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Research Article

Detection of low birth weights in newborns by Foot length as proxy measure

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Abstract

Introduction: Birth weight is an important and sensitive parameter and a determinant factor regarding mortality and morbidity in neonates. However weighing facility may not be available for all home deliveries in remote and rural area in developing countries, where an alternative parameter like foot length may be considered in place of birth weight.

Methods: Foot length, birth weight and various other anthropological parameters were measured and compared in 316 low birth weights out of 500 live newborns. A cutoff foot length was detected for different low birth weight groups and its sensitivity, specificity, positive and negative predictive values was determined.

Results: Cut off Foot lengths of 6.70cm, 7.45cm and 8.20 cm were identified for corresponding birth weight groups of 1-1.499 kg, 1.5-1.999 kg, 2.0-2.500 kg. Sensitivity, Specificity, Positive predictive value for identifying newborns <1.499 kg were 91.91% , 86.54% and 71.84% for newborns <1.99 kg it was 91.01% ,99.14% and 99.18% for newborns <2.5 kg it was 79.32, 100% and 100% respectively. Correlation coefficients between foot length and birth weight showed the highest correlation (r=0.96).

Conclusion: Foot length may be considered an alternate parameter to birth weight to detect low birth weight babies, especially in remote areas (where baby weighing machines are not available) and also in those conditions where baby is less likely to be disturbed. The Calipers, for measuring Foot length may be used by paramedical workers as efficient tool in such places.

Keywords: Foot Length, Low Birth Weight, Newborns

1. Introduction

Parameters of growth are most sensitive indicators of nutritional status of population[1]. Birth weight is an important indicator of survival, future growth and overall development of the child. It is associated with socio-economic, clinical, racial, hereditary personal and geographical factors[2]. Low birth weight is associated with high neonatal morbidity and mortality due to susceptibility to adverse environmental influences predilection to infections and difficulties in maintaining adequate nutrition .The prevalence of low birth weight babies is 22.5% by National family health survey-3, however, birth weight was reported only in 34.1% of cases of live births, this means that actual numbers might be even higher[3]. It is estimated that about 30% of babies born in India are Low birth weights and over 80% of all neonatal deaths are among them in developing countries.[4] In spite of this importance of birth weight, in the developing countries including India recording of birth weight has been a problem. In India 31% of all deliveries in rural area and overall 26% of rural and urban India is conducted by untrained functionaries[5]. According to 2010-11 report, at birth 23% of newborns remained not weighed , as the deliveries are conducted in homes where weighing of baby is not feasible[5],however this can be even higher as no data is available as to how many health centers in India have facility of baby weighing machine.

In fact this is due to the non availability or lack of facility such as baby weighing machines[6]. Accurate weight record of babies is a sensitive index of their well being and availability of a sturdy and reliable weighing machine fulfills a fundamental need.[4] Therefore, there arises a need of alternative measurements for estimation of birth weight which should be easy, simple, and reliable in the hands of inexperience staff and have a good correlation with it[7]. Foot length is one such parameter which can be measured and implemented easily in such conditions even in a sick baby.

2. Material and Methods

The Study was prospective observational type and was conducted in the department of pediatrics in Surat municipal institute of medical education and research, Surat (SMIMER). It was approved by Institutional ethical committee. Five hundred live newborns delivered (SMIMER and municipal city health centers) from October 2011 to October 2012 weighing from 1 to 3.5 kg, out of which those weighing between 1 to 2.5 kg, total numbering to 316 were selected for study. Newborns, having congenital anomalies, dysmorphic features, vertebral, cranial, limb deformities, and having intrauterine infections were excluded from the study. The selected newborns were thoroughly examined by single investigator(to avoid any interpersonal error) within 48 hours of birth and underwent anthropological measurements Newborns were weighed nude on electronic weighing scale to the nearest 10 gm. Digital Sliding calipers(measuring range 0 - 150mm,accuracy +/- 0.02mm) was used for Foot length. Foot length was measured from posterior most prominence of foot to the tip of longest toe(first/second) of the right & left foot with calipers twice and mean of both feet was taken in the study. Flexible non stretchable, fiber tape(measuring nearest to 0.1cm) was used for measuring head circumference ,calf circumference ,chest circumference and Infantometer was used for measuring length. Data were analyzed using SPSS (Version16) software. Correlation between foot length and other parameters was analyzed by correlation and regression. ANNOVA (Leven's and Robust test) was applied to find out difference in means of foot length of different birth weight groups. Linear regression equation to derive cut off foot length for various birth weight groups. Sensitivity, specificity Positive and Negative predictive values were calculated for each birth weight group from each cut-off foot length.

