



Newborn Foot Length Measurement as a Screening tool for the Prediction of Birth Weight

Authors

Shaji SM^{1*}, Hisham Abdu Rahiman M², Leya Sara³, Lalitha Kailas⁴

¹Associate Professor, Department of Paediatrics, Sree Gokulam Medical College & Research Foundation, Thiruvananthapuram, Kerala, India

^{2,3}Resident, Department of Paediatrics, Sree Gokulam Medical College & Research Foundation, Thiruvananthapuram, Kerala, India

⁴Professor & HOD, Department of Paediatrics, Sree Gokulam Medical College & Research Foundation, Thiruvananthapuram, Kerala, India

*Corresponding Author

Shaji SM

Abstract

Background: *Since decades attempts have been made to find an alternative measurement for birth weight estimation of the newborns. Appropriate and timely care of a low birth weight newborn is important but most of the deliveries are conducted at home in rural areas where adequate facilities to weigh a newborn does not exist. Newborn Foot length has been studied by various authors as proxy measurement which can be executed easily in sick and preterm newborns where minimal handling and movements are preferred. This study was done to find correlation between foot length and birth weight.*

Materials & Method: *Birth weight and foot length of 611 babies born in a tertiary level teaching hospital during the period from November 2014 to April 2015 were analysed. Babies with limb deformities were excluded from the study. The birth weight of babies were recorded in electronic weighing scale and documented in kilograms. The foot length was measured and documented in centimetres, from posterior most prominence of foot to the tip of the longest toe of the right foot. Correlation of foot length with birth weight were statistically analysed by correlation and regression analysis.*

Results: *Of the 611 neonates studied, male neonates were more than female neonates in number consisting 54.8% and 45.2% respectively. The birth weight of neonates studied ranged from 1.5-4.41 kg. Low birth weight neonates in present study constituted 86 (14.0%) of which 31 (36.1%) were preterm and 55 (63.9%) were term. In present study, constituted 554 term neonates (90.7%) and 57 preterm neonates (9.3%). The foot length of preterm neonates ranged from 6.4-7.0 cm with the mean foot length of 6.8232 cm. The foot length of term neonates ranged from 7.1-8.7 cm with a mean foot length of 7.9084 cm. In the study, the foot length correlated significantly with birth weight. Correlation coefficient (r-value) was highly positive for birth weight (r=0.923). Our study showed that there was a positive linear correlation between foot length and birth weight in babies and the correlation coefficient (r-value) of low birth weight babies was lower (r=0.768). A regression equation (Birth weight = 0.923 x Foot Length – 3.705) was derived based on this study with birth weight and foot length being the dependent and independent variable respectively.*

Keywords: *Foot Length; Birth Weight; Neonate; Plastic stiff transparent ruler; Electronic Weigh Scale.*

Introduction

The most challenging part of infant mortality is the large proportion of new born deaths, contributing to an estimated 64% of all infant deaths, mostly in the first week of life.¹ Major causes of neonatal mortality and morbidity are diseases associated with prematurity, low birth weight as well as lethal congenital anomalies due to susceptibility to adverse environmental influences, predilection to infections and difficulties in maintaining adequate nutrition. 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 accounts for about 70% of all perinatal and 50% of all infant deaths in India.³

Some adults who were small for-gestational age at birth appear to have a higher risk of coronary heart disease and related health problems, including hypertension, non-insulin-dependent diabetes and stroke. Birth weight and gestational age have traditionally been used as strong indicators for the risk of neonatal death⁴. The situation is made worse due to non-availability of resources in the form of trained or expert health care staff and lack of basic facilities such as electronic weighing machines.⁵ Foot length is one such parameter which can be measured easily in preterm and sick neonates without disturbing the baby. All these factors thus underline the importance of early identification of low birth weight and preterm babies at the rural setup where no medical care facilities are available and early reference to higher centres.

