight is strongly correlated with chest circumference (CC). Here, adjusted R^2= 0.851 and p = 0.000.

Table-V: Estimation of low birth weight by foot length of newborns

Foot length (cm)	Sensitivity %	Specificity %	Average % (Sensitivity+Specificity)/2
7.0	77.7	98.7	88.2
7.1	81.1	98.1	89.2
7.2	87.2	97.5	92.3
7.3	92.6	88.6	90.5

Table V shows the highest average value of FL was 92.3%, so the best cut-off point for foot length was determined as 7.2 cm.

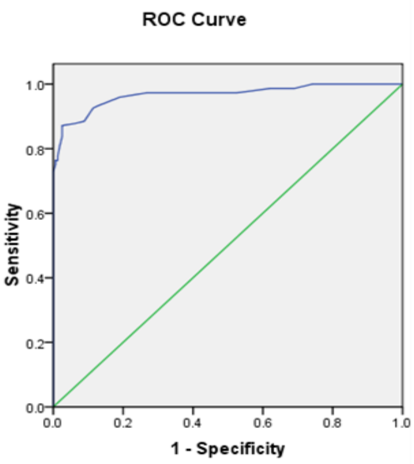

Figure-V: Receiver operating characteristic curve (ROC) of foot length measurements.

Figure V describes the receiver operating characteristics (ROC) curve of foot length measurements based on the false positive, true positive, true negative, and false negative cases of FL. Area under ROC is 0.967 and P=0.000

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

Variable	Cut-off value	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
CC	29.9 cm	99.3	98.1	98.7
FL	7.2 cm	96.9	89.0	92.35

Table VI shows the predictive positive value (< cut-off value), and predictive negative value (≥ cut-off value) and accuracy [(Sensitivity+Specificity)/2] for all anthropometric parameters in newborns. CC had a cut off value of 29.9 cm, 99.3% positive predictive value, 98.1% negative predictive value and 98.7% accuracy. FL had a cut off value of 7.2 cm, 96.9% positive predictive value, 89.0% negative predictive value, and 92.35% accuracy.

Table-VII: Simple regression equations for estimating birth weight

Anthropometry	Regression equation	Adjusted R^2	ANOVA F value	P value
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

*FL= foot length, CC= chest circumference.

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

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 [12]. 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 [4, 9, 13-16]. The goal of the study was to determine the best surrogate parameters to identify low birth weight babies. In the present study, 48.8% of the total sample size had a weight less than 2.5 kg or 2500 grams measured during the neonatal period, and 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 [4, 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 [6, 9, 18]. 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. 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. Different measurements were taken for CC and FL, and based on the accuracy of the measurements, a cutoff point was determined for detecting LBW neonates. CC had the highest accuracy of 98.7%, at 29.9 cm, so the cutoff point was determined as 29.9 cm. This was almost similar to some other studies with very little difference [19, 20]. For foot length, the highest accuracy of 92.3% was found at a foot length of 7.2 cm. the mean foot length was 7 cm. Similar cut off point for foot length was observed in some other studies [21, 22]. A lower cut off point of 6.7 cm was determined at another study where birth weight less than 2000 gm were observed [23]. After determination of cut off value and comparing the results of the regression analysis with digitally obtained weight, it was observed that CC method had the highest accuracy of 98.7%, with 99.3% positive predictive value and 98.1% negative predictive value. On the other hand, using foot length as an anthropometric measure, the positive predictive value was 96.9%, but the negative predictive value was much lower compared to CC, at 89.0%. As a result, the accuracy of using foot length as an anthropometric measure also dropped to 92.35%, which is significantly lower compared to the accuracy of CC.

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%. Chest circumference correlated highly with birth weight compared to foot length, 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.

Conflict of interest: None Declared.

Funding: Self

Ethical approval: The study was approved by the Institutional Ethics Committee.

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