Original Article

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The Correlation between Foot Length and Birth Weight among Newborns

Neonatology Section

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ABSTRACT

Introduction: The birth weight of a newborn is an important parameter which reflects the overall health of neonates, chances of future growth and survival. The large number of neonatal deaths, contributing to an average 64% of all neonatal deaths, mostly occurs in the starting 6-7 days of life. Most of neonatal deaths are due to Low Birth Weight (LBW). In small villages of our country the weighing facility may not be available for all home deliveries. Thus, a simple parameter like foot length may be considered in place of birth weight.

Aim: To find out the correlation between foot length and birth weight so that the birth weight could be assessed by measuring foot length alone.

Materials and Methods: The observational cross-sectional study was conducted in the KD Medical College Hospital and Research Centre, Mathura, Uttar Pradesh, India, between July 2018 to January 2020. All healthy full term (1082) newborns were included in the present study. All the measurements were recorded within 24 hours of birth. Sick newborns and newborns with congenital anomalies were excluded from this study. Birth weight was recorded by electronic weighing scale in fraction of kilograms (kg) and length of foot was measured in fraction of centimetre (cm). Correlation between foot lengths with birth weight were statistically analysed by "Pearson's Correlation Coefficient" test and regression analysis.

Results: Out of 1082 neonates, there were 558 (51.57%) males and 524 (48.43%) females. The newborn in group I (weight below 2.5 kg) had a mean foot length of 7.1357 cm. In group II (weight between 2.5-3.5 kg) the mean foot length was 7.7998 cm. In group III (weight more than 3.5 kg) the foot length was 8.2428 cm. The correlation coefficient between birth weight and foot length, in group I and group II, showed significant positive correlation (r=0.494, r=0.624).

Conclusion: In the present study, foot length of neonates significantly correlated with their birth weight. Thus "Foot Length" parameter can be used in rural areas, by health care workers, for early and quick identification of LBW newborns.

Keywords: Electronic weigh scale, Low birth weight, Preterm newborns, Solid plastic transparent ruler

INTRODUCTION

Anthropometry of newborn is a reasonable, non invasive and advantageous instrument for bedside assessment of health particularly in sick and weak newborns. It can be used in newborn as a tool for various purposes like prediction of early postnatal complications, diagnosis of foetal malnutrition and postnatal assessment of growth. This tool is also used to evaluate the nutritional status and prediction of long term complications i.e., metabolic syndrome, body composition and estimation of body surface [1].

LBW has been explained by the World Health Organisation (WHO) as weight at birth less than 2500 grams (g). The global prevalence of LBW is 15.5%, which means that about 20.6 million such newborns are born each year. The incidence of LBW neonates varies in different geographical regions of world i.e., the highest incidence is observed in South-Central Asia (27.1%) and lowest in Europe (6.4%). These countries can substantially decrease their newborn mortality rates by better care of LBW newborns [2]. Body size is evidently proportional to age and it relates to the newborn throughout early years, until the time of skeletal merge. Thus, size of newborn at birth reflects the average growth rate for that infant from conception to birth [3].

The large number of neonatal deaths, contributing to an average 64% of all neonatal deaths mostly occurs in the starting 6-7 days of life. The perinatal conditions, malnutrition and acute respiratory infections are the major causes of mortality among newborn and child in developing countries including India [4]. The birth weight of newborn not only shows mother and newborn health, mortality and morbidity, but also shows the health of the community, country and area. Birth weight is strongly related with newborn and child morbidity and mortality [5]. Therefore, it is considered as an important parameter which reflects the overall health of neonates, chances of future growth and survival. Birth weight is also related with socio-economic, racial, clinical, individual, genetic, and geographical factors [6].

