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# A STUDY ON BIRTH WEIGHT STATUS OF NEWBORN AND ITS RELATIONSHIP WITH OTHER ANTHROPOMETRIC PARAMETERS

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## ABSTRACT

**Background:** Birth weight is widely recognized as a crucial and reliable indicator of community health, serving as a measure of neonatal morbidity and mortality. In India, however, birth weight is often not documented, as approximately 80% of deliveries occur at home or in rural health centers where weighing scales are frequently unavailable or malfunctioning. The objective of this study was to identify the most effective surrogate parameters for estimating birth weight and to establish cutoff values for various anthropometric measurements to detect low birth weight infants. **Materials and Methods:** All term infants born during the study period were weighed at birth and measured within 24 hours of delivery using a flexible, non-stretchable measuring tape with a precision of 0.1 cm. **Results:** A total of 1,028 newborns were included over a two-year period. The study found that chest circumference and thigh circumference are among the most effective surrogate parameters for identifying low birth weight infants. The cutoff values determined were 30.4 cm and 30.6 cm for chest circumference, and 13.6 cm and 13.8 cm for thigh circumference in male and female neonates, respectively. **Conclusion:** These parameters can be utilized by health workers at the community level to identify infants at high risk of low birth weight, facilitating timely referrals and potentially reducing infant mortality rates in rural regions.

**Keywords:** Birth weight, Anthropometric parameters, New born.

## INTRODUCTION

Anthropometry specifically pertains to measurable morphological characteristics. It serves as an effective and commonly utilized method for screening child health and nutrition. Birth weight is influenced by a variety of factors, including socio-demographic, clinical, hereditary, personal, and even seasonal and geographical elements. It is a crucial indicator of a child's survival, future growth, and overall development. Birth weight is widely recognized as a reliable measure of community health status and serves as an indicator of neonatal morbidity and mortality. However, it is often not recorded, as approximately 80% of deliveries in India occur at home or in rural health centers where weighing scales may be unavailable or malfunctioning. An estimated 15 percent, or 20.3 million, of all live births globally are classified as low birth weight (LBW), defined as less than 2500 grams, which accounts for 60-80 percent of neonatal deaths. The incidence of LBW infants is particularly elevated in South and Southeast Asia, especially in India, where 20-40% of newborns weigh less than 2500

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grams. Recently, there has been growing interest in employing simple anthropometric measures as proxies for birth weight. In response to the need for a quick, straightforward, and reliable screening method for low birth weight, alternative anthropometric measurements at birth have been investigated as substitutes for birth weight. Various studies have reported significant correlations between birth weight and anthropometric measurements. Simple devices have been developed and validated to estimate birth weights and screen for low birth weight in developing countries.

## MATERIALS AND METHODS

The research was conducted over a timeframe from October 2022 to October 2023. It involved a total of 1,028 single, live-born infants who were delivered in the maternity ward during this period. Infants who were seriously ill, had congenital anomalies, or were part of multiple births were excluded from the study. In each instance, various measurements were taken, including birth weight, head circumference, thigh circumference, mid-arm circumference, chest circumference, and foot length, all using standardized techniques. A single individual performed all measurements within 24 hours of delivery, utilizing a flexible, non-stretchable measuring tape that could measure to the nearest 0.1 cm. The nude weight of each infant was recorded using an electronic weighing scale with an accuracy of ± 1 gram. Data was subsequently collected and analyzed through standard statistical methods to identify the most suitable anthropometric parameter for predicting birth weight. The significance of the correlation coefficient was assessed using Student’s t-test. Regression equations were established for each parameter to facilitate the prediction of birth weight. These equations allowed for the determination of cutoff values for each study parameter in relation to a birth weight of 2.5 kg, categorizing newborns into low birth weight (< 2.5 kg) and normal birth weight (≥ 2.5 kg). Measurements falling below the cutoff value for the respective parameter indicated low birth weight, while those above indicated normal birth weight. The validity of these cutoff points for identifying low birth weight infants was evaluated on a case-by-case basis.

