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RESEARCH ARTICLE

ANTHROPOMETRIC SURROGATES TO IDENTIFY LOW BIRTH WEIGHT NEWBORNS IN RESOURCE LIMITED SETTINGS: A HOSPITAL-BASED STUDY

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ABSTRACT

Background & Objective: Prematurity and low birth weights are the important risk factors for Neonatal and Infant mortality. It is not possible to weight significant proportions of newborns in rural areas of many developing countries, mostly due to unavailability of weighing scales. These low birth weight newborns, even if they survive, they used to suffer from long term disability such as malnutrition or gross developmental delay. Many studies earlier have attempted to identify surrogate makers of LBW to find out solution of this problem, but still there is no consensus of cutoff value for these surrogate markers, which can correlate uniformly with LBW. The reproducibility and reliability of these surrogate markers vary in different races and locations. The aim of this study was to identify the reliable surrogate markers for LBW. **Methods:** This prospective cross sectional study was carried out in a tertiary level hospital located in central India. The aim of the study was to identify a surrogate marker/s which can be reliably used for identification of low birth weight newborn. **Results:** All the anthropometric measurements correlate significantly with birth weight. Multiple linear regression analysis showed the best predictors in the descending order for low birth weight were Chest C., Calf C., Head C., length & MUAC with a variance of 77.4%, 3.0%, 1.4%, 1.0%, 0.7% respectively. Sensitivity for head and chest circumference was 92.42 and 92.20 respectively, whereas sensitivity for MUAC was 95.26, the highest among all parameters. This study suggests that mid upper arm circumference below <11 cm may be an optimum anthropometric surrogate to identify LBW newborns. **Conclusion:** Head and chest circumferences were the best specific anthropometric surrogates of LBW. MUAC was the best sensitive and easier and convenient surrogate marker, but it can overestimate LBW infants. Combining MUAC with either HC or CC will be most appropriate for identifying LBW infants in resource limited areas. Further studies are needed in the field to cross-validate our results.

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INTRODUCTION

Children's health is tomorrow's wealth is one of World Health Organization (WHO)'s slogans. Birth weight is a strong indicator not only of a mother's health and nutritional status but also of a newborn's chances for survival, growth, long-term health and development. Birth weight is the single most important predictor of neonatal morbidity and mortality in developing countries (Demelash, 2015). Morbidity associated with LBW is a significant determinant of failure to thrive, poor cognitive development and chronic diseases in adulthood (Barker, 1990 and Sreeramareddy, 2008). Recent studies have found that low birth weight also increases the risk for non communicable diseases such as diabetes and cardiovascular disease later in life (Larroque, 2001). Low birth weight (LBW) defined by WHO as birth weight of less than 2.5 kg which is based on epidemiological observations that infants weighing less than 2,500 gm are approximately 20 times more likely to die than heavier babies (Wardlaw, 2004). Worldwide more than 20 million infants, representing 15.5% of all births are born with low birth weight, 95.6% of them in developing countries. The incidence of low birth weight in developing countries (16.5%) is more than twice the incidence in developed regions i.e. 7% (WHO, 1996). In developing countries most newborns die at home while they are being cared by mothers, relatives, and traditional birth attendants (Risnes, 2011). Currently, a high percentage of infants are not weighed at birth, especially in low-income countries, presenting a significant policy challenge.

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Table 1. Comparative distribution of anthropometric measurement (cm) among normal birth weight and low birth weight newborns

Parameters (cm)	Normal Birth Weight babies [N=289]		LBW babies [n=211]		Student 't' Test Value	P Value
	Mean birth weight	± Std. Deviation	Mean birth weight	± Std. Deviation		
Head C.	33.55	0.83	31.26	1.43	22.422	0.001
Chest C.	31.89	0.98	29.53	1.77	18.980	0.001
MUAC	11.24	3.28	9.53	0.993	7.262	0.001
Length	49.31	4.06	46.53	2.15	9.013	0.001
Thigh C.	13.70	1.13	12.00	1.11	16.695	0.001
Calf C.	10.68	0.87	9.42	0.957	15.375	0.001
Foot length	7.38	0.45	7.48	0.226	2.427	0.016

Identifying these high risk babies and timely referral for proper intensive care increases their chances of survival.