In fact, birth weight is assessed for only about half of the infants born in these areas of developing countries and gestational age is known only in few infants [7]. Main factors of neonatal deaths are diseases associated with preterm birth, LBW, and congenital anomalies. So, the early detection of LBW and preterm newborns are very important. But the situation is more difficult in rural and remote areas because few resources like lack of trained or expert medical care staff and lack of primary facilities. It has been reported that early finding of LBW newborns helps in decreasing the newborns mortality and morbidity [8-10].

Indian illiterate poor and especially many villagers are not aware about the consequences of LBW. A large number of deliveries up to (31%) in Indian rural areas are conducted by untrained functionaries. A 2010-11 report by Ministry of Health & Family Welfare, Govt. of India, described that 23% of newborns were not weighed at birth because the deliveries were conducted in homes where weighing scales were not available and thus weighing of baby was not possible [11]. Measurement of foot length is simple and does not need any type of skill [12]. The diseases associated with LBW are main causes of neonatal mortality [13].

It is easy to measure the foot length of newborn even in incubator and intensive care equipment [14]. Foot length measurement is easily taken in mature, premature and sick newborns. The aim of present study was to find out the correlation between foot length and birth weight in newborns of Mathura region, Uttar Pradesh, India.

MATERIALS AND METHODS

This observational cross-sectional study was conducted in the Department of Anatomy, K.D. Medical College Hospital and Research Center Mathura, Uttar Pradesh, India, between July 2018 to January 2020. The present study consisted of 1082 full term newborn babies from Mathura region, with kind permission of concerned authorities. Informed consent of the parents was obtained for the study. The present study was conducted after taking permission from the Institutional Ethics Committee (KDMCHRC/IEC/2019/17) for Human Research (IECHR). The newborn delivered in the institute during the study period and fulfilling the inclusion criteria were included in the study.

Inclusion criteria: All newborns babies born at or referred to KD Medical College Hospital Mathura Uttar Pradesh, India within 24 hours of birth were included in the present study.

Exclusion criteria: Sick newborns, newborns with congenital malformations and newborns after 24 hours of birth were excluded from this study.

Sample collection and method: Foot length of all the newborns was measured by using solid transparent plastic ruler [Table/Fig-1]. Foot length was measured from anterior end of longest toe to the posterior most prominence of the right foot. When measuring the foot length, the anterior surface of foot was straightened out using light push. The measurement of foot length was recorded in fraction of cm. Newborns were weighed naked in supine position, soon after birth by digital scale with 10 gram subdivision. The newborn were divided into three different groups i.e., group I consisted of newborn weighing below 2.5 kg; group II included newborn weighing between 2.5-3.5 kg and group III consisted of newborns more than 3.5 kg.

[Table/Fig-1]: Photograph showing foot length measured by hard transparent plastic ruler.

STATISTICAL ANALYSIS

The collected data was entered in Microsoft Office Excel sheet and data were analysed using the Statistical Package for the Social Sciences (SPSS) software (version 28.0). Correlation between foot length and birth weight was analysed by "Pearson's Correlation Coefficient" test. The statistical analysis was considered significant when $p<0.05$. A simple linear regression analysis was used to obtain regression equation. This equation was obtained to predict birth weight of newborn from foot length in male and female newborns.

RESULTS

A total of 1082 newborns, 558 (51.57%) males and 524 (48.43%) females were enrolled for the present study [Table/Fig-2]. In this study, 76% of newborns belonged to the rural population. Out of 1082 deliveries, 80% newborns were delivered by normal vaginal delivery. Two hundred twenty (20.333%) newborns of group I (weight below 2.5 kg) were LBW. Group II consisted of total 813 newborns (75.139%) weighing in the range of 2.5-3.5 kg. In group III total 49 newborns (4.528%) had birth weight greater than 3.5 kg.

Birth weight in (kg)	Male		Female		Total	
	Number	%	Number	%	Number	%
<2.5	82	7.58	138	12.76	220	20.333
2.5-3.5	444	41.04	369	34.10	813	75.139
>3.5	32	2.95	17	1.57	49	4.528
Total	558	51.57	524	48.43	1082	100

[Table/Fig-2]: Gender wise distribution of newborn based on their birth weight.