3. Results

Out of 316 low birth weight newborns 172(54%) were male and 144(46%) were females (Table –1). Male: Female ratio was 1.19:1. Out of 316 low births weight newborns 117 weighed between 1 to 1.499 kg, 135 weighed between 1.5 to1.999 and 64 weighed between 2-2.500 kg. Males predominated over females except in the group weighing 1to1.499 kg. Table-1 shows descriptive statistics of birth weight under different categories .Table - 2 shows the mean (along with 95% Confidence Interval) and Standard Deviation of each of the birth weight groups ANNOVA was applied to find out any differences in the means of any of the three birth weight groups. Leven's test of homogenesity of variance was used which came to be significant (<0.05) suggesting ANNOVA results are invalid. As Leven's test failed to demonstrate homogenesity, Robust test was considered for equality of means and p value, which came to be significant (p<0.05), suggesting ANNOVA results are valid.

There was also positive Linear correlation of foot length with all birth weight group (p<0.001) and from this a regression equation was obtained for deriving Foot length as follows.

Foot Length = (1.4907 × Birth Weight) + 4.4715.

Cut off Foot lengths of 6.70 cm, 7.45cm and 8.20 cm were identified for corresponding birth weight groups of 1-1.499 kg, 1.5-1.999 kg, 2.0-2.500 kg from above equation. Table-3 shows Sensitivity, Specificity, Positive and Negative predictive values of Foot lengths for given birth weight groups. Sensitivity, Specificity, Positive predictive value for identifying newborns <1.499 kg were 91.91% , 86.54% and 71.84% ,for newborns <1.99 kg it was 91.01% ,99.14% and 99.18% for newborns <2.5 kg it was 79.32 ,100% and 100% respectively. In Table-4 comparing our study with Elizabeth *et al* shows correlation coefficients between foot length and other anthropological parameters , with regard to Foot length ,birth weight showed the highest correlation(r=0.96) as compared to other parameters ,followed by head circumference ,chest circumference ,calf circumference and length.

Table -1 Descriptive statistics of sex and birth weights

Birth weight (Kg)	Male	Female	Total	Mean	Standard Deviation	95% Confidence interval of Mean	
	Number (%)	Number (%)	Number (%)			Lower Bound	Upper Bound
1.0-1.499	39(12)	78(25)	117(37)	1.29	0.27	1.25	1.33
1.5-1.999	94(30)	41(13)	135(43)	1.52	0.27	1.48	1.57
2.0-2.500	39(12)	25(8)	64(20)	2.17	0.67	2.00	2.34
Total	172(54)	144(46)	316(100)	-	-	-	-

Table-2 Descriptive statistics of Mean Foot Length

Birth weight (kg)	No. of Subjects	Mean	Standard Deviation	Standard Error	95% Confidence interval		Min.	Max.
					Lower	Upper		
1.0-1.499*	117	6.09774	0.518463	0.047932	6.00280	6.19267	5.320	6.959
1.5-1.999*	135	6.85415	0.403167	0.034699	6.78552	6.92278	6.200	7.995
2.0-2.499*	64	8.08169	0.485296	0.060662	7.96046	8.20291	7.010	9.400

