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Original Research Article

A study of correlation between foot length and gestational maturity and anthropometric measurements in neonates

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ABSTRACT

Background: This pinnacle's the importance for alternative measurements which predicts birth weight and gestational age (GA). Foot length is a simple measure and does not require expertise. The aim of this study was to study correlation of foot length and GA among preterm, term and post-term neonates.
Methods: This study was a prospective observational study done in 155 babies. Anthropometric measurements were taken within the first 24 hours of life. GA estimation was done using modified Ballard score. Foot length, head circumference and chest circumference were measured and noted. Weight of the baby was recorded using electronic weighing scale.
Results: Foot length statistically correlated ($p<0.05$) with GA assessment using NBS, weight, length, head circumference and chest circumference. The highest correlation of foot length in term SGA and term AGA babies for foot length was with head circumference (r=0.74 and 0.64 respectively). In pre-terms, foot length correlated well with head circumference and birth weight (r=0.92, 0.84 and 0.92 respectively). There were no babies in preterm LGA group and post term SGA and LGA group.
Conclusions: Foot length also statistically correlated with other parameters like birth weight, length, head circumference and chest circumference.

Keywords: Preterm babies, Foot length, Small for GA, Birth weight

INTRODUCTION

India contributes to one-fifth of live births globally each year out of which around 7000 neonatal deaths happen in the first 24 hours.[1]

Sustainable development goals (SDG) which came into force in the year 2016 aims to reduce neonatal mortality to as low as 12 per 1000 live births. Implementation of SDGs and the success will rely on countries sustainable development policies, plans and programmes.[2]

Neonatal mortality rate (NMR) is defined as total number of neonatal deaths in a given year per 1000 live births. Neonatal deaths are deaths occurring within first 28 days of life. In India as per sample registration system (SRS) 2016 estimates, 24 neonates die per 1000 live births. This proportion is little higher in rural areas (27 per 1000 live births) and lower in urban areas (14 per 1000 live births). The major cause of neonatal deaths in India is identified as prematurity and low birth weight.[3]

An Infant death is death of child from birth to within first year of life. The causes of Infant mortality are multifactorial. Low birth weight and prematurity account for 57% of total infant deaths. Respiratory infections, diarrheal infections are the other important causes of infant deaths in India.[3]

Low birth weight has been defined as a birth weight less than 2.5 kg irrespective of gestation. The birth weight of baby is the single most important determinant of baby's chances of survival, healthy growth and development. Low birth weight babies can be majorly classified as those born prematurely and those with fetal growth retardation.[2,4]

Low birth weight is one of the important challenges in maternal and child health in developed and developing countries. Infant mortality rate is around 20 times higher for all LBW infants than for other infants. A low-birth-weight infant is susceptible to infections, adverse environmental influences, malnutrition etc.[5]

In most of the cases, in India even babies with full term gestation were found to be having low birth weight. Prematurity is the most important cause and early determination of GA is of prime importance. This is one of the main problems in remote areas where there are no treatment services open. Increasing incidence of post term pregnancy poses adverse effects on both the mother and infant health.[6]

In developing countries like India, most women do not remember date of last menstrual period. Ultrasonogram is also out of reach of many poor patients and patients living in rural and tribal areas. Determination of GA by different scoring systems is also not a practical approach.[7]

This illustrates the significance of alternate measurements that can estimate birth weight and GA. The important parameters for these alternate metrics should be reliability, ease of administration and a clear association for both birth weight and GA in all types of newborn children, such as preterm, term and post-term, as well as small GA (SGA), appropriate-for-GA (AGA) and large-for GA (LGA) groups of babies.

Foot is the most accessible part of neonate and foot length can be measured easily in preterm and sick neonates without disturbing the neonate. This technique does not require much expertise and can be easily carried out by health workers.

Aim

The aim of this study was to study correlation of foot length and GA among preterm, term and post-term neonates.

METHODS

This is a prospective observational study conducted in the department of paediatrics, Aarupadai Veedu medical college and hospital, Puducherry from November 2018 to May 2020.

Inclusion criteria

Term newborn, preterm newborn, singleton live births, twin live births of mothers who gave Informed consent were included.

Exclusion criteria

Newborn born with congenital anomalies of the foot, newborn with major congenital anomalies requiring cardiopulmonary support and still birth newborn were excluded from the study.

Methodology

After obtaining ethical committee clearance from the institute, convenient sampling was done and newborns were assessed based on the inclusion criteria.

