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Correlation of Various Anthropometric Measurements to Identify Surrogate Markers for Low Birth Weight

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ABSTRACT

Low birth weight (LBW) is strongly associated with child growth and survival. Having a low birth weight (LBW) results in smaller size at birth, an increased risk of mortality and morbidity. Occurrence of low birth weight (LBW), is a major public health challenge due to its association with neonatal, infant and under-five mortality and morbidity. The incidence of babies born with LBW is regarded as a sensitive indicator of a country's health and development. Anthropometry has been used to assess the quality and quantity of growth and well-being in the fetus and newborn. The study conducted in the Department of Pediatrics at a tertiary care Medical College and Hospital, Chennai between JAN 2020 to JAN 2021 fulfilling the inclusion and exclusion criteria. 200 study participants were enrolled in this study. Among the study population, baby's gender such as male and female was nearly equal. The mean birth weight of the baby was 2.25±0.19 kg. The mean abdominal circumference was 28.65±3.18 cm and chest circumference was 31.18±2.24 cm. Also, the foot length of the baby was 6.67±0.53cm, head circumference was 31.38±1.80 cm observed in this study (Fig.2). Besides, the mean values of length, mid-arm circumference, mid-calf circumference, and mid-thigh circumference was 47.21±2.48 cm, 8.19±1.01 cm, 9.66±0.68 cm, and 12.56±1.16 cm respectively. The above mentioned anthropometric indicators significantly correlate with newborn birth weight. The best correlation is calf and chest circumference.

Keywords: *calf circumference, chest circumference, newborn, preterm*

1. INTRODUCTION

Low birth weight (LBW) is strongly associated with child growth and survival, which is largely due to the prior health and nutritional state of the mother as well as throughout pregnancy**[1].** Having a low birth weight (LBW) results in smaller size at birth, an increased risk of mortality and morbidity**[2,3],** and higher chances of acquiring chronic illnesses in adulthood**[4].**

The occurrence of low birth weight (LBW), is a major public health challenge due to its association with neonatal, infant and under-five mortality and morbidity**[5,6].** Worldwide, out of every seven infants, one is born with LBW.[7] More than 20 million infants (15.5% of all live births) are born with LBW every year around the world**[8].** They account for more than 95% of all newborns in developing countries**[8-10].** Developing countries tend to have LBW rates (16.5 %) twice that of developed (7%)**[8].** More than half of the LBW babies in India are full-term, and India alone accounts for over 40% of the global total newborns that are at or below the reference weight cut-off**[11,12].**

The incidence of babies born with LBW is regarded as a sensitive indicator of a country's health and development. The prevalence of LBW in India is 16.4% according to NFHS-4**[13].** In the first few weeks of life, LBW babies have a 20-fold higher risk of death. LBW is responsible for 40–60% of newborn mortality worldwide**[14].** It restricts their development and growth as children and adults. It is also linked to an increased risk of developing behavioral disorders, psychological disorders, learning and sensory disabilities in developing children and adolescents, all of which impair cognitive function and pose significant challenges in terms of education and quality of life**[15,16]**. Cardiovascular disease, childhood hypertension, metabolic syndrome, and diabetes in adulthood are all linked to LBW**[17,18].** Low birth weight is also linked to an increased risk of abnormal neurological signs such as tone, coordination, and reflexes, which can lead to motor development problems**[19].**

Appropriate and timely care of a newborn is critical, even more so if it is a low birth weight baby, but this is difficult in developing countries, where the majority of deliveries occur at home, where adequate facilities for weighing a newborn do not exist. In our country, where nearly 70% to 80% of births occur at home or in outlying hospitals, obtaining an accurate birth weight is difficult due to a lack of proper equipment and trained personnel. As a result, researchers are constantly on the lookout for more advanced and feasible methods of detecting low birth weight infants in order to initiate early intervention. Additional essential newborn care for LBW babies has been shown to reduce neonatal deaths by 20–40% in resource-limited settings**[20].** In resource-limited settings, where majority of births occur at home, and birth weight is frequently not recorded. As a result, simple, affordable, and practicable methods for identifying low birth weight newborns shortly after birth are required**[21].** One such method may be to identify LBW infants through the use of anthropometric surrogates.

