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A STUDY OF CORRELATION OF POSTNATAL FOOT LENGTH AND GESTATIONAL AGE AND COMPARISION WITH VARIOUS METHODS OF GESTATIONAL AGE ASSESSMENT

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ABSTRACT

Introduction

Foot length is quite simple as a proxy parameter, can be measured easily by a well calibrated ruler or tape and does not require much expertise which can help for early identification of preterm and low birth weight babies at the rural setup and early reference of high risk babies to higher centers to help in decreasing neonatal mortality and morbidity. This study has done to find a correlation between foot length, birth weight and gestational age assessed by various methods in both preterm and term babies and the utility of newborn foot length as screening tool to identify preterm babies.

Material and Methods

400 newborn babies within 48 hours of birth whose mothers with documented LMP and dating USG done at 1st trimester were included in this study. Foot length was measured using sliding calipers which is having an accuracy of a millimeter.

Results

The preterm neonates had a mean foot length of 6.75, 6.46 and 7.28 cms, respectively. The mean foot length for term neonates was 7.65, 7.25 and 8.12 cms, respectively. It was observed that the foot length correlated significantly ($p<0.05$) with gestational age in all maturity groups. There

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was a significant positive correlation observed between gestational age as determined by all methods like USG, LMP and New Ballard Score and average foot length.

Keywords: Postnatal foot length, gestational age, preterm, term, New Ballard Score, screening tool

Abbreviations:

USG: Ultrasonography

LMP: Last menstrual period

MAIN TEXT

ABBREVIATIONS:

USG: Ultrasonography

LMP: Last menstrual period

LBW: Low birth weight

SGA: Small for gestational age

AGA: Appropriate for gestational age

LGA: Large for gestational age

GA: Gestational age

NBS: New Ballard Score

INTRODUCTION

Foot length is quite simple as a proxy parameter which can be measured easily by a well calibrated ruler or tap and does not require much expertise and also in preterm and sick neonates it can be done without disturbing them, where minimal handling and movements are preferred. Even when a baby is surrounded by intensive care unit personnel and various machines, it would still be possible for the paramedics to determine the baby's foot-length. This measurement technique is not influenced by either subcutaneous fat or biological sex. A ruler is small, does not

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take up space, and it can be taken to deliveries outside a hospital premises i.e. in remote areas, and can be adequately cleaned and sanitized. It can help for early identification of preterm and LBW babies at the rural setup where no medical care facilities are available and early reference of high risk babies to higher centers to help in decreasing neonatal mortality and morbidity.

This study is being done to find a correlation between foot length, birth weight and gestational age assessed by various methods in both preterm and term babies and the utility of newborn foot length as screening tool to identify preterm babies.

MATERIALS AND METHOD

Study Area – Department of Neonatology, Tertiary care Hospital, Pune, Maharashtra

Study Population – All live newborn babies admitted to Ruby hall clinic within 0 to 48 hours of birth.

Study Design – Prospective cross-sectional study

Study Duration – 1st September 2021 – 30th June 2022

Sample size – 400 newborn babies.

Inclusion Criteria

All live newborns babies within 48 hours of birth whose mothers with documented LMP and dating USG done at 1st trimester.

1. Pre-term (Small-for-gestational age, Appropriate-for-gestational age, Large-for- gestational age)
2. Term (Small-for-gestational age, Appropriate-for-gestational age, Large-for-gestational age)
3. Post-term (Small-for-gestational age, Appropriate-for-gestational age, Large-for-gestational age)

Exclusion Criteria

Babies with congenital anomalies of lower limbs (e.g. CTEV)

Instruments used

1. Sliding calipers for measuring foot length.
2. Electronic weighing scale for measuring weight.

METHOD OF COLLECTION OF DATA

Data was collected using standard proforma meeting the objectives of the study.

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a) Gestational age assessment was done using modified Ballard's score. LMP and 1st trimester USG was collected from mother and gestational age was calculated from that.

b) Foot length was measured using sliding calipers which is having an accuracy of a millimeter. 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 centimeters.

c) Weight of the baby was measured using electronic weighing scale. The scale offered an accuracy of ± 5 gm. All the dress of baby was removed before weighing.

Babies were grouped into preterm, term and post-term categories. Babies less than 37 weeks of gestation were counted in the preterm group. Babies ≥ 42 weeks of gestation were counted in the post-term age group.