**P<0.001 in each birth weight groups*

Table-3 Sensitivity, Specificity, Positive and Negative predictive values of Foot length in different birth weight groups

Parameter	Birth weight		
	1.0-1.499 kg	1.5-1.999 kg	2.0-2.499 kg
Sensitivity	91.91% CI 95% (85.99-95.89)	91.01% CI 95% (88.92-94.15)	79.72% CI 95%(74.72-83.43)
Specificity	86.54% CI 95% (82.60-89.87)	99.14% CI 95% (96.93-99.87)	100% CI 95% (97.50-100)
Positive Predictive value	71.84% CI 95% (64.53-78.38)	99.18% CI 95% (97.08-99.88)	100% CI 95% (98.68-100)
Negative predictive value	96.63% CI 95% (94.04-98.30)	90.59% CI 95% (86.32-93.88)	66.82% CI 95% (60.17-73.00)

Table -4 Correlation coefficient between foot length and various other anthropometrical Parameters

Parameter	Foot length		Birth weight		Head Circumference		Chest Circumference	
	Our study	Eliza *et al*	Our study	Eliza *et al*	Our Study	Eliza *et al*	Our study	Eliza *et al*
Foot length	1	1	0.96	0.97	0.88	0.89	0.82	0.93

P<0.001 for all variables

4. Discussion

Early identification of low birth weight is an important pre-requisite of any initiative to reduce mortality. However identifying low birth weight newborns may be hampered due to lack of availability of weighing machine ,fears of its cost , maintenance sustainability and to some extent reluctance for health volunteers to carry weighing machines especially in developing countries[7] like India .Other alternatives of growth parameters are measurement of head circumference ,chest ,calf and thigh circumferences , body length etc. These are simple and good alternatives but may require greater exposure of newborns while measurement, to environmental variations (winter) and may be more disturbing and handling in sick children. Foot length is one such alternative in above conditions. Foot length can be measured by simple stiff plastic or metal ruler or more precisely by digital sliding calipers ,which gives a more accurate and direct reading access ,easy to handle and carry ,and can be utilized by a health worker/ volunteer by very simple training.

On comparing cut off Foot lengths with other studies ,it was found that in <1.5 kg newborns group Hirve *et al*[10] had cut off Foot length 6.3 cm, Mukherjee *et al*[11], had 6.8 cm, Marchant *et al*[9] had <7cm and in our study cut off Foot length was 6.7 cm. In newborns <2.0 kg group Sarlahi *et al* had cut off Foot length <6.9 cm, whereas in our study it was 7.4 cm. In newborns <2.5 kg group Mathur *et al*[12] had cut off Foot length <7.2cm, Hirve *et al*[10] had <7.6 cm(wt 1.5-2.5 kg) , Mukherjee *et al*[11] 7.9 cm ,whereas in our case it was 8.2 cm.Sensitivity & specificity of foot length for birth wt < 1.5 kg , was 100% & 95.2% in Hirve *et al*[10],75% & 99 % in Marchant *et al*[9], 100% and 95% in Mukherjee *et al*[11] and in our study it was 92% and 87% respectively. In our study Foot length had highest correlation with birth weight (r=0.96), followed by head circumference (r=0.88),chest circumference(r=0.82), calf circumference(r=0.76) and length (r=0.65), Elizabeth *et al*[8] had also highest correlation of Foot length with birth weight (r=0.97) like us and head circumference (r=0.88), however Foot length had higher correlation with chest circumference in their study (r= 0.93) whereas in our study it was lower (r=0.82).

5. Conclusion

Foot length is an alternative anthropometrical parameter to birth weight and can be useful especially in remote areas with no facility of baby weighing machines and in conditions where baby would not liked to be exposed like in winter and disturbed in sickness. The digital calipers used to measure foot length are less costly, easy to carry and operate in the absence of baby weighing machines.

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