Anthropometry has been used to assess the quality and quantity of growth and well-being in the fetus and newborn**[22].** Additionally, it has been used to forecast gestational age and fetal maturity. Numerous anthropometric parameters have been found to correlate with birth weight to varying degrees. Several of these measurements, such as crown to rump length, biparietal diameter and femoral length, have been useful in obstetric ultrasound which correlates well with birth weight, gestational age, and fetal maturity**[23,24].** Certain tests were also found to accurately predict the birth weight of the baby with varying degrees of sensitivity and specificity at various cutoff points for low and very low birth weight.

There appears to be a lack of consensus regarding the most reliable anthropometric surrogate and a fixed cut-off point. As a result, there is a constant search for newer methods of detecting LBW babies in order to initiate early intervention.

2. MATERIALS AND METHODS

Method:

The study included 200 babies born in the Department of Pediatrics at Sree Balaji Medical College and Hospital, Chennai between JAN 2020 to JAN 2021 fulfilling the inclusion and exclusion criteria. The instruments used in this study are a non stretchable measuring tape and a transparent plastic ruler. After obtaining informed consent from the parents, the anthropometric parameters of the neonate will be measured on day 1 of life. Correlation of various anthropometric measures will be done to identify which is more reliable in identifying low birth weight babies.

Inclusion Criteria:

All live born neonates with birth weight less than 2500g during the study period.

Exclusion Criteria:

1. Neonates with features of intrauterine infection, chromosomal abnormalities or those with congenital malformations.

2. Neonates with prenatal or postnatal structural deformities of chest or limbs or any neuromuscular condition.

Birth Weight Measurement:

Digital weighing scale which has sensitivity of measurement up to 100 grams (00.0 kg) were used in our study. Baby without any clothes was weighed on a weighing scale and measurement was noted on to the nearest of 0.1 kg. Standardization is a very essential aspect of anthropometry which allows identifying any error or deviation in the weighing scale. Accuracy of the machine was checked using standard 5 Kg weight before proceeding to the study.

Length Measurement:

Child was made to lie on supine position for measuring the length and head should touch the base of length board which was placed on a flat surface. Help from another health care assistance was taken for measurement.

Following things must be checked before starting to take measurements.

- Baby is placed in supine position on the board.

- Now hold the knees of the baby with measurer’s index finger and thumb. It should be gently pressed so that back of the knees touches the board. If the measurer is right handed, then knee should be held with left hand and measuring board with right hand and vice versa.

- After checking the checklist, foot was gently pressed against the heel of the child. Nearest of 0.1 cm and noted down and taken as a measurement.

Head Circumference:

It is measured by locating the most prominent part at the back of the skull i.e, the occipital protuberance and placing the tape over it at the back and just over the supraorbital ridge and glabella in the front. It was measured to the nearest 0.1cm.The head circumference was measured after 24 hours in case of caput.

Chest Circumference:

The baby was placed in supine position at the level of nipples at the end of expiration chest circumference was measured. It was measured to the nearest 0.1cm using the non stretchable tape.

Calf Circumference:

Calf Circumference is measured at semi flexed position of the leg at the most prominent point in to the nearest 0.1cm. Help of another health care provider was taken for this.

Foot Length:

Foot Length was measured from tip of the big toe to the heel using a hard transparent plastic ruler which was pressed vertically against the babies' sole and the reading was recorded to the nearest 0.1 cm.