The birth weight range of 1082 newborns was from 0.9-4.01 kg, with a mean of 2.7411 kg (SD±0.4240). This showed 95% confidence interval for mean between 2.7158-2.7664 kg [Table/Fig-3].

Birth weight in (kg)	No. of Newborn	Range	Mean	Stander Deviation	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
< 2.5	220	0.9-2.49	2.1757	0.2927	2.1366	2.2148
2.5-3.5	813	2.5-3.47	2.8390	0.2682	2.8205	2.8574
> 3.5	49	3.5-4.01	3.6297	0.1484	3.5870	3.6723
Total	1082	0.9-4.01	2.7411	0.4240	2.7158	2.7664

[Table/Fig-3]: Descriptive statistics of birth weight under different categories.

The total mean foot length of 1082 newborns was 7.6861 cm with a range of 6-8.9 cm and standard deviation of 0.4702 [Table/Fig-4]. There was corresponding increase in "mean foot length" (7.13 to 8.24 cm) with the increase in birth weight of babies.

Birth Weight in (kg)	No. of Newborn	Range	Mean	Stander Deviation	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
< 2.5	220	6-8.4	7.1357	0.4561	7.0748	7.1966
2.5-3.5	813	6.4-8.8	7.7998	0.3434	7.7762	7.8234
> 3.5	49	6.9-8.9	8.2428	0.3564	8.1404	8.3452
Total	1082	6-8.9	7.6861	0.4702	7.6580	7.7141

[Table/Fig-4]: Descriptive statistics of foot length according to birth weight of babies.

In this study, it was found that the birth weight correlated significantly ($p<0.01$) with foot length in newborns less than 3.5 kg, with positive corelation in group I and group II newborns (with correlation factor 0.494 and 0.624, respectively) [Table/Fig-5].

Birth Weight (in kg)	No. of Newborn	Correlation	t-value	p-value	Sig/NS
<2.5	220	0.494	8.39	0.01**	Sig.
2.5-3.5	813	0.624	22.74	0.01**	Sig.
>3.5	49	-0.081	0.56	0.578	NS.

[Table/Fig-5]: Correlation between birth weight and foot length in newborns.
Pearson's Correlation Coefficient; ** Correlation is significant at the 0.05 level

The estimated regression equation for birth weight of male and female newborns was derived with foot length as the independent variable and birth weight as the dependent variable [Table/Fig-6].

Gender	Dependent Variable	Regression Equation
Male	Birth weight	BW=-2.2944+0.6609 FL
Female	Birth weight	BW=-2.2516+0.6434 FL

[Table/Fig-6]: Regression equation of birth weight on foot length according to gender.

DISCUSSION

In the present study, authors considered foot length as a proxy measurement to detect the newborns birth weight. In present study, out of 1082 newborns, 51.57% were males and 48.43% were females. Elizabeth NL et al., studied total 706 neonates in their study in which there were, 380 (54%) were males and 326

(46%) females [15]. In another study done in Iran by Sajjadian N et al., have shown that 52.2% males and 47.8% females out of 500 neonates studied [16]. Joshi G and Chaudhary N studied 316 LBW newborns out of which 54% were males and 46% were females [17]. Taksande AM et al., studied 520 newborns (51.34% males and 48.65% females), while Kc A et al., studied 811 newborns (53.1% males and 46.8% females) [18,19]. Gowri S and Kumar GV in their study analysed 328 (54.67%) males and 272 (45.33%) females out of 600 newborns [14]. The study done by Kapoor A and Soni TN they were found total 514 newborns, 281 (54.67%) male newborns and 233 (45.33%) were female newborns [20]. Present study findings were close to other studies done in India which have described slight male dominance.