A total of 155 newborn babies were included in this study. The data was collected in a predesigned proforma after obtaining informed and written consent from the mothers of the babies. Antenatal details and history regarding maternal illness were recorded.

All anthropometric measurements were recorded within 24 hours of life using standard techniques.

The birth weight was measured using an automated measuring system with a precision of ±5 gm.

The length of the infant was assessed by the infantometer and recorded in supine pose, with complete extension of the knee and soles of the legs placed tightly against the footboard and the head touching the set board. The distance between the top of the head and the heel was assessed at the nearest 0.1 cm.

Head circumference and chest circumference was measured using non-stretchable measuring tape with accuracy of ±0.1 cm. Head circumference of newborns was measured by wrapping the lightweight, non-stretchable tape measure over the head to cross over the supra-orbital ridges in front and the full occipitofrontal circumference.[5]

The chest circumference was measured by placing flexible non-stretchable measuring tape along level of nipple.

Foot length of the baby was measured from posterior most prominence of foot to the tip of the great toe of the right foot by using a sliding calliper scale.

GA assessment was done by using New Ballard score on day one of life.[6]

Based on GA, babies were grouped as preterm, term and post term babies. All the 3 groups of babies were categorized into small for SGA, AGA and LGA groups.

This classification was done by using intergrowth 21 chart.

All anthropometric measurements were performed by a single observer to prevent the inter-observer differences.

Data collection was done in a predefined format and entered in excel for analysis. These excel file was imported in SPSS version 20 software for further analysis.

RESULTS

A total of 155 newborn babies were included in this study. Birth weight was measured for all the 155 births and overall, 71% had a normal birth weight between 2.5 and 3.5 kg (Table 1).

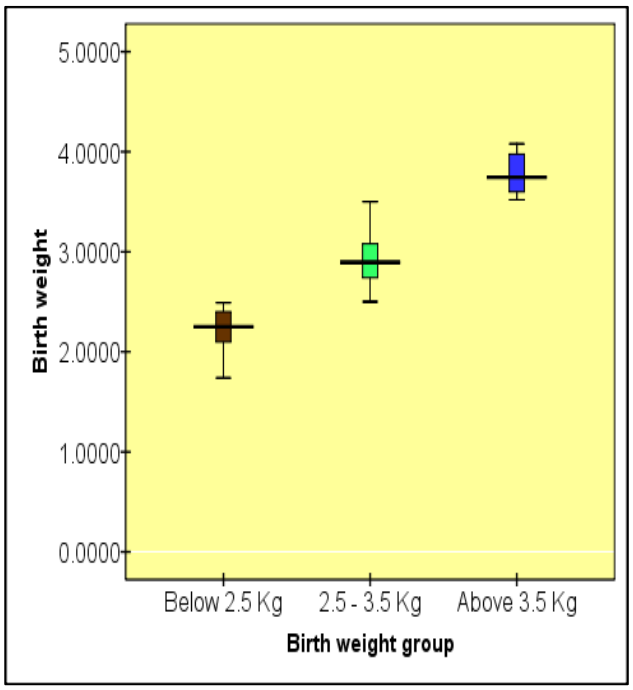

Figure 1: Distribution of birth weight.

It was observed that the overall average birth weight was 2.88 kg with 1.74 kg as minimum and 4.08 kg as maximum. However, the mean birth weight for below normal was 2.23 kg, while it was 2.92 among normal neonates and 2.88 for above normal birth weight babies. Birth order was elicited and a high proportion of newborn were in birth order 2 (51.6%), primi were 31.6% and third order was 14.8% (Figure 1).

LMP had found 21.3% of babies as pre-term and it was only 8.4% by NBS method. Term births were 71.0% in LMP but it was 90.3% by NBS. Post term births were 7.7% by LMP and it was only 1.3% by NBS method (Table 2).

The differences between the proportion of "terms" by these 2 methods of measurements was tested using Wilcoxon signed rank test and found that the differences were not significant (p=0.105). Hence, grouping of terms by both the methods are not significantly different from each other (Table 3).

Maternal illness was assessed for all the mothers and found that 69.0% (107) had no illness. Rest of the mothers had either one or more number of illness. Oligohydramnios leads the disease with 14.3% (22) followed by Anaemia 6.5% (10), PIH 5.2% (8) and gestational diabetes mellitus 2.6% (4). Mode of delivery was recorded for all the mothers and found that 74.2% had LSCS, 24.5% had NVD and Forceps delivery were 1.3%.