This points towards the need for an alternative measurement which is reliable, having a very good correlation with both birth weight and gestational age in all groups of new born babies such as preterm, term and post-term as well as in the small-for gestational age (SGA), appropriate-for-gestational age (AGA) and large-for gestational age (LGA) groups of babies. A number of studies have been done in this regard for

finding suitable substitute measurements for gestational assessment and birth weight estimation. The technique used for measuring such a parameter should be simple so that even an untrained health care staff can do the measurement reliably. This study is being done to find a correlation between foot length and birth weight

Materials and Methods

This cross-sectional study was conducted over six months period (November 2014 to April 2015) in 611 newborns less than 72 hours of age admitted in Neonatology Unit of a tertiary level teaching hospital in Kerala. Babies having skeletal deformities of the foot has been excluded from the study. The Study Variables for mother were parity, gestational age, antenatal risk factors (GDM, PIH), history of drug intake during pregnancy, mode of delivery and for the baby was birth weight, sex, gestational age and foot length. Study Instruments were Electronic weighing scale for measuring weight and Plastic stiff transparent ruler for measuring foot length. After obtaining valid written consent from mother before delivery, 611 consecutive babies born during the study period, satisfying the inclusion and exclusion criteria were recruited for the study. The study was started after getting the clearance from both the Human Ethical and Research committee.

Babies birth weights, sex and mode of delivery were noted. The foot length of the newborns has been taken by measuring the right foot of each baby from the heel to the tip of great toe using a plastic stiff transparent ruler. Foot length was measured from posterior most prominence of foot to the tip of the longest toe of the right foot. At the time of measuring ventral surface of foot was straightened out using gentle pressure. The length of foot was documented in centimetres.

Analysis

The data were entered prospectively in to a Microsoft excel sheet and the results were analysed using SPSS statistics version 20.0.

Results

Table 1: Sex wise Distribution of Study Population

Sex	Number of cases	%
Girl	276	45.2
Boy	335	54.8
Total	611	100

In the present study, male babies constituted 335 (54.8 %) and 276 female babies (45.2 %)

Table 2: Sex Distribution of Babies based on their birth weight

BIRTH WEIGHT (kg)	Male		Female		Total	
	Number	%	Number	%	Number	%
<2.5	43	12.8	43	15.6	86	14.0
2.5- 4.0	289	86.3	231	83.7	520	85.1
>4.0	3	0.9	2	0.7	5	0.9
Total	335	100	276	100	611	100

In the study group 86 babies (14.0%) were low birth weight babies, i.e. weight below 2.5 kg. 520 newborns (85.1%) had birth weight in the range of 2.5-4.0 kg. 5 newborns (0.9%) had birth weight

more than 4 kg. Maximum number of newborns were in 2.5-3.5 kg group. Males predominate over females in all groups.

Table 3: Distribution of babies according to their maturity and weight for gestational age

MATURITY	AGA		SGA		LGA		TOTAL	
	No.	%	No.	%	No.	%	No.	%
TERM	458	74.9	87	14.2	9	1.7	554	90.8
PRETERM	42	6.8	13	2.1	2	0.3	57	9.2
TOTAL	500	81.7	100	16.3	11	2.0	611	100

Among 611 neonates in present study, small for gestational age, appropriate for gestational age, and large for gestational age babies were 100 (16.3%), 500 (81.7%) and 11(2%) respectively. The number of Term AGA, SGA and LGA in

present study were 458 (74.9%), 87 (14.2%) and 9 (1.7%), respectively. The number of Preterm AGA and SGA and LGA were 42(6.8%), 13(2.1%) and 2 (0.3%) respectively.

Table 4: Descriptive Statistics Of Foot Length For Preterm Babies

Gestation	Number of Subjects	Mean	Standard deviation
PRETERM < 2.5 KG	31	6.8483	0.32951
PRETERM 2.5 – 4 KG	26	7.5692	.294983
Total	57	7.1771	.477724

Of the 611 neonates studies the mean foot length of 57 preterm neonates was 7.1771 cms with a range of 6.4 – 7.0 cms and standard deviation of 0.477724. The 31 preterm babies weighing below

2.5 kg had a mean foot length of 6.8483 cms and 57 preterm babies weighing in between 2.5 kg to 4 kg had a mean foot length of 7.5692 cms.

Table 5: Descriptive Statistics of foot length for term babies

Gestation	Number of Subjects	Mean	Standard deviation
TERM < 2.5 KG	55	7.1218	.251433
TERM 2.5 – 4 KG	494	7.9263	.353246
TERM > 4 KG	5	8.6400	.547723
Total	554	7.8528	.425456

Of the 611 neonates studied the mean foot length of 554 term neonates was 7.8526 cms with a range of 6.6 – 8.7 cms and standard deviation of 0.425456. The 55 term babies weighing below 2.5 kg had a mean foot length of 7.1218 cms and 494

term babies weighing in between 2.5 kg to 4 kg had a mean foot length of 7.9263 cms. The 5 term babies weighing more than 4 kg had a mean foot length of 7.8528 cms.

