Original Article

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Paediatrics Section

Foot Length as a Proxy Indicator for Detection of Birth Weight in Newborns: An Observational Cross-sectional Study

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ABSTRACT

Introduction: Birth weight is an important parameter to assess the overall wellbeing of a newborn. In developing countries like India, where large number of home deliveries occur, measuring birth weight is difficult. Studies have reported a positive correlation between birth weight and foot length. Hence, foot length may be considered as an alternative in place of birth weight, the former being an easy and cheap parameter to assess.

Aim: To assess the correlation between foot length and birth weight in newborns, delivered or referred within 24 hours of birth.

Materials and Methods: This observational cross-sectional study was conducted in the Neonatal Intensive Care Unit (NICU) at Shimoga Institute of Medical Sciences, Karnataka, India, (tertiary care hospital), from February 2021 to October 2021. A total of 902 newborns were included in the study. Foot length was measured with transparent ruler scale with 0.1 cm precision, and birth weight was recorded using digital weighing scale with 10 g precision. The correlation coefficient was calculated between foot length and birth weight.

Results: Out of 902 newborns, 495 (54.88%) were males. The mean birth weight was 2.57±0.56 kg. The mean foot lengths were 7.27±0.58 cm in <2.5 kg category, 7.3±0.47 cm in 2.5-3.5 kg category, and 7.82±0.48 cm in >3.5 kg category. The correlation coefficient between foot length and birth weight in <2.5 kg, 2.5-3.5 kg and >3.5 kg group were 0.96, 0.93 and 0.78, respectively.

Conclusion: Foot length can be used as a proxy measure to detect low birth weight in newborns in resource-limited settings where weighing is not possible.

Keywords: Correlation coefficient, Digital weighing scale, Low birth weight, Transparent ruler scale

INTRODUCTION

Health indicators are quantifiable characteristics of a population that are used for describing the health of the population. The Infant Mortality Rate (IMR), being one of the top five indicators, is an important marker of the overall health of a society. Hence, it is an important parameter to be focused on to improve overall health of a society.

The IMR is the number of deaths of infants under one year of age per 1000 live births in a given population. A large portion of infant deaths usually occur in the early neonatal period, mainly in the first week after birth, the main cause being Low Birth Weight (LBW), prematurity, and congenital abnormalities [1].

LBW and premature babies have higher risk for developing respiratory distress, neonatal sepsis, hypothermia, metabolic and neurological morbidity and neonatal mortality [2]. LBW and prematurity accounts for 50% of IMR [3]. Early identification of LBW and premature babies can significantly reduce the neonatal mortality. Care should be taken for the prevention of infections and very severe cases should be referred to higher centre for further interventions [4].

In developing countries, most of the time deliveries occur outside the healthcare facilities. In India, 31% of rural deliveries and 26% of overall deliveries are conducted by untrained persons [5]. Measuring birth weight is challenging due to poor healthcare facilities and untrained staff [6]. Even in tertiary care centres, weighing of babies in incubators and those on ventilators is difficult [7]. Hence, there is a need for an alternative and easily available method for assessing birth weight.

One such alternative parameter is the measurement of foot length which can be easily measured in mature, premature, and even sick babies. There are very few studies done across the world to assess the importance of foot length in determining the birth weight [8-10]. These studies demonstrated a positive correlation between birth weight and foot length. Hence, the present study was conducted to find a correlation between foot length and birth weight in newborns delivered or referred within 24 hours of birth.

MATERIALS AND METHODS

This observational cross-sectional study was conducted in the Neonatal Intensive Care Unit (NICU) at Shimoga Institute of Medical Sciences, Karnataka, India, (tertiary care hospital), from February 2021 to October 2021. This study included 902 newborns who satisfied the inclusion criteria, and the parents provided the consent for study. The study was approved by the Institutional Ethics Committee (SIMS/IEC/451/2020-21).

Inclusion and Exclusion criteria: All newborns delivered or referred to the study institute within 24 hours of delivery were included in the study. All congenital anomalies, limb deformities, and sick babies were excluded from the study.

Sample size calculation: Sample size was calculated using G Power software (version 3.1.9.4) based on linear regression (effect size f=0.02, alpha error=0.05, power=80%), using foot length to predict birthweight, and sample size required was 395.