With preliminary data of all enrolled newborns, GA was calculated based on LMP, NBS and intergrowth 21 chart and foot length were measured using a sliding calliper scale. The mean value in each GA was studied and the results are shown below (Table 4).

Comparing the mean foot length of preterm and intergrowth 21 fetal growth standard, there was a statistically significant difference noted between intergrowth 21 fetal growth standard SGA, AGA and LGA, 62.60±2.6 mm, 65.86±2.67 mm and 70.00±0 mm respectively, (p=0.047).

Comparing the mean foot length of term and intergrowth 21 fetal growth standard, there was a statistically significant difference noted between intergrowth 21 fetal growth standard SGA, AGA and LGA, 63.44±1.33 mm, 67.93±1.92 mm and 70.56±1.5 mm respectively, (p<0.0001).

The mean foot length of post-term and intergrowth 21 fetal growth standard AGA was 69.50±0.5 mm.

There is statistically significant correlation of foot length with weight, length of the neonates, head circumference, chest circumference and NBS GA (Table 6).

Table 1: Distribution of birth weight by sex.

Sex	Birth weight (kg), n (%)			Total, n (%)	P value
	<2.5	2.5-3.5	>3.5		
Male	12 (14.3)	61 (72.6)	11 (13.1)	84 (100)	
Female	17 (23.9)	49 (69)	5 (7.0)	71 (100)	0.183
Total	29 (18.7)	110 (71)	16 (10.3)	155 (100	

Table 2: Distribution of term by LMP and NBS methods.

Term	LMP method		NBS method	
	N	%	N	%
Pre-term	33	21.3	13	8.4
Term	110	71.0	140	90.3
Post-term	12	7.7	2	1.3
Total	155	100.0	155	100.0

Table 3: Agreement in measuring terms by LMP and NBS methods (Wilcoxon Signed rank test).

	Rank	N	Mean rank	Sum of ranks	Z value	P value
Term by NBS and term by LMP	Negative ranks	14[a]	19.50	273.00	1.622	0.105
	Positive ranks	24[b]	19.50	468.00		
	Ties	117[c]				
	Total	155				

a. Term by NBS <term by LMP; b. Term by NBS >term by LMP; c. Term by NBS=Term by LMP.

Table 4: Descriptive statistics of foot length for different groups of babies based on NBS and intergrowth 21 chart.

GA by NBS	Intergrowth 21	Percentages (%)	Foot length (mm)		Minimum/ maximum	P value
			Mean	SD		
Preterm	SGA	5.8	62.60	2.6	60/66	0.047
	AGA	15.4	65.86	2.67	61/70	
	LGA	N/A	70.00	N/A	N/A	
Term	SGA	3.2	63.44	1.33	61/65	<0.0001
	AGA	67.7	67.93	1.92	62/72	
	LGA	6.4	70.56	1.5	69/73	
Post-term	SGA	N/A	N/A	N/A	N/A	N/A
	AGA	1.2	69.50	0.5	69/70	
	LGA	N/A	N/A	N/A	N/A	

Table 5: Distribution of head circumference and chest circumference.

GA	N	Head circumference, (Mean ± SD)	Chest circumference, (Mean ± SD)
SGA	14	31.29±0.82	29.21±0.97
AGA	131	33.58±1.34	31.37±1.11
LGA	10	35.8±1.69	32.9±1.73
Overall	155	33.52±1.59	31.28±1.36

Table 6: Correlation between foot length with selected variables.

Variables correlated with foot length	Over all			
	N	Pearson correlation	P value (2-tailed)	R^2 (%)
Age (in days)	155	0.100	0.215	1
GA by NBS	155	0.329	0.001	11
Weight (kg)	155	0.824	0.001	68
Length (cm)	155	0.622	0.001	39
Head circumference (cm)	155	0.733	0.001	54
Chest circumference (cm)	155	0.665	0.001	44

Table 7: Distribution of neonate's foot length based on GA by NBS.

GA by NBS	N	Mean	SD	P value
Pre-term	13	64.92	3.28	<0.0001
Term	140	67.81	2.28	
Post-term	2	69.50	0.71	
Total	155	67.59	2.49	

Table 8: Comparison of neonate's foot length among various groups by NBS.