All the three groups of babies were categorized into small for gestational age (SGA), appropriate for gestational age (AGA) and large for gestational age (LGA) groups. This classification was done by using Intergrowth-21st Newborn size growth charts.

STATISTICAL ANALYSIS

Data had analyzed using SAS (University Edition). Karl Pearson's correlation coefficient has been using to check correlation between gestational and foot length. Unpaired student's t test had used for comparison between Gestational Age by USG and foot length, Birth Weight. Liner regression analysis was used for prediction of Gestational age. Chi square test was for qualitative data. Other appropriate statistical tests were applied for the data. P value < 0.05 will be considered as statistically significant.

Ethical considerations- The Institutional Ethical Committee permissions was taken before Beginning the study

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RESULT

This study included a total of 400 neonates of which males were 54% and females were 46%. In the study group 149 babies (37.25%) were low birth weight babies, i.e. weight below 2.5 had birth weight > 3.5 kg. Maximum numbers of newborns were in 2.5-3.5 kg group. Males predominate over females except LBW (< 2.5 kg) group.

Table 1: Descriptive statistics of foot length for different groups of babies

Maturity	Number of Subjects	Range	Mean	Standard Deviation	95% confidence interval for Mean	
					Lower bound	Upper bound
Preterm SGA	23	5.60-7.00	6.4604	0.3743	6.2985	6.6223
Preterm AGA	113	4.80-7.70	6.7586	0.5005	6.6653	6.8519
Preterm LGA	6	6.30-7.80	7.2816	0.5597	6.6942	7.8690
Term SGA	35	6.71-7.76	7.2560	0.3154	7.1476	7.3643
Term AGA	213	6.80-8.60	7.6540	0.3721	7.6038	7.7041

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Term LGA	8	7.75-8.60	8.1250	0.2852	7.8865	8.3634
Post term AGA	2	8.16-8.40	8.2800	0.1600	-	-
Total	400	4.80-8.60	7.3000	0.6100	7.2420	7.3610

This table shows the descriptive statistics of foot length for different groups of babies. Of the 400 neonates studied the mean foot length was 7.30 cm with a range of 4.80-8.60 cms and standard deviation of 0.61 with 95% confidence interval for mean between 7.24 cm to 7.36 cm. The preterm AGA, SGA and LGA had a mean foot length of 6.75, 6.46 and 7.28 cms, respectively. The mean foot length for term AGA, SGA and LGA was 7.65, 7.25 and 8.12 cms, respectively. The mean foot length for post-term AGA was 8.28 cm. There were no newborns in post-term SGA and post-term LGA groups.

Table 2: Correlation between foot length and gestational age

Maturity	**Number of Subjects**	**GA by USG**	
		Correlation (r)	**P - value**
Preterm AGA	113	0.8420	0.0001
Preterm SGA	23	0.7814	0.0001
Preterm LGA	6	0.8459	0.0001
Term AGA	213	0.5424	0.0001
Term SGA	35	0.6631	0.0001
Term LGA	8	0.1126	0.0001
Post-term AGA	2	-	-

From this table, it could be observed that the foot length correlated significantly ($p<0.05$) with gestational age in all maturity groups. Correlation coefficients (r-value) of all the groups were highly positive. Maximum correlation was observed with preterm LGA