## RESULTS

In a study involving 1,028 neonates, 582 were identified as male and 446 as female. Due to the significant differences observed in various parameters between the sexes, we conducted separate analyses for males and females. The characteristics of the neonates, categorized by sex and accompanied by significant statistical parameters, are presented in Table 1. It was noted that male infants exhibited greater measurements in weight, chest circumference, head circumference, thigh circumference, mid-arm circumference, and foot length compared to their female counterparts. However, the Student's t-test revealed that weight, head circumference, thigh circumference, and foot length were significantly greater in males, while chest circumference and mid-arm circumference did not show statistically significant differences. (Table 1)

**Table 1: Characteristics of study population.**

| Gender | Statistics | Weight | CC | HC | TC | MAC | FL |
|---|---|---|---|---|---|---|---|
| Males | Minimum | 1.6 | 27.3 | 30.1 | 10 | 7.6 | 6.1 |
| | Maximum | 3.7 | 33.7 | 35.3 | 18 | 14 | 8.4 |
| | Mean | 2.7052 | 31.1144 | 33.6007 | 14.438 | 10.3399 | 7.2912 |
| | Standard Deviation | 0.39075 | 1.04864 | 0.91252 | 1.31434 | 1.10539 | 0.47738 |
| Females | Minimum | 1.6 | 27 | 30.1 | 10 | 7.5 | 5.9 |
| | Maximum | 3.68 | 33.8 | 35.3 | 17.5 | 14 | 8.3 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean | 2.6192 | 31.0025 | 33.4596 | 14.2173 | 10.2224 | 7.2278 |
| | Standard Deviation | 0.38351 | 1.06457 | 1.00255 | 1.34413 | 1.13035 | 0.45679 |
| Unpaired t value | - | 3.524 | 1.685 | 2.352 | 2.642 | 1.672 | 2.150 |
| p value | - | <0.001 | 0.092 | 0.019 | 0.008 | 0.095 | 0.032 |

**Chest Circumference = CC, Head Circumference = HC, Thigh Circumference = TC, Mid Arm Circumference = MAC, Foot Length = FL**

Table 2 shows the correlation coefficient between weight and study parameters of male and female babies where weight significantly correlated (p<0.001) with all study parameters; head circumference, chest circumference, mid arm circumference, thigh circumference and foot length.

**Table 2: Correlation coefficient (r) between weight and study parameters**

| **Gender** | **Weight** | **Chest Circumference** | **Head Circumference** | **Thigh Circumference** | **Mid-arm Circumference** | **Foot Length** |
|---|---|---|---|---|---|---|
| Male | P value | 0.710** | 0.636** | 0.789** | 0.590** | 0.461** |
| Female | P Value | 0.741** | 0.676** | 0.804** | 0.644** | 0.505** |

** Correlation is significant at the 0.01 level (2-tailed).

Linear regression analysis was carried out to predict birth weight of male and female babies from each of the study parameters. The regression models predicting birth weight of the all babies from the values of the respectiveparameters. ANOVA revealed that all these parameters werepredicting the birth weight significantly. (Table 3)

Table 4 presents the statistical indices for sensitivity (birth weight < 2.5 kg), specificity (birth weight ≥ 2.5 kg), and predictive capabilities for both low birth weight and normal weight based on various anthropometric parameters in male neonates. Chest circumference accurately identifies 76.80% of low birth weight infants and 83.0% of those with normal weight. In contrast, head circumference detects 81.57% of low birth weight and 77.47% of normal weight infants. Thigh circumference shows an accuracy of 76.21% for low birth weight and 87.80% for normal weight infants, while mid-arm circumference identifies 66.01% of low birth weight and 81.91% of normal weight infants. Foot length is less effective, detecting only 33.33% of low birth weight and 84.31% of normal weight infants. Among these parameters, head circumference emerges as the most significant predictor of low birth weight, followed closely by chest circumference and thigh circumference in male neonates.