Table 6 : Correlation Between Foot Length And Birth Weight

Anthropometric Variable	Correlation (r)	R – square (r ²)
Birth weight (kg)	0.923	0.852

From this table, it could be observed that of the 611 neonates in the study, the foot length

correlated significantly with birth weight (r= 0.923).

Table 7 : Correlation Between Foot Length And Birth Weight less than 2.5 kg and between 2.5 kg and 4 kg

Anthropometric Variable	Correlation (r)	R – square (r ²)
< 2.5 kg	0.768	0.590
2.5 – 4 kg	0.871	0.759

From, this table it could be observed that foot length of babies correlated with birth weight of babies weighing between 2.5 kg and 4 kg (r =

0.768) and the correlation of foot length with birth weight of babies less than 2.5 kg was lower (r = 0.768).

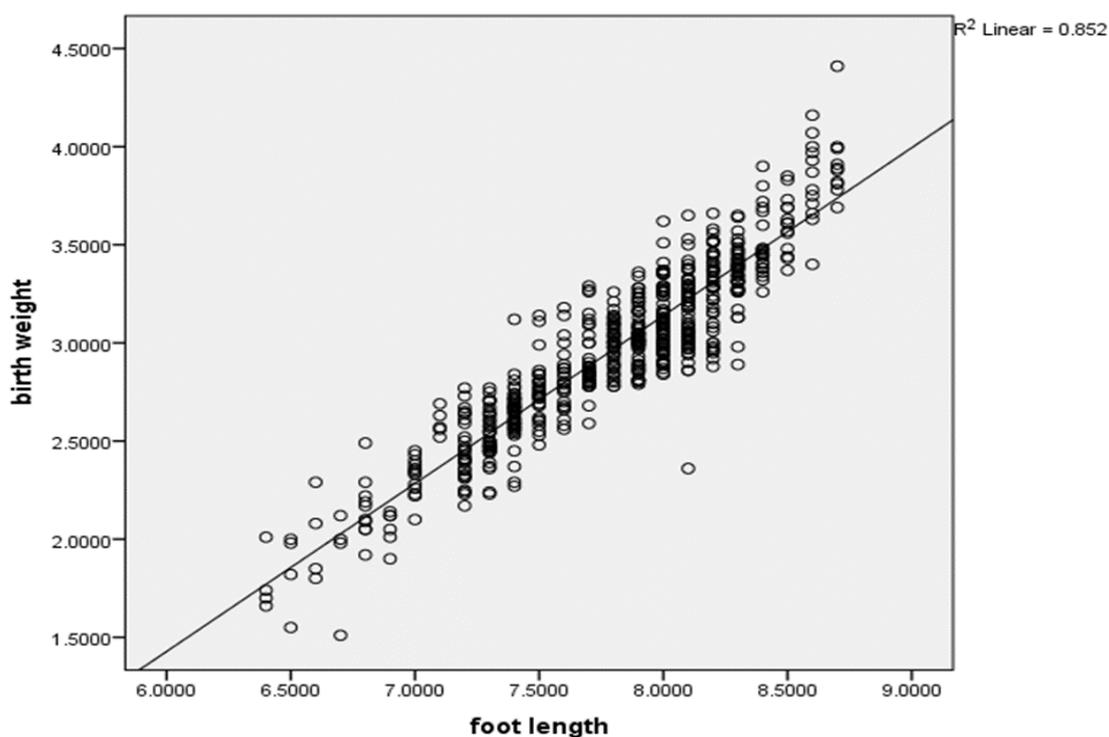


Fig 1 : Graph Showing The Correlation Between Foot Length And Birth Weight

In this study, a positive linear correlation between foot length and birth weight was observed.