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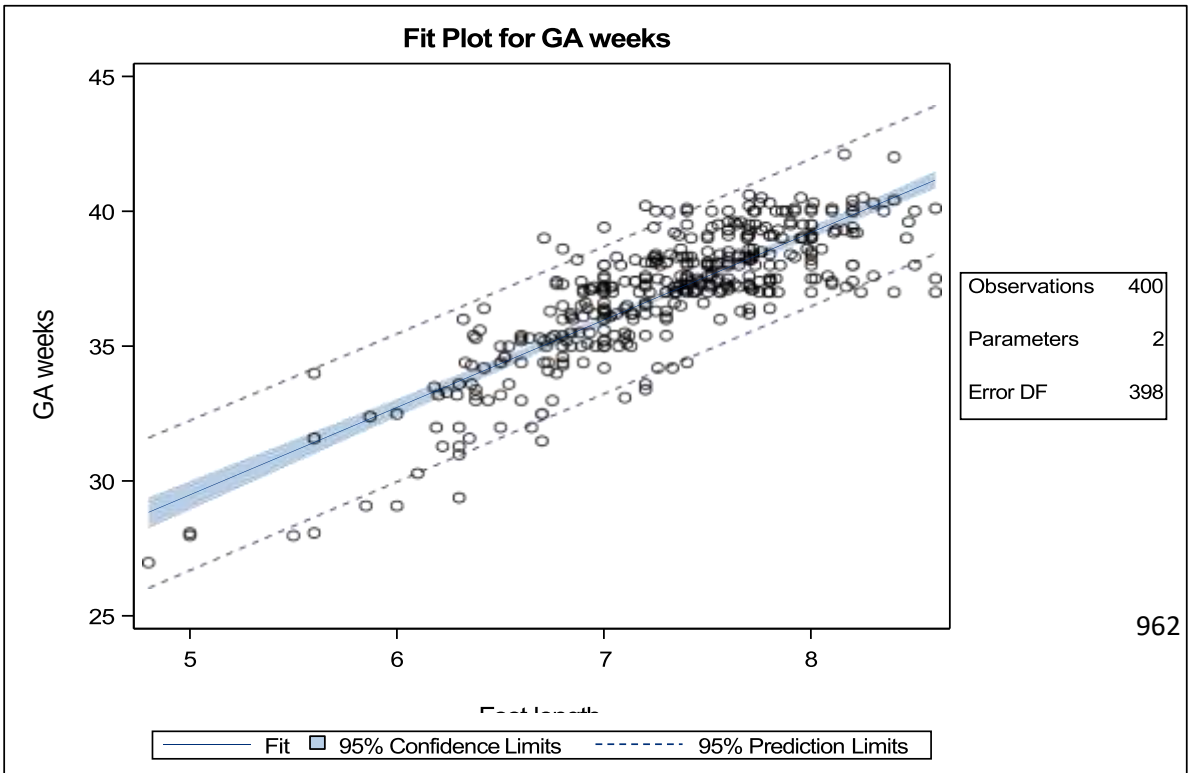
group (r = 0.8459). As the post-term group was very small, statistical analysis was not possible.

Table 3: Overall correlation between gestational age by USG and foot length

Variable	N	Mean	SD	Mean	SD	Correlation (r)	P Value	df	t	P Value
USG	400	36.949	2.398	29.646	1.943	0.819	0.0001	399	305.05	0.0001
Foot length	400	7.302	0.610							

In this table, gestational age by USG and foot length average was compared with paired sample ‘t’ test. The ‘r’ value or correlation value was 0.81, which denoted a strong positive correlation among the two variables. The ‘p’ value was found to be 0.0001 which was statistically significant.

Graph 1: Correlation between foot length and gestational age



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This graph is showing a positive linear correlation between gestational age and foot length. The regression equation for gestational age was derived with foot length as the independent variable and gestational age as the dependent variable.

REGRESSION EQUATION = GA = 3.24 x FL + 13.27 (R^2 = 0.672)

Here, 3.24 indicate the slope of the equation and 13.27 are constant. The slope value infers that 1cm increase in foot length means 3.24 weeks increase in the gestational age. The R^2 value infers that the regression equation correctly predicts the gestational age in 67.2% of the times.

Table 4: Correlation between gestational age by LMP and foot length

Variable	N	Mean	SD	Mean	SD	Correlation (r)	P Value	df	t	P Value
LMP	400	36.949	2.398	29.646	1.942	0.802	0.0001	399	305.22	0.0001
Foot length	400	7.302	0.610							

When the gestational age using LMP was compared with the average foot length using paired sample 't' test, a strong positive correlation among the two variables with correlation value (r=0.80) was noticed. It was again supported by a statistically significant 'p' value of 0.0001.

Table 5: Correlation between gestational age by NBS and foot length

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Variable	N	Mean	Std Dev	Mean	StdDev	Correlation (r)	P Value	df	t	P Value
NBS	400	37.21	2.426	29.912	1.946	0.834	0.0001	399	307.38	0.0001
Foot length	400	7.302	0.610							

On comparing the gestational age by New Ballard Score with average foot length using paired sample 't' test, a strong positive correlation value (r=0.83) was noticed with a 'p' value of 0.0001, which was statistically significant.