MATERIAL AND METHODS

This prospective cross sectional study was carried out in a tertiary level hospital located in central India. The aim of the study was to identify a surrogate marker/s which can be reliably used for identification of low birth weight newborn and their correlation. The study protocol was approved by institutional research advisory committee and institutional ethics committee. All live newborns (singleton baby without any major congenital malformation) delivered in the hospital during the study period (1st February 2014 to 30th April 2015) irrespective of gestational age were included in the study. Newborns with major congenital anomalies like hydrops, foot abnormality, microcephaly or hydrocephalus were excluded from the study. All live births were examined by investigator within 24-48 hours of birth. Data was recorded and entered in MS excel sheet. To ensure reliability, the principal investigator recorded the anthropometric parameters of newborns using standard techniques. Babies were weighed naked on electronic weighing scale (after standardization) to the nearest of 5g. Head circumference (HC) measured by non stretchable measuring tape to the nearest of 0.1cm along the maximum occipitofrontal diameter over occiput & eyebrow. Chest circumference (CC) measured by non stretchable measuring tape to the nearest of 0.1 cm along the nipple line at the end of expiration phase. Mid Upper Arm Circumference (MUAC) measured by non stretchable measuring tape to the nearest of 0.1 cm of left arm at the midpoint between the tip of acromian process and olecranon process. Crown heel length (CHL) measured by infantometer recording to nearest of 0.1 cm with the baby supine, knees fully extended & soles of feet held firmly against the foot board & head touching the fixed board. Foot length (FL) measured by a plastic scale recording to nearest of 0.1 cm with the sole of foot pressed against that vertical scale. Calf circumference measured by non stretchable measuring tape to the nearest of 0.1 cm at the most prominent point in a semi-flexed position of the leg. Thigh circumference measured by non stretchable measuring tape to the nearest of 0.1 cm at the lowest furrow of gluteal region.

Statistical Analysis

Statistical analysis was done using SPSS software Version 20; Chicago Inc., USA. Specific statistical tests applied for data comparison to find out the statistical significance of the comparisons. Quantitative variables were compared using mean values and qualitative variables using proportions. Significance level was fixed at $P \leq 0.05$. Statistical tests employed for the obtained data in our study were: Chi-Square (χ^2) Test, Student's t-test, Pearson's Correlation and multiple linear regression analysis.

OBSERVATIONS AND RESULTS

It revealed that 42.20 percent of the total babies were found to be low birth weight babies. As per gender wise distributions of newborns, it has been observed that among low birth weight newborns, 50.2% were males and 49.8% were females. Among normal weight newborns, 52.9% were males and 48.2% were females. Hence in both the groups, male newborns were having higher percentage than female newborns and the differences between birth weight and gender of the newborns were found to be non significant.(P=0.550). The differences between all anthropometric measurements of newborns and birth weight were found statistically highly significant. (P=0.001) Mean head circumference was 31.26 cm in low birth weight babies and 33.5 cm in normal weight babies. While MUAC was 9.53 cm in low birth weight babies and 11.24 cm in normal weight babies (Table 1, Figure 1a figure 1b).

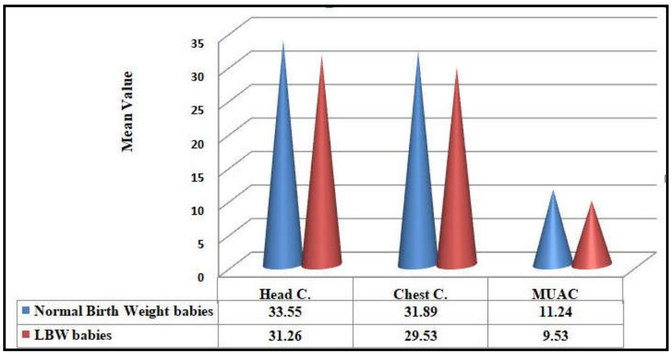


Figure 1a. Mean anthropometric measurements of normal birth weight and low birth weight newborns

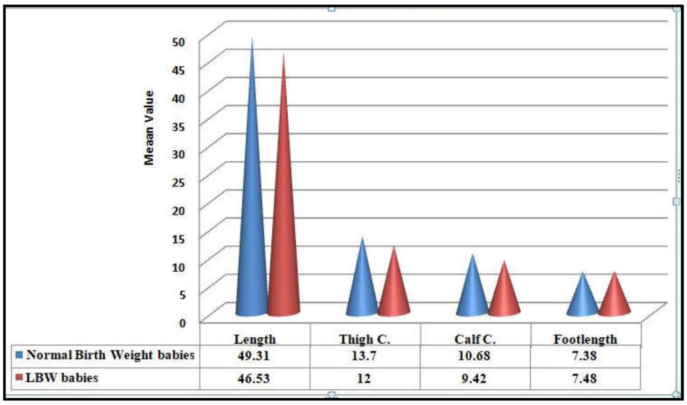


Figure 1b. Mean anthropometric measurements of normal birth weght and low birth weight newborns

All the parameter shows positive correlation with birth weight, which is highly significant (P=0.001). Pearson correlation Coefficient was highest for Chest Circumference i.e. 0.88

