Original Research Article

A study on new-born foot length measurement to identify high risk neonate

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ABSTRACT

Background: In India, most of the neonatal mortality is due to low birth weight and prematurity. Since the majority of deliveries were conducted at the peripheral level, logistic constraints make it difficult for early and reliable identification of low birth weight babies who require extra care. There are so many studies have been conducted to find out an alternative anthropometric measurement for birth weight and Gestational age. One such innovation is the Foot length measurement. Various studies have been conducted on foot length reliability as a proxy measurement. The aim of the present study is to study the correlation between foot length and other variables like birth weight, gestational age, chest circumference and head circumference among small for gestational age, appropriate for gestational age and large for gestational age and to determine utility of using foot length as a screening tool to identify small babies (LBW/premature) in need of extra care.
Methods: It is a cross-sectional descriptive study of 2000 neonate conducted in Government Mohan Kumaramangalam Medical College Hospital, Salem. Babies with lower limb anomaly were excluded from the study. The foot length, head & chest circumference, birth weight and gestational age of the study population were collected by using standard methods. The study group was categorized based on their sex, maturity and gestational age.
Results: The study group included 53.7% of male and 46.3% female babies. There were 81.4% term and 18.6% preterm babies. In this study group, there were 85.1%, 14.3% and 0.6% of AGA, SGA and LGA babies respectively. The mean foot length for term babies observed in this study is 6.91 cm with the standard deviation of 0.44. The mean foot length for preterm babies is 5.94 cm with a standard deviation of 0.43. Statistically, by performing Scheffe's multiple comparisons tests the foot length was found to be significantly different in AGA, SGA and LGA babies.
Conclusions: Foot length is a simple and more reliable anthropometric measurement to assess the birth weight and gestational age in newborn babies. Foot length can emerge as an important anthropometric measurement in neonates and can be used to screen prematurity and SGA babies in need of care.

Keywords: Foot length, Low birthweight, Neonatal mortality, Preterm baby

INTRODUCTION

Birth weight is the single most important factor for the outcome of the neonate. Approximately 80% of all neonate deaths are due to LBW in both developed and developing countries. In India, 30% babies are LBW as against to about 5-7% in western countries and also is in second place in South Asia region.[1] Gestational age and birth weight are both used as primary indicators in the risk of neonatal death. The higher neonatal mortality rate occurs for any given gestational age, the lower the birth weight and for any given birth weight, the lower the

gestational age.[2] Foot length is one of the measurements, which can be measured very easily, bears good correlation with birth weight, a good predictor of gestational age, rapid to perform, can be measured in critically ill neonates and in level III NICU.

This study is being done to analyze the correlation between the foot length, birth weight, gestational age and other anthropometric measurements and to evaluate the possibility of Foot Length emerging as an alternate anthropometric measurement for identifying high-risk babies.[3] The foot of the newborn is easily accessible to measure their length in LBW, VLBW, and premature babies. There is a practical barrier to measure all anthropometric parameters of a newborn who is on a ventilator, require minimum handling and nursed in the incubator, particularly daily measurement of weight is difficult. The foot length can be used as a proxy measure in all sick newborn babies receiving NICU care who are inaccessible to measure crown-heel length and body weight, the measurement of foot length guides to calculate drug dosages and fluid requirement.[4]

The foot length can predict the prematurity and low birth weight. Foot length is a very simple, easily accessible and more reliable anthropometric variable to assess the birth weight and gestational age in the preterm neonate and term neonates. For measuring the newborn foot length does not require any special training and equipment. Foot length is a simple, reliable and reproducible in the prediction of nasotracheal tube length, which is more useful in the sick neonate.

Foot length is one of anthropometric measurement which has fascinated researchers since decades. Many studies have been done regarding the correlation of foot length with birth weight and gestational age and found to be foot length is a superior.[5]

METHODS

The study period started from August 2016 and continued till a target of 1000 consecutive live-born babies in our hospital was reached at Government Mohan Kumar Mangalam Medical College and Hospital, Salem.

Inclusion criteria

All live Neonates born in the Hospital during the study period.

Exclusion criteria

All babies with lower limb congenital anomalies.

Methods of collection of data

The required data was collected by using standard proforma containing all objectives of the study.

Foot length

It was measured by using ISI certified Sliding Calliper having the most accuracy of a millimeter. It was measured from the most prominence of heel to tip of the great toe or second toe whichever is longer. During the measurement foot length, ventral surface of the foot was straightened out gently. The foot length was recorded in centimeters.

Baby weight

It was measured by using an electronic weighing scale with an accuracy of ±10 grams. Before weighing the newborn babies, all the dresses were removed.

Head circumference

Measured by using flexible, non-stretchable fiber, measuring tape with the accuracy of a millimeter. During measurement, the tape should encircle posteriorly the occipital prominence, anteriorly just above the supraorbital ridge and laterally above the earlobes.

Chest circumference was measured at the level of the nipple by using flexible, non-stretchable tape. Gestational assessment was assessed by using New Ballard Scoring system.