Table 6: Correlation between foot length and birth weight in different groups

Maturity	Number of Subjects	Birth weight	
		Correlation (r)	P - value
Preterm AGA	113	0.6420	0.0001
Preterm SGA	23	0.8455	0.0001
Preterm LGA	6	0.8975	0.0001
Term AGA	213	0.6420	0.0001
Term SGA	35	0.7528	0.0001
Term LGA	8	0.1602	0.0001
Post-term AGA	2	-	-

From this table, it could be observed that the foot length correlated significantly ($p<0.05$) with birth weight in all maturity groups. Correlation coefficient (r-value) of all the groups was highly positive. Maximum correlation was observed with preterm LGA group (r = 0.8975). As the post-term group was very small, statistical analysis was not possible.

Table 7: Overall correlation between birth weight and foot length

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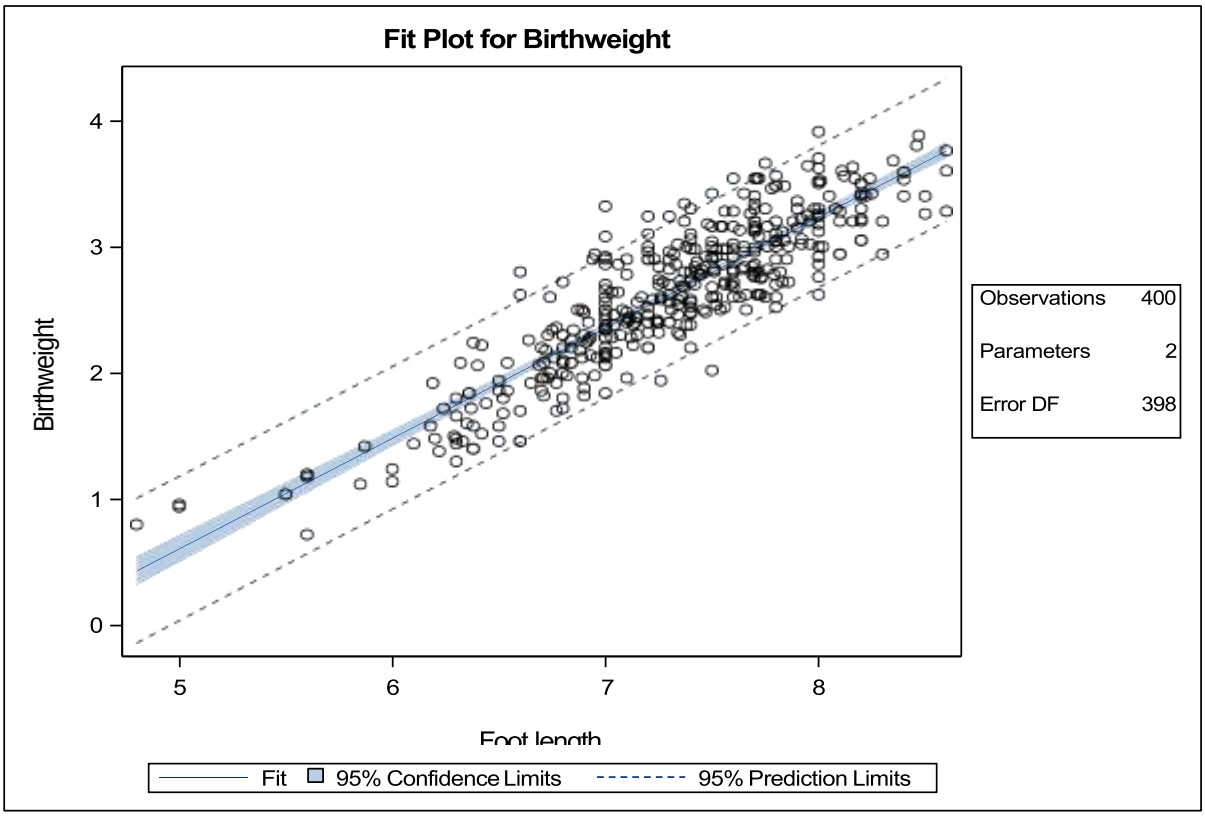
Variable	N	Mean	SD	Mean	SD	Correlation (r)	P Value	df	t	P Value
Birth Weight	400	2.627	0.605	4.67	0.294	0.882	0.0001	399	317.38	0.0001
Foot length	400	7.302	0.610							

In this table, birth weight and foot length were analyzed using paired sample‘t’ test. The ‘r’ value (correlation value) was found to be 0.882 which meant a strong positive correlation between the two variables (foot length and birth weight), which was supported with a ‘p’ value (0.0001) of statistical significance.

