Correlation of Calf Circumference in Relation to Other Anthropometric Measurements in Low Birth Weight Babies

Deepshikha Mandloi
Lourdes Hospital

Justin Thomas (✉ dr.justinthomas@gmail.com )
Dr SN MEDICAL COLLEGE JODHPUR

Preethy Peter
Lourdes Hospital

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Abstract

Background

India having 3rd highest incidence of low birth weight (LBW) infants (28%) in the world. In India most of the deliveries are performed at home by untrained Dhais and midwifes. So if we train them to use alternative approach for estimating low birth weight like simple anthropometric indicators such as calf circumference, which can be easily implemented by rural communities.

Methods

We conducted a cross-sectional, prospective study at a tertiary care hospital in Kerala, a southern state in India, during a one-year period in 2021–2022. We included 80 neonates without any congenital malformations who were delivered at the hospital, irrespective of gestational age, and subjected them to anthropometric measurements. We measured calf circumference, chest circumference, mid-arm circumference, thigh circumference, and head circumference using non-stretchable measuring tape. Birth weight was recorded on an electronic weighing machine. Correlation coefficients were calculated using Pearson's correlation coefficient.

Results

From different anthropometric measurements, calf circumference did not show significant correlation with birth weight. The best correlation was observed in mid arm circumference and chest circumference for identifying babies with birth weight group. Birth weight can be roughly calculated from derived formula weight (kg) = 0.06(CC + MAC) - 1.76

Conclusions

In the absence of a weighing machine, simple measurements like chest and mid arm circumference can identify babies with low birth weights. Calf circumference was not well correlated with birth weight in our study.

Introduction

Low birth weight babies have high morbidity and mortality especially in developing countries1. The percentage of low birth weight in developing countries is 16.7% which is double than that of developed countries2. Screening of LBW babies in the community is the highest priority to provide effective postnatal care to decrease morbidity and mortality among them2. Since majority of deliveries are conducted at home in Rural and remote parts of India, search for a simple, reliable, inexpensive and quick method for screening such newborns has always been felt in community. Health personnel posted at the
peripheries are often supplied with limited facilities. They can screen high risk babies using surrogate parameters with the help of non stretchable measuring tape which is cheap and easily available. This study was designed to compare the sensitivity and specificity of calf circumference with sensitivity and specificity of other anthropometric indicators for detecting low birth weight babies at birth via mid-arm circumference, chest circumference, thigh circumference and head circumference and find out the feasibility of calf circumference in detection of low birth weight babies at birth in our tertiary health care centre.

**Methods**

A cross sectional observational study of sample size of 80 was conducted in a tertiary care teaching hospital in Kerala, a small state in South India. Study was approved by Institute Ethics committee. Data were collected after obtaining informed written parental consent from all cases. History was taken and data collected according to study performa. Calf circumference was measured using non stretchable measuring tape measured to the nearest 0.1cm at the most prominent point in the semi flexed position of the leg and was compared with other anthropometric measurements like head circumference, chest circumference, foot length, thigh circumference, birth weight and correlation was studied.

Measurements of anthropometric data were made as follows:

(1) **BIRTH WEIGHT**: It was recorded on an electronic weighing machine in a warm room with baby in naked state. The machine was sensitive up to 1 gm of weight.

(2) **HEAD CIRCUMFERENCE**: It was measured after 24 hours of birth and before completion of 48 hours. As it has been suggested that maximum moulding takes place during first 24 hours. The head circumference was measured with the help of measure tape touching the external occipital protuberance and glabella.

(3) **CHEST CIRCUMFERENCE**: The measurement was taken at the level of nipple with the help of measuring tape.

(4) **MIDARM CIRCUMFERENCE**: This anthropometric measurement was taken at a point midway down the left arm between the tips of acromion and olecranon processes with the help of measure tape.

(5) **MAXIMUM THIGH CIRCUMFERENCE**: In supine position, the maximum thigh circumference was taken at the level of the lowest furrow in the gluteal region, measure tape being placed perpendicular to the long axis of the lower limb.

(6) **LENGTH**: In supine position length was measured using Infantometer

**Definition Of Variable**
LBW: Babies born with birth weight less than 2500 gm. As per WHO criterion, a LBW baby is one with a birth weight of less than 2500gm irrespective of the period of gestation. This definition has less practical significance in countries like India where the mean birth weight is 2800 gm as compared to more than 3000 gm in affluent countries.

**Statistical analysis**

The correlation between LBW and indicators were estimated by multiple regression and Karl Pearson correlation coefficient. The collected data was analyzed by using Mean and standard deviation (SD) were calculated for all anthropometric parameters. The relationship between anthropometric parameters and birthweight was investigated by correlation analysis using a linear model. A multivariate linear regression analysis with backward selection was used to develop a simple three-parametric model to predict the birthweight. The backward selection was started using all anthropometric parameters of the infant.