In this study, birth weight ranged from 0.9-4.01 kg with a mean of 2.74 kg. The study done by Mukherjee S et al., a total of 351were included out of which 182 (51.8%) were LBW. Their mean birth weight was 2.09 (±0.81) kg [12]. Work done by Gowri S and Kumar GV included total 600 newborn, the birth weight ranged from 0.7-3.88 kg, with the mean of 2.64 kg [14]. Manivannan G et al., study showed that 10 newborns (16.67%) had weight below 2.5 kg with minimum and maximum values of foot length 6.2 and 8.7 cm respectively. They reported mean birth weight 2.85 kg [5]. Kapoor A et al., found birth weight ranged from 1200-3600 gm and the mean birth weight was 2650.18 gm with the standard deviation of 377.89 [20].

In present study, foot length ranged from 6-8.9 cm and mean foot length was 7.686 cm with standard deviation of 0.47. It clearly shows that when birth weight of newborns rise the foot length also rise. This finding was compared with various other studies [Table/Fig-7] [5,14,15,18,20,21].

Authors	Place of Study	Publication Year	Mean of foot Length (cm)	Stander Deviation	Correlation coefficient (r)
Modibbo MH and Taura MG [21]	Kano State, Nigeria.	2013	8.12	0.58	0.657
Elizabeth NL et al., [15]	Kampala, Uganda.	2013	7.2	0.46	0.76
Taksande AM et al., [18]	Wardha, Maharashtra, India.	2016	7.83	2.21	0.715
Gowri S and Kumar GV [14]	Tumkur, Karnataka, India.	2017	6.94	0.56	0.94
Manivannan G et al., [5]	Bengaluru, Karnataka, India.	2019	7.59	0.51	0.98
Kapoor A and Soni TN [20]	Bhopal, Madhya Pradesh, India	2020	7.16	0.48	0. 802
Present study	Mathura, Uttar Pradesh, India.	2021	7.686	0.47	0.624

[Table/Fig-7]: Mean, Standard deviation and Correlation coefficient (r) of foot length in various studies [5,14,15,18,20,21].

The correlation coefficient (r) of birth weight and foot length for group I was 0.494 and for group II was 0.624. The correlation coefficient (r) values for both the groups (I & II) were statistically significant ($p<0.01$). In present study the estimate regression equation for birth weight of male and female newborns was considered with "foot length" as the independent variable and "birth weight" as the dependent variable.

BW (male)=-2.2944+0.6609 FL

BW (female)=-2.2516+0.6434 FL

The results and observations of present study were compared with the data from other studies is shown [Table/Fig-8].

Authors	Place of study	Publication year	Regression equation
Modibbo MH and Taura MG [21]	Kano State, Nigeria	2013	BW = 0.624 x FL- 1.98
Minhajuddin A et al., [22]	Karad, Maharashtra, India	2014	BW(male)= (0.377) x FL – (-0.44) BW(female)= (0.424) x FL – (-0.444)
Gowri S and Kumar GV [14]	Tumkur, Karnataka, India	2017	BW = 0.151 x FL- 2.69
Manivannan G et al., [5]	Bengaluru, Karnataka, India	2019	BW=0.64638 FL- 2.16694
Present study	Mathura, Uttar Pradesh, India	2021	BW (male) =-2.2944+0.6609 FL BW (female) =-2.2516+0.6434 FL

[Table/Fig-8]: Regression equation for birth weight using foot length in various studies [5,14,21,22].

Limitation(s)

Here, the foot measurement was considered within 24 hours of birth and newborns after 24 hours of birth were excluded.

CONCLUSION(S)

The present study was carried out to determine the birth weight in newborn babies by measuring their foot length. Positive significant correlation was found between two parameters i.e., birth weight and foot length- such that one parameter could be predicted from other. The determination of birth weight by measuring foot length is an easy and useful method for villages especially in underdeveloped countries. The parameter of foot length is useful in early identification of LBW newborns which may help to decrease newborn mortality. In future, further studies like comparison of LBW with other parameters like head, thigh and calf circumferences are recommended.

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