**Table 3: Linear regression models predicting birth weight of babies.**

| **Gender** | **Regression** | **Equation** | **ANOVA F Value** | **P Value** |
|---|---|---|---|---|
| Males | CC | Birth weight(male)=(0.264) x CC – (-5.522) | 588.358 | <0.001 |
| | HC | Birth weight(male)=(0.272) x HC – (-6.448) | 394.321 | <0.001 |
| | TC | Birth weight(male)=(0.234) x TC – (-0.680) | 954.034 | <0.001 |
| | MAC | Birth weight(male)=(0.209) x MAC – 0.549 | 309.498 | <0.001 |
| | FL | Birth weight(male)=(0.377) x foot length – (-0.44) | 156.243 | <0.001 |
| Female | CC | Birth weight(female)=(0.267) x CC – (-5.652) | 359.382 | <0.001 |
| | HC | Birth weight(female)=(0.258) x HC – (-6.028) | 372.831 | <0.001 |

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| | | | | |
|---|---|---|---|---|
| | TC | Birth weight(female)=(0.229) x TC – (-0.642) | 811.065 | <0.001 |
| | MAC | Birth weight(female)=(0.219) x MAC – 0.384 | 315.337 | <0.001 |
| | FL | Birth weight(female)=(0.424) x FL – (-0.444) | 151.828 | <0.001 |

**Chest Circumference = CC, Head Circumference = HC, Thigh Circumference = TC, Mid Arm Circumference = MAC, Foot Length = FL**

**Table 4: Cut off value and its predictive ability with normal and low birth weight of males.**

| **Variable** | **Cut off value** | **According to birth weight** | | **According to cut off value** | |
|---|---|---|---|---|---|
| | | **Low birth weight (<2.5 kg)** | **Normal birth weight(≥2.5 kg)** | **< cut off value Low Birth Weight (LBW)** | **≥ cut off value Normal Birth Weight (NBW)** |
| CC | 30.4cm | 56.3% | 92.6% | 76.80% | 83.00% |
| HC | 32.9cm | 35.2% | 96.6% | 81.57% | 77.47% |
| TC | 13.6cm | 71.0% | 90.4% | 76.21% | 87.80% |
| MAC | 9.4cm | 51.7% | 94.8% | 66.01% | 81.91% |
| FL | 7.8cm | 90.9% | 21.2% | 33.33% | 84.31% |

**Chest Circumference = CC, Head Circumference = HC, Thigh Circumference = TC, Mid Arm Circumference = MAC, Foot Length = FL, Low Birth Weight = LBW, Normal Birth Weight = NBW**

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Table 5 presents the sensitivity indices for low birth weight (defined as less than 2.5 kg) and specificity for normal birth weight (2.5 kg or greater), along with the predictive positive and negative values for various anthropometric parameters among female neonates. Chest circumference demonstrates an accuracy of 80.00% in identifying low birth weight infants and 84.5% for those of normal weight. In contrast, head circumference accurately identifies 71.15% of low birth weight and 78.60% of normal weight infants. Thigh circumference shows an accuracy of 79.22% for low birth weight and 82.50% for normal weight infants, while mid-arm circumference accurately detects 79.85% of low birth weight and 79.80% of normal weight infants. For male infants, foot length identifies 66.33% of low birth weight and 64.21% of normal weight babies. Among female neonates, chest circumference is the most reliable predictor of low birth weight, followed by mid-arm circumference and thigh circumference.

Our findings indicate that head circumference is highly specific for identifying low birth weight infants in both male and female neonates. However, due to the unreliability of head circumference as a measurement, we propose that chest circumference, followed by thigh circumference, serves as more dependable indicators for detecting low birth weight in both male and female neonates.

