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Original article

Birth Weight Status of Newborn and Its Relationship With Other Anthropometric Parameters

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ABSTRACT

Background : Birth weight has been accepted as the most important reliable index of the health status of the community and is an indicator of neonatal morbidity and mortality. In India weight at birth is not recorded because almost 80% of the deliveries take place at home or at rural health centre where weighing scales tend to be either non available or defective. **Objective:** To find the best surrogate parameter to determine birth weight and cut off values of various anthropometric measurements to identify low birth weight babies. **Material and Methods :** All the term babies born in Krishna hospital, Karad were weighed at birth and measured within 24 hours of delivery with the help of a flexible non stretchable measuring tape capable of measuring up to 0.1 cm. **Results:** 1028 newborn infants were included in the study period of two years. Chest circumference and thigh circumference are among the best surrogate parameters to identify low birth weight babies. The cut off value of chest circumference was 30.4 cms and 30.6 cms and thigh circumference was 13.6 cms and 13.8 cms in male and female neonates respectively. **Conclusion:** These parameter can be used at community level by health workers for identification of high risk and low birth weight babies so that their timely referral can thereby help in reducing infant mortality in rural areas.

KEYWORDS: Birth weight, Anthropometric parameters, New born.

INTRODUCTION

Anthropometry refers specifically to morphological traits which can be externally measured [1]. Anthropometry is an effective and frequently performed child health and nutrition screening procedure. Birth weight has been associated with socio-dermographic, clinical, radial, hereditary, personal and even seasonal and geographical factors. It is an important indicator of survival, future growth and overall development of the child. [2] Birth weight has been accepted as the most important reliable index of the health status of the community and is an indicator of neonatal morbidity and mortality. [3] However, most of the times, weight at birth is not recorded because almost 80% of the deliveries in India take place at home or at rural health centre where weighing scales tend to be either non available or defective. [4,5] About 15 percent or 20.3 million of all live birth worldwide are estimated to be low birth weight (LBW) <2500 gms accounting for 60-80 percent of all neonatal deaths. [6] The proportion of LBW infants is particularly high in south and south- Asia, especially India, where between 20-40% of babies have weights below 2500 grams. [7,8] In recent years, there has been a considerable interest in using simple anthropometric measures as a proxy for birth weight. In response to the demand for a rapid, simple, and reliable screening approach for a low birth weight, other anthropometric measurement at birth have been studied as surrogates for birth weight.[9,10] Significant correlations between birth weight and anthropometric measurements have been reported by various research workers. Simple devices to estimate birth weights and screen for low birth weight to delineate in developing countries have been developed and validated.

MATERIALS AND METHODS

This study was carried out in the maternity ward of Krishna Hospital and Medical Research Centre, Karad. The study was done during the period extending from October 2010 to October 2012. The study included a total of 1028, single, live born babies delivered in the maternity ward during the given time period. The study did not included babies who were seriously ill, babies with congenital anomalies and twins. In all cases, birth weight, head circumference, thigh circumference, mid arm circumference, chest circumference and foot length were measured by standard techniques. All the measurement were taken by one person. All the measurement were taken within 24 hours of delivery with the help of a flexible non stretchable measuring tape capable of measuring up to 0.1 cm.

Nude weight of the baby was taken in an electronic weighing machine, with an accuracy of ± 1 gram. Data was collected and then analyzed, using the standard statistical method, so as to find out the most appropriate anthropometric parameter to predict the birth weight. Significance of correlation of coefficient was tested by applying student's t test. Then the regression equations were set up separately for each parameter so as to predict the birth weight. With the help of regression equations cut off values were determined for each of the study parameter relation to birth weight (2.5 kg), which divides the newborns into low birth weight (< 2.5 kg) and normal birth weight (≥2.5 kg). The measurement below the cut off value of respective parameter indicates low birth weight otherwise normal birth weight. Validity of these cut off points for detecting low birth weight babies was determined case to case.