3. RESULTS

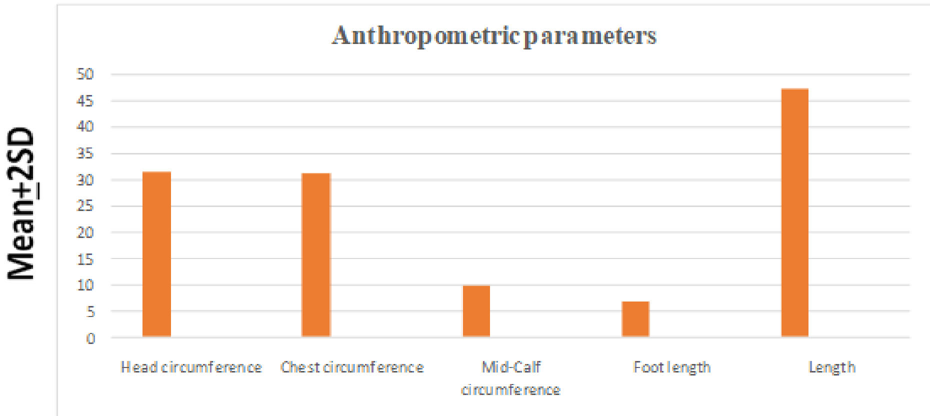
3.1 Baseline Anthropometric Measurement of the Study Population

200 study participants were enrolled in this study. Among the study population, baby's gender such as male(51%) and female(49%) was nearly equal. The mean birth weight of the baby was 2.25±0.19 kg. The baseline characteristics of the baby were determined and displayed in **Table 1**. The mean abdominal circumference was 28.65±3.18 cm and chest circumference was 31.18±2.24 cm. Also, the foot length of the baby was 6.67±0.53cm, head circumference was 31.38±1.80 cm observed in this study **(Figure.1).** Besides, the mean values of length, mid-arm circumference, mid-calf circumference, and mid-thigh circumference was 47.21±2.48 cm, 8.19±1.01 cm, 9.66±0.68 cm, and 12.56±1.16 cm respectively.

Table 1: Baseline anthropometric measurement of the study population

Parameters	**Mean ± SD**
Birth weight in kg	2.25±0.19
Baby's gender (M: F)	103:97
Chest Circumference in cm	31.18±2.24
Foot Length in cm	6.67±0.53
Head Circumference in cm	31.38±1.80
Length in cm	47.21±2.48
Mid-Calf Circumference in cm	9.66±0.68

Figure 1: Anthropometric Parameters



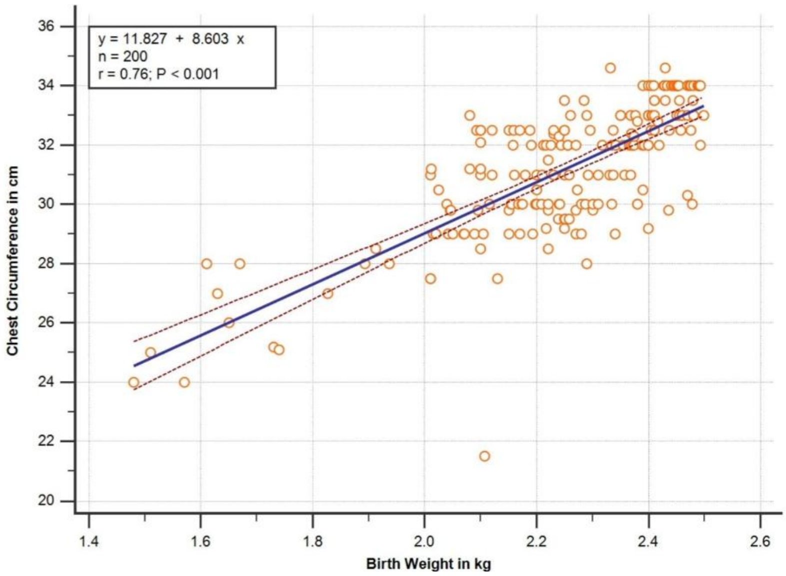
1.2 Correlation of Birth Weight with Study Parameters

The birth weight was correlated with the study parameters overall and with the gender. The chest circumference (r=0.76; P<0.0001) shown a statistically significant positive correlation with the birth weight of the baby **(Table 2 & Figure2).**