**Table 5: presents the cutoff values and their predictive capabilities concerning normal and low birth weight in females.**

| Variable | Cut off value | According to birth weight | | According to cut off value | |
|---|---|---|---|---|---|
| | | Low birth weight (<2.5 kg) | Normal Birth weight(≥2.5 kg) | < cut off value Low Birth Weight (LBW) | ≥ cut off value Normal Birth Weight (NBW) |
| CC | 30.6 cm | 74.0% | 88.3% | 80.00% | 84.50% |
| HC | 33.1 cm | 62.2% | 83.5% | 71.15% | 78.60% |
| TC | 13.8 cm | 70.5% | 88.3% | 79.22% | 82.50% |
| MAC | 9.7cm | 64.2% | 89.7% | 79.85% | 79.80% |
| FL | 7.0 cm | 38.7% | 87.5% | 66.33% | 69.27% |

**Chest Circumference = CC, Head Circumference = HC, Thigh Circumference = TC, Mid Arm Circumference = MAC, Foot Length = FL, Low Birth Weight = LBW, Normal Birth Weight = NBW**

## DISCUSSION

In Since the time of Hippocrates, mortality of small babies has been reported in medical literature. Biologists all over the world appreciated the importance of normal birth weightand effect of maternal factor on off springs, long before Charaka Samitha devoted a complete chapter to the role of healthy parents and care of pregnant women for a healthy pregnancy. [11] In India the works on anthropometry dates back to 1920. [12]

The recording of birth weight has always been a problem ina third world country like India, where 75% of population resides in rural areas and almost 80% of deliveries are done by trained or untrained birth attendants or relatives. [5] Several studies have been done to identify a suitable alternative parameter for predicting the birth weight of the newborn. There is yet no consensus in respect of an ideal parameter and the research in this field is still on. Many of the anthropometric indices have been proposed such as head circumference, mid arm circumference, chest circumference,thigh circumference and calf circumference. [5]

The present study was conducted to find the best surrogate parameters, which could be used

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by birth attendants in rural areas and health workers at community level, to identify lowbirth weight babies. Such an indicator should have a good correlation with birth weight, should be highly sensitive so that a good proportion of 'at risk' neonates can be identified and referred to a higher centre. At the same time good specificity is also required so that unnecessary referrals do not burden the referral centre. In our study since there was significant difference in parameters in males and females weanalyzed separate data for both sexes.

In our study we found that head circumference followed by chest circumference and thigh circumference were best parameters to assess low birth weight babies in male neonates while chest circumference followed by mid-arm circumference and thigh circumference in female neonates. Head circumference has shown a correlation of 0.636 in males and 0.676 in females with low birth weight. Although head circumference is based on bony land marks, moulding and / or caput succedaneum may alter it immediately after birth, so it is not considered as a reliable parameter.

The strongest correlation between birth weight and surrogate parameters for identifying low birth weight male infants was observed with thigh circumference (0.789), followed by chest circumference (0.710), head circumference (0.636), mid arm circumference (0.590), and foot length (0.461). A similar pattern emerged for female low birth weight infants, where thigh circumference exhibited the highest correlation (0.804), followed by chest circumference (0.741), head circumference (0.676), mid arm circumference (0.644), and foot length (0.505). To establish criteria for identifying low birth weight infants weighing less than 2.5 kg, cutoff values were derived from regression equations. The cutoff values for male infants were determined to be 13.6 cm for thigh circumference, 30.4 cm for chest circumference, 32.9 cm for head circumference, 9.4 cm for mid arm circumference, and 7.8 cm for foot length. For female infants, the corresponding values were 13.8 cm, 30.6 cm, 33.1 cm, 9.7 cm, and 7.0 cm, respectively. Numerous studies have been conducted to identify the most effective surrogate parameters for assessing birth weight. Our findings indicated that chest circumference serves as a significant parameter, with correlation coefficients of 0.741 for females and 0.710 for males, and cutoff values of 30.4 cm for males and 30.6 cm for females to detect low birth weight. Bhargava *et al.* reported a high correlation of 0.86 between birth weight and chest circumference, establishing a cutoff of ≤ 30 cm. Verma and Sharma found even higher correlations of 0.93 in males and 0.92 in females, identifying chest circumference as the most sensitive measure for estimating low birth weight. They developed multiple linear regression equations for predicting birth weight based on chest circumference, recommending a cutoff value of <30.5 cm, with a suggestion to use ≤ 29.5 cm to <30.5 cm to classify newborns as 'high-risk' and 'at high-risk,' respectively. In contrast, Sreeramareddy *et al.* conducted a study that also contributed to this body of research.