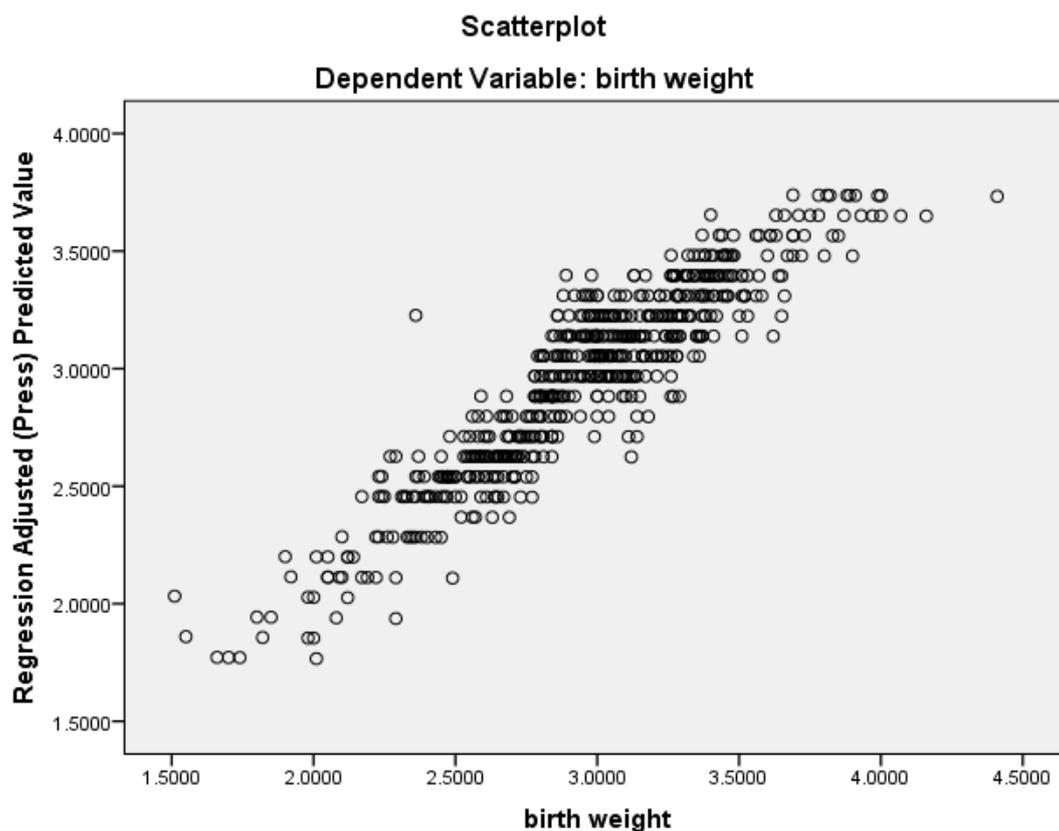


Fig 2 : Scatter Plot Diagram Of Birth Weight

This figure shows the scatter plot of the birth weight of the 611 neonates present in the study.

Table 8 : Regression equation of birth weight on foot length

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	REGRESSION EQUATION
BIRTH WEIGHT	FOOT LENGTH	BW = 0.923 X FL – 3.705

The regression equation for birth weight was derived with foot length as the independent variable and birth weight as the dependent variable.

Discussion

The early identification of low birth weight babies is an important prerequisite of any initiative to reduce mortality. There are various measurements to assess newborn growth. Some of the routine measurements done at birth are head circumference, chest circumference, crown heel length, birth weight, etc. In many developing countries including India, the equipments required to measure them may not be available or the babies will be sick and minimum handling is needed to get the maximum information about the growth of the baby. Flexed posture of term baby

also lead to difficulty in measurement of length. In such cases foot length is an easy tool which can be measured even in sick neonates. It requires less handling and is less disturbing to the neonate.

The present study is being done to find correlation between foot length and birth weight in neonates, so that foot length can be used as a proxy measurement for estimation of birth weight.

Of the 611 neonates studied, male neonates were more than female neonates in number consisting 54.8% and 45.2% respectively. This is comparable to the study done by Shambhu Sharan Shah et al.⁹ which showed 52.4% males and 47.6% females. However, James et al.⁶ study showed 59 males (48%) and 64 females (52%) out of 123 neonates studied.

The birth weight of 611 neonates studied ranged from 1.5-4.41 kg with a mean of 2.9592 kg. In the

study done by Shambu Sharan Shah et al.⁹ where 1000 newborns were studied, showed a birth weight range of 0.85-4.3 kg and had a mean birth weight of 2.931 ± 0.464 kg which is comparable to the present study.

In a study done by Huque F et al.² in 217 newborns the mean birth weight was 2.679 kg which is comparable to present study. The study done by Hossain MM et al. in 148 newborns showed a mean birth weight of 3.5 kg.