Study Procedure

The relevant data of all newborns were collected in preformed proforma. Foot length was measured using a transparent ruler calibrated to 0.1 cm precision. While measuring, newborns were placed in supine position with plantar surface of right foot straightened by gentle push. Ankle was held to prevent grasp reflex. The ruler

was pressed over the sole of foot and measurement was taken from tip of great toe or tip of longest toe to posterior most prominence of the heel. The length was recorded in centimeters. Weight was measured by placing newborn naked on digital weighing scale (with 10 g precision) [Table/Fig-1].

[Table/Fig-1]: Measuring birth weight and foot length.

Based on the birth weight, the study population was divided into three groups:

- <2.5 kg
- 2.5-3.5 kg
- >3.5 kg

Mean birth weight and standard deviation were calculated in each group. Foot length in each group was recorded, mean and SD were calculated. The upper limit and lower limit of foot length with 95% confidence interval were calculated in each group.

STATISTICAL ANALYSIS

Data were entered in Microsoft Excel. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 18.0. Birth weight and foot length were summarised as mean and standard deviation with 95% confidence interval for mean. Pearson Correlation was done and correlation coefficient (r) was estimated along with p-values. A p-value of less than 0.05 was considered as statistically significant. Linear regression equation was derived separately for male and female newborns with birth weight as outcome variable and foot length as predictor variable.

RESULTS

Total of 902 newborns were included in the study, out of which 495 (54.88%) were males and 407 (45.12%) were females; 651 newborns were born in house and 251 newborns were referred from elsewhere. Out of 495 males, 317 (64%) belonged to the 2.5 to 3.5 kg group. Out of 407 females, 282 (69.29%) belonged to the 2.5 to 3.5 kg group [Table/Fig-2].

The birth weight of 902 newborns ranges between 0.84 and 4.2 kg with mean of 2.57±0.56 kg [Table/Fig-3]. The mean foot length of 902 newborns was 7.3±0.51 cm, ranging from 5.4 to 8.5 cm. 95% confidence interval for mean of foot length was 7.26 to 7.33 cm [Table/Fig-4]. The mean foot length increased with increasing birth weight.

Birth weight (kg)	Male n (%)	Female n (%)	Total n (%)
<2.5	171 (34.55)	120 (29.48)	291 (32.26)
2.5-3.5	317 (64)	282 (69.29)	599 (66.41)
>3.5	7 (1.41)	5 (1.23)	12 (1.33)
Total	495 (100)	407 (100)	902 (100)

[Table/Fig-2]: Segregation of newborns in groups based on their birth weight.

Birth weight (kg)	Number of newborns	Birth weight Mean±SD (kg)	Range	95% CI for mean	
				LL	UL
<2.5	291	1.91±0.41	0.84-2.47	1.87	1.96
2.5-3.5	599	2.87±0.22	2.50-3.50	2.85	2.89
>3.5	12	3.90±0.23	3.60-4.20	3.76	4.04
Total	902	2.57±0.56	0.84-4.20	2.53	2.61

[Table/Fig-3]: Descriptive statistics of birth weight under different categories.
SD: Standard deviation; CI: Confidence interval; LL: Lower limit; UL: Upper limit

Group	Birth weight (kg)	Number of newborns	Foot length Mean±SD (cm)	p-value (One-way ANOVA)
A	<2.5	291	7.27±0.58	0.001
B	2.5-3.5	599	7.30±0.47	
C	>3.5	12	7.82±0.48	
Comparison	A vs B	A vs C	B vs C	
Pairwise p-value (Post-hoc Bonferroni test)	0.99	0.001	0.001	

[Table/Fig-4]: Descriptive statistics of foot length according to birth weight of newborns.
p<0.05 was considered as statistically significant; (Mean FL=7.30±0.51 cm)

There was significant correlation between birth weight and foot length, with p<0.001 and correlation factor of 0.55. The highest correlation was seen in the group of birth weight <2.5 kg with correlation coefficient of 0.96 [Table/Fig-5]. The regression was calculated for males and females with foot length as independent variable and birth weight as dependent variable [Table/Fig-6].

Birth weight (kg)	Number of newborns	Correlation (r)	p-value
<2.5	291	0.96	<0.001
2.5-3.5	599	0.93	<0.001
>3.5	12	0.78	0.003
Total	902	0.55	<0.001

[Table/Fig-5]: Correlation between birth weight and foot length in newborns.