GA by NBS		Mean difference	P value
Preterm	Term	-2.89	<0.0001
	Post-term	-4.58	0.036
Term	Preterm	2.89	<0.0001
	Post-term	-1.69	0.956
Post-term	Preterm	4.58	0.036
	Term	1.69	0.956

The mean foot length of preterm, term and post-term neonates was 64.92±3.28 mm, 67.81±2.28 mm and 69.50±0.71 mm respectively. Overall, there was a statistically significant increase in mean foot length noted when an increase in GA (p<0.0001) (Table 7).

Comparing the mean foot length of GA, there was a statistically significant mean difference noted between preterm with term and post-term, -2.89 mm (p<0.0001) and -4.58 mm (0.036) respectively. No statistically significant mean difference noted between term and post-term, -1.69 mm (p=0.956) (Table 8).

Multiple regression is used to assess the prediction capacity of GA measured by NBS method as an independent variable which was able to explain 10.2% variation in foot length. The regression formula equation-

foot length=64.07+0.645× GA by NBS.

Again, multiple regression analysis was carried out to obtain prediction of foot length by GA by NBS, weight, length, head circumference as independent variables.

Multiple regression analysis was done using various variables viz. GA by NBS, weight, and length and head circumference of the newborn after removing chest circumference due to multilinearity issues. Weight, length, head circumference of the baby was significantly contributing to estimate foot length.

DISCUSSION

The present study was done in 155 newborns to study the correlation between foot length, GA and anthropometric measurements in neonates, Assessment of the GA by Ballard's scoring requires expertise and handling of sick babies makes it difficult. Thus, foot length of the newborn can be used to replace all other measurement for estimation of GA and birth weight.

The present study shows that as the GA increases head circumference also increases. Gohil et al study showed lower head circumference for term SGA compared to term AGA which is similar to present study.[8] James et al study showed mean head circumference for term AGA and term SGA as 34.03±2.88 cm and 32.6±1.32 cm, respectively which is comparable to present study.[9]

Foot length for term SGA was 63.4 mm and post-term neonates was 69.5 mm. the foot length of the babies increased with increasing GA, which was comparable to the study by Gupta et al which revealed that preterm mean foot length varied from 6.23 cm and 6.87 cm for preterm SGA and AGA respectively. Whereas the mean foot length for term SGA, AGA, LGA were 7.07 cm, 7.7 cm and 8.71 cm respectively.[10]

The Kulkarni et al found a mean foot length of preterm neonates, varied from 4.6 cm to 6.89 cm, the foot length of the term neonate varied from 6.99 cm to 7.58 cm.[11]

The Gohil et al analysis found that the mean foot length of the preterm was 6.56±0.43 cm, the term SGA was 7.13±0.26 cm and the term AGA was 7.6±0.33 cm.[8] Shah et al analysis revealed a mean foot length of 7.18±0.57 cm in pre-terms and a mean foot length of 8.0±0.28 cm marginally higher than this study.[12] Another study done by Srinivasa et al had 7.63±0.35 cm as mean foot length of term babies and 6.92±0.49 cm as mean foot length preterm babies which was also higher than the present study.[13]

The James et al found that there was a strong linear association among foot length and other body size indices (birth weight, head circumference, crown rump length and crown heel length) in infants of both GAs.[9] Gohil et al have reported important association among foot length and other variables of the body (head circumference, birth weight) in preterm and term infants.[8]

The highest correlation of foot length in term SGA and term AGA babies for foot length was with head circumference (r=0.74 and 0.64 respectively) indicating that foot length and head circumference are affected in a similar fashion in term babies. In pre-terms, foot length correlated well with head circumference and birth weight (r=0.92, 0.84 and 0.92 respectively).[8,9,12]

The correlation of foot length with GA was ascertained and found that the GA measured by NBS were moderately and positively correlated (p<0.001). Apart from the GA, head circumference, chest circumference weight and length of the newborn were significantly correlated with foot length. This finding coincides with the results of Gavhane et al with maximum correlation in preterm AGA.[14] Among the anthropometric variables, weight of the newborn had the highest correlation with

foot length followed by head circumference, chest circumference and length of the newborn.

Limitation

Main limitation of the study is the sample size as the generalizability of the result in to the community is poor.

CONCLUSION

There was significant correlation observed between foot length and GA in different groups of newborns (preterm AGA, preterm SGA, term AGA and term SGA term LGA and post term AGA). Foot length also statistically correlated with other parameters like birth weight, length, head circumference and chest circumference and all these anthropometric parameters can be replaced by the single parameter foot length.

Recommendations

We recommend pre designed color coded tapes with mean foot length of various GA. In our opinion, it can provide timely identification of the newborns at risk in primary health centers for further referral.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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