Statistical analysis

The data collected was analyzed using Statistical Package for Social Studies - Version 16. The correlation between foot length and parameters such as gestational age, birth weight, head circumference and chest circumference were analyzed by applying Correlation and regression analysis. Regression analysis was derived to predict gestational age from foot length in babies.

RESULTS

Based on the weight of the baby at birth and gestational age, the babies are classified as appropriate for gestational age, small for gestational age and large for gestational age. In this study 85.1% of the babies were appropriate for gestational age, 14.3% were small for gestational age and 0.6% were large for gestational age.

Table 1: Gestational weight classification of the study population.

Gestational weight	No.	Percentage
Appropriate for gestational age	851	85.1
Small for gestational age	143	14.3
Large for gestational age	6	0.6
Total	1000	100

Table 2 shows the birth weight distribution of the study population. In this study the mean birth weight in the <2.5 kg group was 1.9 kg with a range from 0.5 to 2.45

kgs. The mean birth weight in the 2.5 to 3.5 kg group was 2.90 kg. The mean birth weight in the >3.5 kg group was 3.77 kg with a range from 3.5 to 4.25 kg. Table 3 shows the foot length of study population. The range of gestational week were calculated from 26-42 weeks. Foot length was found to be 4.6 cm as mean in 26th week. Head circumference was around 22.33 cm. chest circumference was found to be 18.33 cm and baby weight was around 0.6 cm.

Table 2: Birth weight distribution.

Birth Weight (kg)	Male No.	%	Female No.	%	Total No.	%	Range	Mean
<2.5	118	45.9	139	54.1	257	100	0.5-2.45	1.96
2.5-3.5	395	55.9	311	44.1	706	100	2.5-3.5	2.90
>3.5	24	64.8	13	35.2	37	100	3.6-4.25	3.77
Total	537	53.7	463	46.3	1000	100	0.5-4.25	2.69

Table 3: Mean foot length, HC, CC, and birth weight for babies of various gestational ages.

Gest age weeks	Fl (cm) Range	Mean	Hc (cm) Range	Mean	Cc (cm) Range	Mean	BW (cm) Range	Mean
26	4.5-4.7	4.6	21-24	22.33	17-20	18.33	0.5-0.7	0.6
28	4.9-6.0	5.26	23-29	25.16	19-24	21.00	0.7-1.25	0.9
30	5.2-5.9	5.5	25-29	27.14	22-26	23.42	1-1.6	1.4
32	5-6.2	5.52	23-31	27.18	20-32	24.13	1-1.9	1.41
34	5.3-6.9	6.11	26-32.5	30.05	21-29	26.95	1.2-2.4	2.03
36	6.0-7.5	6.58	29-34.5	31.67	18.5-28.5	28.98	1.7-3.5	2.56
38	6.3-7.9	6.98	30-35	32.44	26-38.5	29.00	2.1-3.75	2.92
40	6.7-8.2	7.45	32-36	33.36	29-33	29.68	2.7-4.2	3.44
42	8.0-8.3	8.15	35-35.5	35.00	30-30.5	30.00	4-4.25	4.12

In 42 weeks foot length was found to be 8.15 cm as mean in 26th week. Head circumference was around 33 - 33.5 cm. Chest circumference was found to be 18.33. and baby weight was around 4.12cm. Table 4 depicts the range and mean of foot length in various groups of babies. As expected the foot length increases with increasing gestational age. In 92 babies 4.5-6.9 cm, in 94 babies 5.5-7.0 cm in 51 babies 6.0-7.2 cm, in 757 babies 6.0-8.0cm and in 6 babies 8.0-8.3 cm which is found to be significant.

Table 4: Foot length for various groups of babies.

Maturity and Gestational age	No. of babies	Range	Mean	SD
Preterm SGA	92	4.5-6.9	5.7663	0.5041
Preterm AGA	94	5.5-7.0	6.1191	0.2428
Term SGA	51	6.0-7.2	6.3156	0.2043
Term AGA	757	6.0-8.0	6.9519	0.3541
Term LGA	6	8.0-8.3	8.1166	0.1329

Table 5: Descriptive statistics of the selected anthropometr1c variables of the new-born babies by their sex.

Variables	Sex	No. of babies	Minimum	Maximum	Median	Mean	SD	95% Confidence limit for mean	
Foot length (cms)	Male	537	6.40	8.30	6.80	6.78	0.61	6.73	6.83
	Female	463	4.50	8.30	6.80	6.68	0.55	6.63	6.73
Head circumference (cms)	Male	537	23.0	36.0	32.00	31.88	1.71	31.74	32.03
	Female	463	21.0	35.5	32.00	31.58	1.80	31.41	31.74
Chest circumference (cms)	Male	537	19.0	38.5	29.00	28.45	1.83	28.29	28.61
	Female	463	17.0	38.0	28.50	28.17	1.85	28.00	28.34
Birth weight (kgs)	Male	537	0.70	4.20	2.80	2.74	0.56	2.70	2.79
	Female	463	0.50	4.25	2.70	2.63	0.56	2.58	2.68

Table 5 shows the descriptive statistics of the selected anthropometric variables of the newborn babies by their sex. The median foot length and median head circumference for the male and female babies have been equal. Regarding the chest circumference, the female babies have a slightly lesser median value than male babies. The female babies have 0.5 cm less chest circumference than male babies. Regarding the birth weight of the male and female babies, it has been observed that the female babies are having 0.1 kg lesser birth weight than male babies.