Gender	Dependent variable	Regression equation	p-value for FL
Male	Birth weight	-1.88+0.607*FL	<0.001
Female	Birth weight	-1.67+0.587*FL	<0.001

[Table/Fig-6]: Regression equation of birth weight on Foot Length (FL) according to gender.

DISCUSSION

This study was conducted to determine the correlation between foot length and birth weight. Mean foot length increased with increase in birth weight. The correlation coefficient between birth weight and foot length was 0.55 with p<0.001.

In studies conducted by Gowri S and Kumar GV [8], Gaur NL et al., [9] and Shaji SM [10] there was a linear association between birth weight and foot length with gradual increase in foot length as birth weight increased. This study showed a positive correlation

Authors of previous studies	Sample size (n)	Mean birth weight (kg)	Mean foot length (cm)	Correlation			Regression equation
				<2.5 kg	2.5-3.5 kg	>3.5 kg	
Gowri S and Kumar GV [8]	600	2.64±0.53	7.47±0.56	0.94	0.64	0.29	BW (<2.5 kg)=-2.69+0.151 FL
							BW (2.5-3.5 kg)=-0.9+0.23 FL
							BW (>3.5 kg)=2.63+0.6FL
Gaur NL et al., [9]	1082	2.74±0.42	7.68±0.47	0.494	0.624	-0.081	BW (Male)=-2.2944+0.6609 FL
							BW (Female)=-2.2516+0.6434 FL
Shaji SM [10]	611	2.95	7.85±0.42	0.768	0.871		BW=0.923×FL-3.705
Modibbo MH and Taura MG, [11]	551	3.08±0.55	8.12±0.58	0.657			BW=-1.98+0.624 FL
Dagnew N et al., [12]	205	2.62±0.77	7.41±0.68	0.803			
Taksande AM [13]	520	2.55±0.40	7.83±2.21	0.715			
Present study	902	2.57±0.56	7.3±0.51	0.96	0.93	0.78	BW (Male)=-1.88+0.607*FL
							BW (Female)=-1.67+0.587*FL

[Table/Fig-7]: Comparison of birth weight, foot length, correlation coefficient and regression equation between different studies [8-13].
FL: Foot length; BW: Birth weight

between birth weight and foot length (r=0.55). This correlation was significant (p<0.001). A strong positive correlation was seen between birth weight and foot length in newborns belonging to <2.5 kg group (r=0.96; p<0.001) and the least positive correlation was seen in >3.5 kg group (r=0.78; p=0.003). A higher correlation coefficient were seen by Gowri S and Kumar GV [8], Shaji SM [10] and Dagnew N et al., [12]. Other studies showed a lower correlation coefficient [9,11,13]. The regression equations of different studies were compared in [Table/Fig-7] [8-13].

After the analysis of data, the cut-off foot length to identify LBW in newborns was 7.5 cm. This cut-off would help in classifying newborns and early referral. In the study conducted by Mehta DR et al., the cut-off foot length was 7.34 cm [14]. Similarly in others, the cut-off foot length to recognise LBW was 7.85 cm and 6.9 cm [15,16].

Different methods for measuring foot length were described in different studies. Few studies used higher equipment like calipers or measuring board [16-18]. The calipers may not be available easily. A tape may be better than a transparent scale because the tape can be bent. But the most commonly used method is a transparent ruler scale [19,20]. This method is cheap and easy to train Anganwadi workers and other healthcare providers at the community level. These community workers may visit every newborn immediately after birth within 24 hours. If foot length is below the cut-off then that newborn should be referred to higher centres where facilities are available.

Limitation(s)

Since, this was a hospital-based study, it may not represent the population in the community. Hence, larger studies in the community are required to validate this study.

CONCLUSION(S)

This study showed positive correlation between foot length and birth weight with (r=0.55). Maximum correlation was seen in newborns with birth weight <2.5 kg. Measuring foot length using transparent ruler is cheap, easily available and does not require any expert staff. It can be used in rural areas with limited resources and even in sick newborns in incubators and on ventilators where weighing is not possible. To conclude, foot length can be used as a proxy measure to detect LBW in newborns which will help in early referral and reduction in mortality and morbidity.

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