**Results**

Out of 80 neonates, 5% of the children were belong to the weight group 1-1.5 kg, 37.5% of the children belong to the weight group of 1.5 to 2 kg, 57.25% of the children belong to the group of 2-2.5 kg and no patients less than 1 kg were not included in the cohort. About 2/3rd of the children were first born child and 28.3% of the children were second born child. 5.0% children with birth order 3 were also noted.

81.67% of our study population consisted of male babies. 5.0% of the mothers have high school education, 30.0% of the mothers have intermediate / diploma, 53.3% were graduates/post graduates and 11.7% of mothers with professional degree were also noted.

In our study 62% of babies were born out of Normal and 38 % out of Caesarian delivery. The maximum cohort was between 2 to 2.5 kg and 1/3rd of them were term and 2/3rd were preterm. In babies between 1 to 1.5kg none were term delivered.

The mean weight of the cohort was 1.94±0.38 kg with 2.39 the maximum weight and 1.035 the minimum weight. The mean head circumference of the babies was 31.08±2.64 cm(24.3-34). The mid arm circumference ranged from 6 to 11 cm with a mean of 8.66±1.25 cm. The chest circumference ranged from 23 to 31.5 cm with mean of 28.42±2.42. The mean thigh circumference was 11.7 cm with standard deviation of 1.55 cm. The calf circumference ranged from 6 to 10 cm with a mean value of 8.7±1.24. The mean length of babies was 45 cm with SD of 4.52 with a range from 36 to 50. (Table1).
TABLE 1
Details of anthropometric parameters

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Max value</th>
<th>Min value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>31.08</td>
<td>2.64</td>
<td>34</td>
<td>24.3</td>
</tr>
<tr>
<td>MAC</td>
<td>8.66</td>
<td>1.25</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>CC</td>
<td>28.42</td>
<td>2.42</td>
<td>31.5</td>
<td>23</td>
</tr>
<tr>
<td>TC</td>
<td>11.67</td>
<td>1.55</td>
<td>17.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Calf Circumference</td>
<td>8.7</td>
<td>1.24</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Length</td>
<td>45</td>
<td>4.52</td>
<td>50</td>
<td>36</td>
</tr>
<tr>
<td>Weight</td>
<td>1.94</td>
<td>0.38</td>
<td>2.39</td>
<td>1.035</td>
</tr>
</tbody>
</table>

We plotted scattered plot diagram to find linear correlation between Head circumference and weight. (Figure 1). Although the variables were scattered the linear equation was derived between weight and head circumference

\[ \hat{y} = 0.06833X - 0.14467 \]

The correlation between birth weight and chest circumference was more linear with scattered values more near to the plot. (Figure 2). Linear regression was measured by XY plot as \( \hat{y} = 0.08264X - 0.37725 \)

Correlation between birth weight and MAC was also linear. Linear regression was plotted using scattered plot by using equation \( \hat{y} = 0.15163X + 0.64078 \) (Figure 3)

The correlation between thigh circumference was not linear as the plots are scattered widely (Figure 4). The calf circumference was not well linearly correlated with birth weight as there was extremes of values (Figure 5). The correlation between birth weight and length was seen with minimal scattering, but with extremes of values (Figure 6).
The correlation coefficient between various anthropometric parameters showed that mid arm circumference, head and chest circumference showed maximum correlation whereas calf circumference showed least correlation with birth weight.

Using backward regression model the predictive birth weight was calculated as follows:

\[
\text{Birthweight (kg)} = 0.0605115 \times \text{CC} + 0.0648799 \times \text{MAC} -1.761786
\]

Where CC is the chest circumference (cm), MAC is the mid arm circumference (cm).

Predicted vs original plot of birth weight

When we plotted original weight and predicted weight on a scattered plot they showed excellent correlation. (Figure 7). So this formula can be successfully applied to determine average birth weight from chest and mid arm circumference. For practical use the formula was simplified by rounding the figures, so that it can be used by health workers in the field as follows:

\[
\text{Birthweight (kg)} = (\text{CC+MAC}) \times 0.06-1.76. \text{ But for values nearing 1 kg there was maximum error in predicted weight.}
\]

**Discussion**

The present study was done with 80 newborn babies of gestational age ranging from 28 weeks to 44 weeks in 2021–2022. The anthropometric measures of the newborn babies in the form of weight, length, head circumference, chest circumference, mid arm circumference, maximum thigh circumference was taken between 24 hours and 48 hours of birth. Smoothed percentile values of all the anthropometric parameters of the babies of each weight group were derived.