RESULTS

Out of 1028 neonates studied, there were 582 males and 446 were females. In our study since there was significant difference in parameters in males and females we analyzed separate data for both sexes. The characteristics of the total babies studied, classifies as males and females with significant statistical parameters are shown in Table 1. It was observed that weight, chest circumference, head circumference, thigh circumference, mid arm circumference and foot length was higher in male babies than in female babies. However, the student t – test showed weight, head circumference, thigh circumference and foot length were found significantly higher in males than in females where as chest circumference and mid arm circumference were not statistically significant. (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
	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 respective parameters. ANOVA revealed that all these parameters were predicting the birth weight significantly. (Table 3)

Table 4 shows the statistical indices sensitivity (Birth weight< 2.5 kg), specificity (birth weight ≥2.5 kg), predictive ability of < cut off value as low birth weight, predictive ability of ≥ cut of value as normal weight for each anthropometric parameter, in all the male neonates. Chest circumference detects 76.80% of low birth weight babies accurately while 83.0% of normal weight babies, while head circumference detects 81.57% of low birth weight and 77.47% normal weight babies accurately.

Thigh circumference detects 76.21% of low birth weight and 87.80% of normal weight babies accurately while mid-arm circumference accurately detects 66.01% of low birth weight and 81.91% normal weight babies. Foot length detects 33.33% low birth weight and 84.31% normal weight babies in male babies. Head circumference was very high predictor of low birth weight followed by chest circumference and thigh circumference in male babies.

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
	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

Table 5 shows the statistical indices sensitivity (Birth weight< 2.5 kg), specificity (birth weight ≥2.5 kg), predictive positive value (< cut off value), predictive negative value (≥ cut of value) for each anthropometric parameter, in all the female neonates. Chest circumference detects 80.00% of low birth weight babies accurately while 84.5% of normal weight babies, while head circumference detects 71.15% of low birth weight and 78.60% normal weight babies accurately. Thigh circumference detects 79.22% of low birth weight and 82.50% of normal weight babies accurately while mid-arm circumference accurately detects 79.85% of low birth weight and 79.80% normal weight babies. Foot length detects 66.33% low birth weight and 64.21% normal weight babies in male babies. Chest circumference was very high predictor of low birth weight followed by mid arm circumference and thigh circumference in female neonates.

Thus we found that head circumference was highly specific for detection of low birth weight babies in both male and female neonates but as head circumference is not a reliable parameter we consider chest circumference followed by thigh circumference in both male and female neonates as reliable parameters for detection of low birth weight.

Table 5 : Cut off value and its predictive ability with normal and low birth weight of 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 weight and 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 in a 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 by birth attendants in rural areas and health workers at community level, to identify low birth 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 we analyzed 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 best correlation between birth weight and surrogate parameter to identify low birth weight male baby was shown by thigh circumference (0.789) followed by chest circumference (0.710), then head circumference (0.636), mid arm circumference (0.590) and lastly foot length (0.461). Similar results were found in correlation between birth weight and surrogate markers to identify female low birth weight babies which were thigh circumference (0.804) followed by chest circumference (0.741), then head circumference (0.676), mid arm circumference (0.644) and lastly foot length (0.505). For determining low birth weight babies < 2.5kg the cut off limits or values were formed using regressions equation. The cut off value for thigh circumference, chest circumference, head circumference, mid arm circumference and foot length were 13.6 cms, 30.4 cms, 32.9 cms, 9.4 cms and 7.8 cms respectively in male babies and 13.8 cms, 30.6 cms, 33.1 cms, 9.7 cms and 7.0 cms respectively in female babies.

Many studies have been conducted in the past to determine the best surrogate parameters to determine birth weight. We found chest circumference as best parameter and found a correlation coefficient of 0.741 in females and 0.710 in males, with a cut off value of 30.4 cms in males and 30.6 cms in females to detect low birth weight . Bhargava et al in their study found the highest degree of correlation of 0.86 between birth weight and chest circumference and a cut off ≤ 30 cms. [5] Verma and Sharma in their study had found the highest degree of correlation of 0.93 in males and 0.92 in female, thus they found chest circumference to be most sensitive in estimation of low birth babies, by developing multiple linear regression – equations for predicting birth weight from chest circumference. They found a cut off value of <30.5 cms and recommended to use ≤ 29.5 cms to < 30.5 cms for chest circumference to identify 'high-risk' and 'at high-risk' newborn respectively. [13] Whereas Sreeramareddy et al [14] in their study found a correlation coefficient of 0.86 and Etio Goto [15] found a coefficient correlation of 0.95 between chest circumference and birth weight with a cut off value of 30.8 cms and 31.25 cms respectively.