Table 2: Correlation of Birth Weight with Chest Circumference

	(N=200)	
	R	***P***
CC	**0.76**	**<0.001**

Figure 2: Regression analysis of birth weight with chest circumference

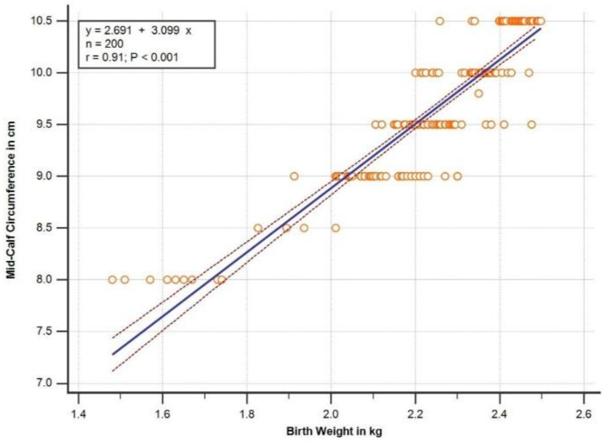


The mid calf circumference (r=0.91; P<0.0001) showed a statistically significant positive correlation with the birth weight of the baby **(Table 3 & Figure.3).**

Table 3: Correlation of Birth Weight with Mid-Calf Circumference

	(N=200)	
	R	***P***
MCC	**0.91**	**<0.001**

Figure 3: Regression Analysis of birth weight with mid calf circumference

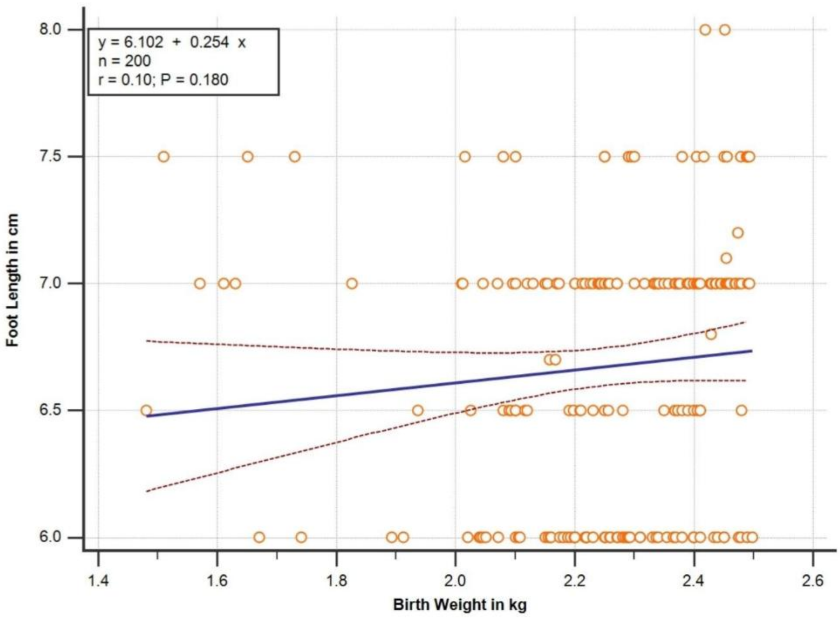


The foot length did not show any statistically significant correlation (r=0.10 P=0.180) with the birth weight of the baby **(Table 4 & Figure.4).**

Table 4: Correlation of Birth Weight with Foot Length

	(N=200)	
	R	***P***
FL	0.10	0.180

Figure 4: Regression Analysis of birth weight with foot length

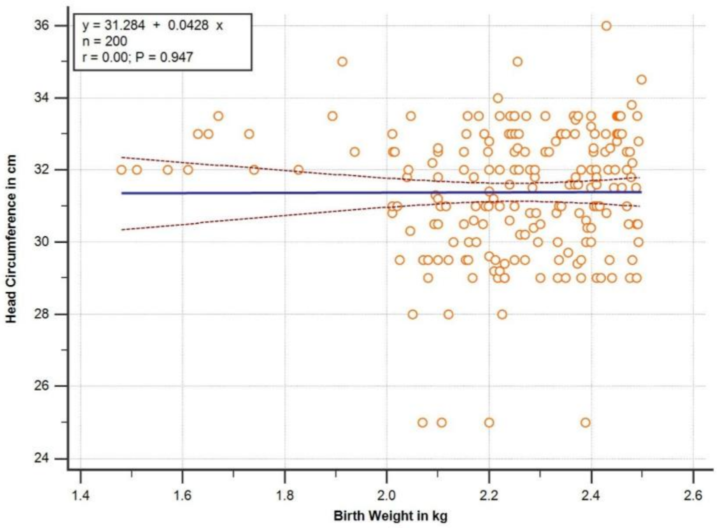


The head circumference did not show any statistically significant correlation (r=0.001 P=0.947) with the birth weight of the baby **(Table 5 & Figure 5).**