The aim of our study was to investigate the correlation between birth weight and various anthropometric measurements to develop a simple and cost-effective method of identifying low birth weight babies in resource-limited areas. The correlation between birth weight and various body parameters, such as maximum mid arm circumference, chest circumference, and head circumference, was determined using the correlation coefficient. The best correlation was found with the maximum mid arm circumference and chest circumference followed by head circumference. This was also seen in a study conducted by Ahmed FU et al 3 who observed MAC as a best predictor of Low birth weight. The original aim of our study was whether Calf circumference mostly correlated with birth weight. But various other studies by Biswas et al 4, Bhat IA et al 5, P Sunil Kumar 6 et al in their studies demonstrated that Calf circumference was the most sensitive marker for identifying low birth weight babies and we wanted to recheck this finding. Kokku et al7 also suggested calf circumference most accurately predicted low birth weight in the absence of weighing machine. But our study showed calf circumference was showing least correlation. This difference may be due to regional and racial characteristics between all these studies. Nonetheless there have been many studies like Sk Bhargava et al8, Arisoy et al 9 in their studies identified chest and mid arm circumference to have highly correlated with birth weight. So one can arrive at a conclusion that all
of these parameters may be useful and provide a cheap alternative to electric weighing machine which is costly and difficult to be operated in remote and rural settings where electricity and availability of cells are scarce. So one can prepare a simple measuring tape for the maximum MAC, chest circumference, head circumference etc for the help of the health workers in the resource limited areas. These measurements can be taken by a health professional like a midwife or a traditional birth attendant who have special training. This allows for the identification of most high-risk infants so the health professional can offer appropriate advice about how to keep the infant warm and isolated and adopt behaviors that minimize the risk of infection and give advice about breastfeeding until transport is available to the nearest equipped health facility.

Developing countries often lack comprehensive newborn anthropometric data that could be utilized to evaluate deviations from normal. Most studies that were conducted to predict LBW used only one anthropometric parameter which is far from being satisfactory because differences between individual anthropometric measurements were found between whites and blacks in the United States and Researchers are continuing their attempts to find a method to predict birthweight, however Stetzer et al studied neonatal anthropometric measurements to predict birthweight by ultrasound, which may be useful only in a hospital setting. A study conducted in Nepal suggested using foot length together with chest circumference to predict birthweight. The efforts are continuing, and recently an attempt was made to use a spring-calibrated handheld scale to measure birthweight to overcome the difficulty. However, such handheld scales are not widely available, and checking their accuracy is not always guaranteed in the field. Our study aimed to study multiple parameters and found correlation in 3 parameters (MAC, CC and HC) with birth weight which can be easily measured with a measuring tape.

Conclusion

Birth weight can be roughly predicted using chest and mid arm circumference in low birth babies. Calf circumference had less correlation to the birth weight.

Limitations Of The Study

The study was done in a tertiary care hospital setting for a limited time, so the sample may not represent the population in community

Declarations

Ethical approval

The study was approved by the Institutional Ethics committee, with no. LH/SC/2020-26.

Consent to participate
Informed consent for publication was obtained from all the parents for collecting data from the newborns. But any images or data regarding patient’s information was not published.

**Availability of data and materials**

Relevant data generated or analyzed during this study are included in this published article and any raw data if needed are available from the corresponding author on reasonable request because of patients identity confidentiality.

**Competing Interest**

Nil among authors

**Funding**

No external fundings or grant was involved.

**Authors contribution:**

DM and JT wrote the manuscript, text and studied review of literature. JT and PP prepared the figures and tables. All authors reviewed the manuscript.

**Acknowledgment**

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**References**


Figures
1. Correlation between head circumference and weight

Figure 1

See image above for figure legend.
2. Correlation between birth weight and Chest circumference

![Graph showing correlation between birth weight and chest circumference]

**Figure 2**
See image above for figure legend.
3. Correlation between birth weight and mid arm circumference

Figure 3

See image above for figure legend.
4. Correlation between thigh circumference AND BIRTH WEIGHT

![Graph showing correlation between thigh circumference and birth weight with regression line $\hat{y} = 0.07x + 1.08$.]

Figure 4

See image above for figure legend.
5. Relation between birth weight and calf circumference

Figure 5

See image above for figure legend.
6. Correlation between birth weight and length

See image above for figure legend.

Figure 6
**Predicted vs original plot of birth weight**

![Graph showing predicted vs original birth weight](image)

Y = Birth weight and Predicted Y is the expected birth weight based on the above formula.

**Figure 7**

See image above for figure legend.