Table 6: Mean comparison of the selected anthropometric variables of the new-born babies by their sex.

Variables	Sex	No. of babies	Mean	SD	T-test value	P-value
Foot Length (cm)	Male	537	6.78	0.61	2.737	.006
	Female	463	6.68	0.55		
Head circumference (cm)	Male	537	31.88	1.71	2.761	.006
	Female	463	31.58	1.80		
Chest circumference (cm)	Male	537	28.45	1.83	2.425	.015
		463	28.17	1.85		
Birth weight (kg)	Male	537	2.74	0.56	3.285	.001
	Female	463	2.63	0.56		

Table 6 shows the mean wise comparison between the male and female babies for the selected anthropometric variables. Student T-test has been applied to compare the mean values of the four variables of the male and female babies. The significant p-value for the four variables infers that male babies are having slightly higher anthropometric values than female babies. The male babies are having 0.1 kg higher mean birth weight than female babies. The mean chest circumference and mean head circumference for the male babies have been 0.3cm higher than female babies. The mean foot lengths of the male babies are having 0.1 cm higher values than female babies.

Table 7: Predicting gestational age using foot length of the new-born babies.

Variable	Regression equation	R^2 value
Overall	GA = 15.343+3.183 (FL)	0.652
Sex		
Male	GA = 17.465+2.873 (FL)	0.586
Female	GA = 12.440+3.614 (FL)	0.739
Maturity status		
Term	GA = 23.368+2.057 (FL)	0.376
Preterm	GA = 15.050+3.056 (FL)	0.572
Weight for gestational age		
Appropriate	GA = 17.567+2.867 (FL)	0.514
Small	GA=10.671+3.913(FL)	0.679
Large	Since only 6 cases equation is not fitted.	

Table 7 shows the prediction of the gestational age based on foot length of the new-born babies. Linear regression analysis has been applied to predict the gestational age of the babies by their foot length. For the overall sample, the Gestational age has been expressed as an equation of 15.343+3.183 (FL). Here, 3.183 indicates the slope of the equation and 15.343 is the constant. The slope value infers that as one cm increase in the foot.

DISCUSSION

The reduction of neonatal mortality in developing countries like India requires the simple measurement too early identification of the preterm and low birth weight babies. At birth chest circumference, head circumference and birth weight are routinely measured.[6] In India non-availability of equipment to measure the above parameters, the imperative need to identify the high-risk new-born babies, there is a need of appropriate, alternate parameter, which can be easily measurable and not sophisticated one. The foot length is one of the measurements which can be measured easily even in very sick babies.[7]

This study was done to find out the correlation of foot length with other anthropometric measurements in new-born babies and the use of foot length as a proxy measurement for estimation birth weight and gestational age. To determine the utility of using foot length as a screening tool to identify small babies (LBW/premature) in need of extra care.[8] In this study 1000 new-born babies were recruited, and their anthropometric measurements were recorded. Among them, 53.7% are male babies and 46.3% are female babies. These values are nearly close to the results in the Neela.j et al study showed 52.4%.[9] The study conducted by Ramji S et al showed term babies are 89.5% and preterm babies are 10.5%. In this study, small for gestational age babies is 14.3%, appropriate for gestational age are 85.1% and large for gestational age are 0.6%.[10,11] This study is comparable to Hirve SS et al which showed SGA 13.2%, 84.8%, and LGA 2.1%. Birth weight of 1000 new-born babies in this study ranges from 0.5 to 4.25 kg with the mean of 2.69. This is comparable

to the study done by Hirve SS et al birth weight range of 0.85-4.3 kg with the mean of 2.931 kgs.[12] Sauerborn et al study the mean birth weight was 2.679 kg which are comparable to present study. As the LGA group was small, statistical analysis was not possible.[13] This was also the case in many studies. By performing the regression equation, Foot length has been shown to have the potential to predict the gestational age in this study. In this study the mean foot length for gestational ages of 26, 28, 30, 32, 34, 36, 38, 40 and 42 weeks were found to be 4.6, 5.26, 5.5, 5.52, 6.11, 6.58, 6.98, 7.45and 8.15 cm respectively.[14,15]

CONCLUSION

in the ever-expanding field of pediatrics, the pediatrician's quest for innovations and inventions for the betterment of children continues at a rapid pace. one such innovation is the development of newer anthropometric measures which will guide us in assessing growth and development of children. this study evaluated the measurement of foot length as an important anthropometric measure in neonates. the study group included 1000 neonates from gmkmch, salem and was diverse in sex, maturity and birth weight. The foot length was compared to other anthropometric measures. The foot length correlated significantly with gestational age, head and chest circumference and birth weight of all the subgroups. This study also demonstrated the capability of foot length to predict gestational age by regression equation and thereby identifying high-risk babies with prematurity or SGA in need of care. This study also yielded mean foot length values for gestational ages from 26 weeks to 42 weeks.

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