Low birth weight neonates in present study constituted 86 (14.0%) of which 36.1 % were preterm and 63.9% were term. Shambu Sharan Shah et al.⁹ showed 12.6% low birth weight babies of which 39.7% were preterm and 60.3% were term. In a study done by Kamaladoss et al.¹⁰ prevalence of low birth weight was 24.6%.

In present study, constituted 554 term neonates (90.7%) and 57 preterm neonates (9.3%). This is comparable with other studies. Gohil JR et al.⁷ study showed 10.4% preterm babies and 89.5% term babies. Kulkarni et al.⁸ study showed 17.5% preterm and 82.4% term neonates. James et al.¹¹ study showed 76.4% term and 39.6% preterm neonates. Shambhu Sharan Shah et al.⁹ study showed 92.9% term, 6.7% preterm and 0.4% post-term neonates. Majority of the studies have not analysed anthropometric parameters in post-term neonates.

Among 611 neonates in present study, small for gestational age, appropriate for gestational age, and large for gestational age babies were 16.3%, 81.7% and 2% respectively. This is comparable to Shambu Sharan Shah et al.⁹ study which showed 13.2% small for gestational age, 84.8% appropriate for gestational age and 2.1% large for gestational age babies.

Term AGA, SGA and LGA in present study were 74.9%, 14.2% and 1.7%, respectively. Preterm AGA, SGA and LGA were 6.8%, 2.1% and 0.3% respectively.

In James et al.¹¹ study, 59.7% were term AGA and 29.7% were term SGA. Shambhu Sharan Shah et al.⁹ study showed term AGA, SGA and LGA as 78.4%, 12.5% and 2%, respectively, preterm AGA

and SGA babies were 6% and 0.7%, respectively and post-term AGA were 0.4%.

Foot length is an easy anthropometric measurement which can be measured in sick and preterm neonates receiving intensive care which can act as a proxy measurement. The foot length of preterm neonates ranged from 6.4-7.0 cm with the mean foot length of 6.8232 cm. The foot length of term neonates ranged from 7.1-8.7 cm with a mean foot length of 7.9084 cm. This shows that foot length increases with respect to gestational age.

Kulkarni et al.⁸ study which showed mean foot length of preterm neonates ranged from 4.6 cm to 6.89 cm and the mean foot length of term neonates ranged from 6.99 cm to 7.58 cm. Gohil JR et al.⁷ study showed the mean foot length of preterms as 6.56 ± 0.43 cm which is comparable with present study. Shambhu Sharan Shah et al.⁹ study showed the mean foot length in preterms as 7.18 ± 0.57 cm and terms as 8.0 ± 0.28 cm which are slightly higher than ours. Though the mean foot length of all the above studies showed there is a positive linear relationship between foot length and birth weight, the correlation coefficient (r-value) of foot length and birth weight was different in different studies.

In the present study, the foot length correlated significantly with birth weight. Correlation coefficient (r-value) was highly positive for birth weight ($r=0.923$). Our study showed that there was a positive linear correlation between foot length and birth weight in babies and the correlation coefficient (r-value) of low birth weight babies was lower ($r=0.768$). A regression equation (Birth weight = $0.923 \times$ Foot Length – 3.705) was derived based on this study with birth weight and foot length being the dependent and independent variable respectively.

James et al.¹¹ study showed that there was a positive linear correlation between foot length and other birth weight in SGA and AGA babies of all gestational ages.

Gohil JR et al.⁷ study showed significant relationship between foot length and other body

parameters (crown heel length, head circumference, birth weight) in preterm and term neonates. The present study results were comparable to those of James et al¹¹, Gohil JR et al.⁷ and Shambhu Sharan Shah et al.⁹ In the present study, foot length correlated significantly with birth weight.

The present study was done to assess the correlation of foot length with birth weight and was found to show significant correlation.

Conclusion

Significant correlation was observed between foot length and birth weight of the babies in the study. The correlation (r-value) of foot length and birth weight was 0.923. A positive linear correlation between foot length and birth weight was observed. The regression equation for birth weight was derived $BW = 0.923 \times FL - 3.705$ with foot length as the independent variable and birth weight as the dependent variable. For screening low birth weight babies foot length serves as an efficient tool. Foot length is a easy and reliable anthropometric measurement and can be used as a proxy measurement of birth weight especially in sick and pre-term neonates admitted in Neonatal ICU where minimal handling is recommended. It can be easily assessed by medical practitioners and traditional birth attendants in the community.

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