Table 2. Pearson's Correlation of birth weight with various parameters

Parameters	Pearson correlation Coefficient (r)	P value	Correlation
Head C.	0.84	0.001	Strong
Chest C.	0.88	0.001	Strong
MUAC	0.34	0.001	Moderate
Length	0.54	0.001	Moderate
Thigh C.	0.74	0.001	Strong
Calf C.	0.79	0.001	Strong
Foot length	0.15	0.001	Weak
Gestational Age	0.54	0.001	Moderate

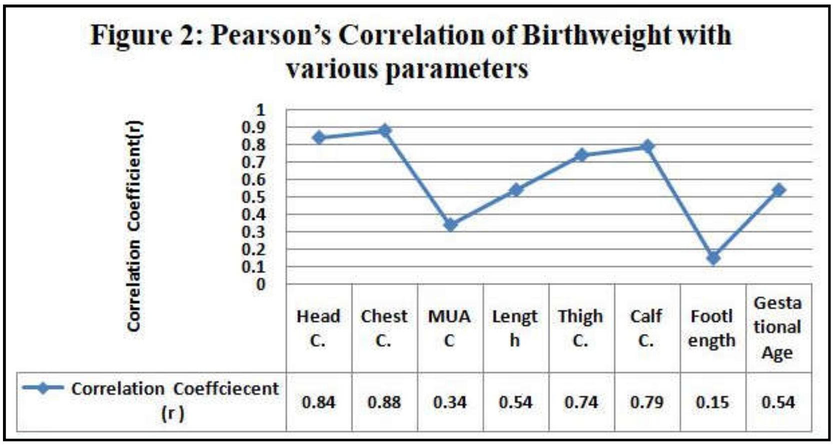
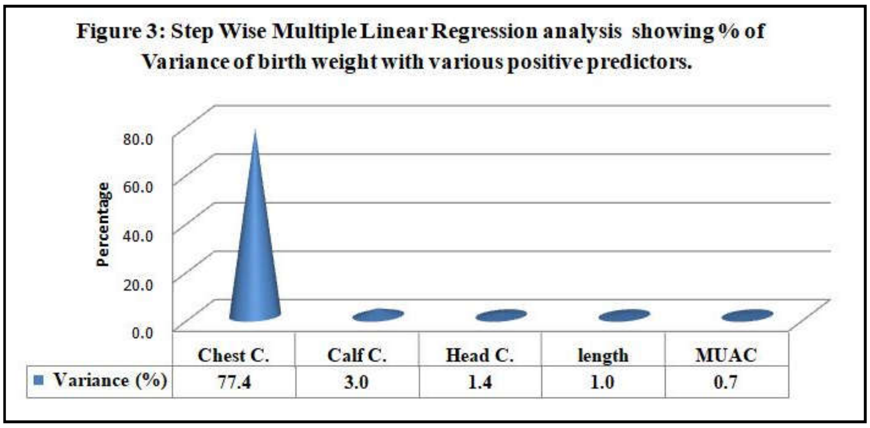


Table 3. Step Wise Multiple Linear Regression analysis with Birth Weight as a dependent variable and various anthropometric measurements as an independent Variables

Model	Anthropometric measurements	Constant	Regression Coefficient Beta	't' Value	P value	R Square	Mean
1	Chest C.	-5.029	0.880	41.34	0.001	0.774	30.89
2	Calf C.	-4.474	0.271	8.59	0.001	0.804	10.15
3	Head C.	-5.158	0.281	6.20	0.001	0.818	32.58
4	MUAC	-5.088	0.093	4.68	0.001	0.825	10.51
5	Length	-5.510	0.174	5.41	0.001	0.835	48.13



followed by Head Circumference i.e. 0.84. Head, Chest, Thigh and Calf Circumference had strong correlation with birth weight while foot length had weak correlation (Table 2, Figure 2). Multiple linear regression analysis which was executed to estimate the linear relationship between the Birth weight as a dependent variable and various independent variables shows that the best predictors in the descending order for low birth weight were Chest C., Calf C., Head C., length & MUAC with a variance of 77.4%, 3.0%, 1.4%, 1.0%, 0.7% respectively. It also reveals that all the independent variables were significantly associated with birth weight (Table 3,Figure 3). Association of independent anthropometric variables with birth weight in terms of sensitivity & specificity also exist. Sensitivity for head and chest circumference was 92.42 and 92.20 respectively, whereas sensitivity for MUAC was 95.26, the highest among all parameters. There was high prevalence of low birth weight baby in case if head circumference, chest circumference and MUAC was below the cut-off point (Table 4).