Table 5: Correlation of Birth Weight with Head Circumference

	(N=200)	
	R	***P***
HC	0.001	0.947

Figure 5: Regression Analysis of birth weight with head circumference

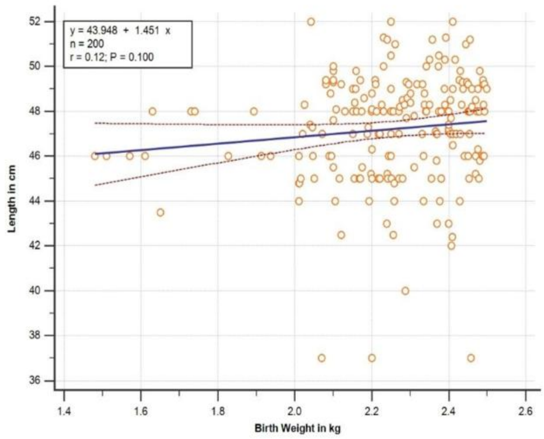


The length did not show any statistically significant correlation (r=0.12 P=0.100) with the birth weight of the baby **(Table 6 & Figure 6).**

Table 6: Correlation of Birth Weight with Length

	(N=200)	
	R	***P***
L	0.12	0.100

Figure 6: Regression Analysis of birth weight with length



The diagnostic accuracy of chest and calf circumference was displayed in **(Table 7).** The diagnostic accuracy of the chest **(Figure 7)** and mid-calf circumference **(Figure 8)** were analyzed using ROC analysis. The analysis showed that the mid-calf circumference has high sensitivity and specificity than the chest circumference.

Table 7: Diagnostic Accuracy of the Chest and Calf Circumference

	AUC	Sensitivity (%)	Specificity (%)	95 % CI	*P* Value
Chest circumference	0.870	99	75	0.815 to 0.913	0.003
Calf circumference	0.994	98.9	100	0.969 to 1.000	

Figure 7: ROC Analysis for chest circumference

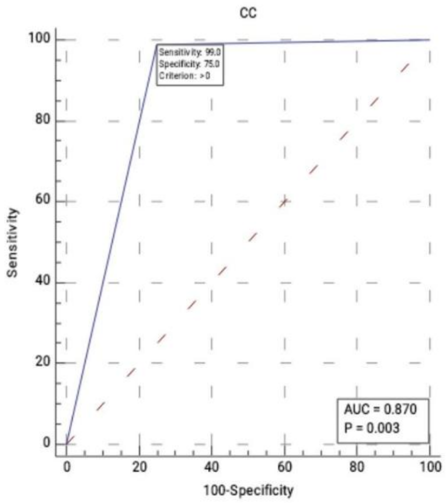
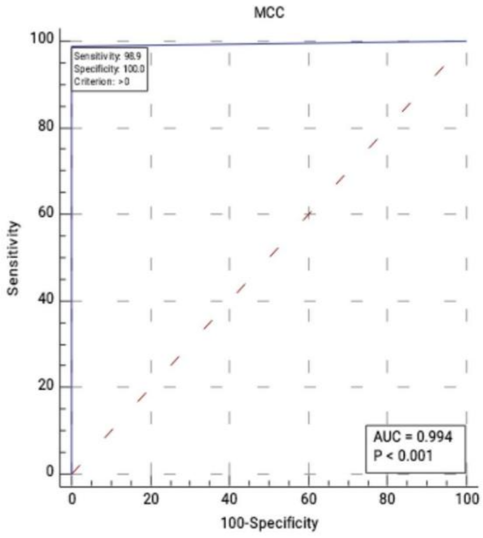


Figure 8: ROC Analysis for mid-calf mid circumference



4. DISCUSSION

The most important factor is birth weight that impacts neonatal mortality, as well as infant and childhood morbidity, in both developing and developed countries. A simple and effective alternative for measuring BW is constantly being sought after. The use of BW substitute markers with single anthropometric measure was investigated to overcome this.