In our research, mid-arm circumference demonstrated a significant correlation with birth weight, with coefficients of 0.644 for females and 0.590 for males, making it the second most effective measure for identifying low birth weight infants. The established cutoff values were 9.7 cm for females and a less consistent 9.4 cm for males. Numerous studies have affirmed mid-arm circumference as a superior parameter for assessing birth weight, revealing a strong correlation coefficient. Utilizing these cutoff values, head circumference emerged as the most dependable metric for detecting low birth weight in male neonates, accurately identifying 81.57% of low birth weight and 77.47% of normal weight infants. Chest circumference followed closely, identifying 76.80% of low birth weight and 83% of normal weight babies. Thigh circumference was able to detect 76.21% of low birth weight and 87.80% of normal weight infants. In contrast, mid-arm circumference and foot length were less reliable, identifying only 66.01% and 33.33% of low birth weight, and 81.91% and 84.31% of normal weight male neonates, respectively. For female neonates, chest circumference was the most

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effective, accurately identifying 80% of low birth weight and 84.50% of normal weight infants. Mid-arm circumference followed closely, identifying 79.85% of low birth weight and 79.80% of normal weight babies. Thigh circumference was also effective, detecting 79.22% of low birth weight and 82.50% of normal weight infants. The least reliable parameters were head circumference and foot length, which identified 71.15% and 66.33% of low birth weight, and 78.60% and 69.27% of normal weight female neonates, respectively.

Numerous studies conducted over the years have indicated that Bhargava *et al.* reported a sensitivity of 82.88% for chest circumference. In contrast, our study revealed that 76.80% of low birth weight male infants, along with 83% of normal weight male infants, and 80% of low birth weight female infants, as well as 84.50% of normal weight female infants, were accurately identified. Sreeramareddy *et al.* and Sajjadian *et al.* found sensitivities of 87.98% and 84%, respectively, for estimating low birth weight using chest circumference. Additionally, Etio Goto demonstrated the highest sensitivity at 87% for detecting low birth weight through chest circumference. Ramaji S *et al.* reported a sensitivity of 81.8% when comparing thigh circumference to birth weight, which is lower than the 76.21% sensitivity for low birth weight and 87.80% for normal weight male infants, as well as 79.22% for low birth weight and 82.50% for normal weight female infants identified using thigh circumference. Sharma J N *et al.* and Kadam Y R *et al.* observed high sensitivities of 98.11% and 94.95%, respectively, in the relationship between thigh circumference and birth weight. Although foot length is recognized as a significant parameter for assessing birth weight and identifying high-risk infants, our study did not find a substantial correlation. In conclusion, the findings of this study indicate that both chest circumference and thigh circumference serve as effective surrogate parameters for identifying low birth weight infants. These measurements can be utilized by health workers at the community level to identify high-risk and low birth weight infants, facilitating timely referrals that may contribute to reducing infant mortality rates in rural areas.

## CONCLUSION

This study concludes that among the various parameters examined, chest circumference and thigh circumference serve as viable alternatives to birth weight for identifying low birth weight infants. These measurements can be easily obtained using a non-stretchable flexible measuring tape. Chest circumference is measured at the nipple level while the thigh circumference is taken at the thigh's most prominent point. Consequently, these measurements can be effectively utilized in rural settings by trained dais or family members to estimate birth weight in the absence of weighing facilities for newborns, as community workers can be readily equipped with a measuring tape. By employing these anthropometric parameters, a significant number of low birth weight infants can be identified at the grassroots level, allowing for specialized care at dedicated centers, thereby reducing both short-term and long-term mortality and morbidity, ultimately contributing to a healthier future generation for the nation.

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