Our second best parameter to assess the birth weight was thigh circumference where we found a correlation coefficient correlated of 0.804 in females and 0.789 in males with a cut off value off 13.6 cms in male and 13.8 cms in females. Similarly Ramaji S et al showed a high degree of correlation of 0.918 between thigh circumference and birth weight and cut off value of 14.7 cms. [16] Sharma J N et al in their study revealed that birth weight was significantly

correlated with thigh circumference with a correlation coefficient of 0.920 with a cut off value of 14.5 cms. [17] Matto G M et al [18] and Kadam Y R et al [19] in their studies found correlation of 0.50 and 0.863 between thigh circumference and birth weight respectively with cut off value of 13.6 and ≤15.29 respectively.

In our study mid arm circumference, correlated (0.644 in females and 0.590 in males) second best with birth weight for identification of low birth weight babies with a cut off value of 9.7 cms in females and a less reliable parameter in male with cut off value of 9.4 cms. Many studies have been conducted which concluded mid-arm circumference to be the best parameter to assess birth where a high degree of correlation coefficient has been found. [20,21]

Using the above cut off limits the most reliable parameter for detecting low birth weight babies in male neonates was found to be head circumference where 81.57% of low birth weight and 77.47% of normal weight babies were correctly identified. This was followed by chest circumference where 76.80% of low birth weight and 83% of normal weight babies were identified. Thigh circumference could detect 76.21% of low birth weight and 87.80% of normal weight babies accurately. Mid-arm circumference and foot length were relatively less reliable parameters as they could detect 66.01% and 33.33% of low birth weight and 81.91% and 84.31% of normal weight male neonates respectively. In female neonates was seen with chest circumference where 80% of low birth weight and 84.50% of normal weight babies were correctly identified. This was followed by mid arm circumference where 79.85% of low birth weight and 79.80% of normal weight babies were identified. Thigh circumference could detect 79.22% of low birth weight and 82.50% of normal weight babies accurately. The least reliable parameters were head circumference and foot length as they could detect 71.15% and 66.33% of low birth weight and 78.60% and 69.27% of normal weight female neonates respectively.

In various studies conducted over the years Bhargava et al had sensitivity for chest circumference was 82.88% as compared to our study where 76.80% of low birth weight and 83% of normal weight male babies and 80% of low birth weight and 84.50% of normal weight female babies were correctly identified. [5] Sreeramareddy et al and Sajjadian et al [23] found a sensitivity of 87.98% and 84% for estimating low birth weight with chest circumference respectively. Etio Goto showed highest sensitivity of 87% for detecting low birth weight with chest circumference. [15]

Ramaji S et al [16] found a sensitivity of 81.8% between thigh circumference and birth weight as compared to 76.21% of low birth weight and 87.80% of normal weight male babies and 79.22% of low birth weight and 82.50% of normal weight female babies who were correctly identified with thigh circumference. Sharma J N et al [20] and Kadam Y R et al [19] found a high sensitivity of 98.11% and 94.95% between thigh circumference and birth weight. Foot length is being considered as an important parameter for detection of birth weight and identification of high risk babies but no significant correlation was found in our study. [24]

Thus the analysis of the result of this study shows that chest circumference and thigh circumference are among the best surrogate parameters to identify low birth weight babies which can be used at community level by health workers for identification of high risk and low birth weight babies so that their timely referral can thereby help in reducing infant mortality in rural areas.

CONCLUSION

Thus it can be concluded from this study that amongst all the parameters studied chest circumference and thigh circumference can be used as an alternative to birth weight as an indicator for detection of low birth weight babies. These measurements are also easy with the help of a non stretchable flexible measuring tape. Chest circumference can be easily measured at the level of the nipple in supine position and thigh circumference is measured at the most prominent position of the thigh. Thus these measurements can be easily used even in rural areas by trained dais or relatives to predict the birth weight where weighing facilities for newborns is not available as community workers can easily provided with a measuring tape. With these anthropometric parameters most of the low birth weight babies can be identified at grass-root level and these babies can be given special care at specialized centers preventing short term as well as long term mortality and morbidity thus giving the nation healthy next generation.

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