Many researchers tried to identify an adequate anthropometric substitute for identifying LBW infants which, in field conditions, would be reliable, simple, and logistically feasible. A recent study has recommended that CHC and foot length be used to identify LBW babies as an anthropometric substitute.Some other studies recommended that CC could be adequately used to identify LBW babies as anthropometric substitutes. For this study we have therefore considered every anthropometric measure. The same results were seen in this study but CC was found to be a good marker. Certain studies indicated that MUAC was the appropriate anthropometric birth weight substitute.

Measuring CHC is suggested as it is relatively easier to identify the nipple line than other measurements. Consequently, CHC may be more functional. This is because waddling clothing must be removed to measure CHC. Similar studies have been reported in previous years where the LBW percentage ranged from 14% to 22.5%**[25].** There is no data in population-based information on LBW proportion in India.

In a recent study it is reported that CHCs of 29 centimeters and 30 centimeters can identify newborns at 'high-risk'**[26].** The maximum specificity and sensitivity for CHC was observed at 31.18 centimeters in our study. Higher mean birth weight of babies born resulted in higher cut- off points in this study. We have taken full-term born babies, which was different from previous studies. Even though some trials have shown that CC, MUAC and TC are superior to other measures in LBW newborns, the chest circumference was found to be a useful surrogate marker of LBW newborns.

Our study found a 9.66 cm calf circumference correlated with a 2.5 kg birth weight. It was found that of 9.6cm calf circumference correlates with babies whose birth weight is less than 2.5kg (r=0.882) and also found to be more specific than thigh circumference and mid-arm circumference. In our study, calf circumference correlated well with birth weight, compared to length and other circumferences of chest, head, thigh and mid-arm. Compared to other studies, ours had the best calf circumference correlation. Our findings echoed prior research. Compared to all other indicators, calf circumference is found to have best correlation for identifying babies born with less than 2.5kg.

The present study results are in agreement to a recent study by Kokku PK et al**[27].,** the best correlation with birth weight was found in calf circumference (r =0.818) and (r=0.986) for identifying babies whose birth weights are less than 2 kg and 2.5 kg, respectively.

Suneetha et al., discovered a Pearson's correlation coefficient of 0.70 (P0.001) between calf circumference and birth weight. This research was in accordance with the findings of the current study. The cutoff point for the Sheikh et al**[28].,** study was 9.75 cm calf circumference, with 42.86 % specificity and 89.97 % sensitivity. The cutoff is 9.66 cm in this study, which was correlated with previous study, but the specificity (100%) and sensitivity (98.9%) were higher compare to the previous study. Another study revealed that Chest Circumference was the most useful single anthropometric measure to predict Low Birth Weight. Its specificity of 67.5% and sensitivity of 100% indicates its ability to rule out LBW in a baby, if CC is >10.5 cm**[29].**

According to Srivastava and Chandrakar**[29].,** calf circumference is a better surrogate anthropometric parameter for screening LBW babies, which is consistent with the findings of the current study. According to Mani et al**[30].,** the mean calf circumference was significantly lower in Low Birth Weight babies (P<0.0001), and the cutoff value 9.90 cm for LBW, with a sensitivity of 85.6 % and a specificity of 82.2%. Except for sensitivity and specificity, the other findings in this study are consistent with previous findings. The sensitivity and specificity are higher than the results of the previous study.

According to a recent study, calf circumference as a predictor of LBW is a reliable and inexpensive method. Furthermore, it is also easy to train birth attendants to measure calf circumference for screening babies born in a community which has no facility to weigh the baby immediately after birth. As a result, in remote areas, LBW babies can be identified by measuring calf circumference at the time of birth.

5. CONCLUSION

Anthropometric indicators measured in this study correlated significantly with birth weight of the child. It was also concluded that there exists best correlation with both calf and chest circumference for identifying babies born with birth weight of below 2.5 kg. Besides, the diagnostic accuracy was more with mid-calf circumference than chest circumference for babies whose birth weight is <2.5 kg.

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