DISCUSSION

Despite several national level programms still the skill attendance at birth is not available in central India. These facts lead us to evaluate various surrogate markers which can be used by peripheral health worker to identify these high risk children and managed them. This study showed a higher number of LBW in central India in comparison to previous data by UNICEF. Study also showed the lower average birth weight 2310 grams in comparison to previous studies.

Table 4. Association between independent variables and Prevalence of low birth weight and its Sensitivity & specificity

Independent Variables	LBW babies [<2.5 kg]	Normal babies [≥2.5 kg]	Total	Chi Square value	P value	Sensitivity/Specificity
Head Circumference						
<33 cm	195	46	241	286.0	0.001	92.42/84.08
≥ 33 cm	16	243	259			
Total	211	289	500			
Chest Circumference						
<31 cm	185	48	233	248.0	0.001	92.20/83.39
≥ 31 cm	26	241	267			
Total	211	289	500			
MUAC						
<10.60 cm	201	162	363	94.2	0.001	95.26/43.94
≥ 10.60 cm	10	127	137			
Total	211	289	500			
Calf Circumference						
<10.20 cm	190	110	300	137.0	0.001	90.05/61.94
≥ 10.20 cm	21	179	200			
Total	211	289	500			
Length						
< 48.60 cm	194	105	299	157.0	0.001	91.94/63.67
≥ 48.60 cm	17	184	201			
Total	211	289	500			

A value of <8 cm and <6.8 cm for mid upper arm circumference showed highest validity for picking up newborns weighing <2000 gm and <1500 gm respectively in India (Das et al, 2005). In Bangladesh, it has been concluded that a mid upper arm circumference of <9 cm had the best sensitivity and specificity for identifying newborns with a birth weight of less than 2500 gm (Ahmed et al, 2000). Validity of cut off values for best surrogate anthropometric parameters in the present study depict that mid upper arm circumference ≤11cm has best sensitivity for identifying infants weighing<2.5 Kg. In our study, head circumference of 33 cm was found to be second best indicator on the basis of sensitivity after mid upper arm circumference. Other studies have also reported a similar cutoff point of 33.5cm (Chandrashekhar *et al*., 2008). The sensitivity and specificity in our study for head circumference is 92.42% and 84% respectively. Some of the studies questioned the efficacy of head circumference as surrogate marker, as the measurement of head circumference at birth could not be accurate due to molding of head, particularly in cases of prolonged and obstructed labour. In present study, chest circumference of 31 cm was found to be next best indicator after mid upper arm circumference & head circumference. Other studies have also reported a cutoff point between 29.5 and 30 cm (Bhargava, 1985 and Singh, 1988). WHO collaborative study has recommended that chest circumference of 29 centimeters and 30 centimeters may identify 'highly at risk' and 'at risk' newborns respectively. In our study maximum sensitivity and specificity was at chest circumference of 31 centimeters. Chest circumference has a larger cross-section with less chance of systematic or random errors in measurement. Measuring chest circumference is simpler because identification of nipple line is relatively easier than other measurements but may be operationally difficult as it require removal of clothes. Thus, chest circumference may have a drawback with reference to maintenance of warm chain for the newborn especially during the months of winter. This study suggests a cutoff value of 48.6 cm with a sensitivity of 91.9% for crown heel length with a lower specificity of 63.6% and a cutoff value of 12.9 cm for thigh circumference with sensitivity of 91.8% but with a lower specificity. Similarly a calf circumference of 10.2cm with a sensitivity of 90% was suggested in our study, whereas a foot length of 7.5cm has poor sensitivity (72%) in this study.

Conclusion

It can be concluded that all the anthropometric measurements correlate significantly with birth weight. Anthropometric parameters can be considered as a useful tool to identify low birth-weight using their cut-offs in situations where weighing machine is not easily available like that in rural areas. Head and chest circumferences were the best anthropometric surrogates of LBW in terms of specificity. The results of our study suggest that mid upper arm circumference below <11 cm may be an optimum anthropometric surrogate to identify LBW newborns having the best sensitivity. Addition of head circumference and chest circumference in the screening tool will increase the specificity to identify LBW infants. Measurement of MUAC is easier, convenient as compared to chest circumference since it does not require full undressing of baby. Also MUAC unlike HC does not get altered by the process of difficult labor. All these factors have implications for use of these measurements by community health workers. The midwives are advised to refer new born whose mid upper arm circumference falls below the cutoff value for further assessment in nearby hospital. The same tape can be used by midwives for follow up at home visits. As this study is hospital-based study, further community based studies on larger scale are needed in the field to cross-validate our results.

Key Points

- Anthropometric parameters can be considered as a useful tool to identify low birth-weight.
- Head and chest circumferences were the best anthropometric surrogates of LBW in terms of specificity.

Conflict of interest and Funding statement- none

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