Graph 2: Correlation between foot length and birth weight



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This graph is showing a positive linear correlation between birth weight and foot length. The regression equation for birth weight was derived with foot length as the independent variable and birth weight as the dependent variable.

REGRESSION EQUATION = BW = 0.876 x FL – 3.770 (R^2 = 0.779)

Here, 0.876 indicates the slope of the equation and 3.770 is constant. The slope value infers that 1cm increase in foot length means 0.876 kg increase in the birth weight. The R^2 value infers that the regression equation correctly predicts the birth weight in 77.9% of the times.

DISCUSSION

The birth weight of 400 neonates studied ranged from 0.72-3.91 kg with a mean of 2.62 kg and the standard deviation of 0.60. In the study done by Shambu Sharan Shah et al [1] where 1000 newborns were studied, showed a birth weight range of 0.85-4.3 kg which is comparable to present study, but had a mean birth weight of 2.931 ± 0.464 kg. In a study done by Huque F et al in 217 newborns the mean birth weight was 2.679 kg which is comparable to present study [2]. The study done by Hossain MM et al in 148 newborns showed a mean birth weight of 3.5 kg [3].

Low birth weight neonates in present study constituted 149 (37.25%) of which 80.5% were preterm and 19.5% were term. Shambu Sharan Shah et al.53 showed 12.6% low birth weight babies of which 39.7% were preterm and 60.3% were term [1]. In a study done by Kamaladoss et al prevalence of low birth weight was 24.6% [4]. In a study by Mathur A et al showed 33% low birth weight babies which is comparable to our study [5].

In present study, majority of neonates were term (64%), 35.5% were preterm and 0.5% were post-term neonates. This is comparable with other studies. Gohil JR et al study showed 10.4% preterm babies and 89.5% term babies [6]. Kulkarni et al study showed

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17.5% preterm and 82.4% term neonates [7]. James et al study showed 76.4% term and 39.6% preterm neonates [8]. Shambhu Sharan Shah et al study showed 92.9% term, 6.7% preterm and 0.4% post-term neonates [1].

As the post-term group was small in number to be statistically significant, statistical analysis of this group was not done. This was also the case in many studies such as Kulkarni, Gohil, James, Shambhu Sharan Shah etc. [7,6,8,1].

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 4.80-7.80 cm with the mean foot length of 6.46 cm, 6.75 cm and 7.28 cm for preterm SGA, AGA and LGA, respectively. The foot length of term neonates ranged from 6.71-8.80 cm with a mean foot length of 7.25 cm, 7.65 cm and 8.12 cm for term SGA, AGA and LGA, respectively. The foot length for post-term neonates ranged from 8.16-8.40 cm, with a mean foot length of 8.28 cm. This shows that foot length increases as the gestational age increases.

These findings are comparable to Kulkarni et al which showed mean foot length of preterm neonates ranged from 4.60 cm to 6.89 cm and the mean foot length of term neonates ranged from 6.99 cm to 7.58 cm [7]. Gohil JR et al study showed the mean foot length of preterm as 6.56 ± 0.43 cm, term SGA as 7.13 ± 0.26 cm and of term AGA as 7.6 ± 0.33 cm which is comparable with present study [6]. Shambhu Sharan Shah et al study showed the mean foot length in preterm as 7.18 ± 0.57 cm and terms as 8.0 ± 0.28 cm which are slightly higher than ours [1].

Though the mean foot length of all the above studies showed there is a positive linear relationship between foot length and gestational age, the correlation coefficient (r-value) of foot length and gestational age was different in different studies.

In the present study, Gestational age, as determined by early USG was taken as the gold standard. In pre-term AGA neonates, foot length correlated significantly ($p < 0.05$) with gestational age and birth weight. Correlation coefficient (r-value) was highly positive for GA and birth weight, 0.84 and 0.64, respectively which indicates strong positive association between them.

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In pre-term SGA neonates, foot length correlated significantly ($p < 0.05$) with gestational age and birth weight. Correlation coefficient (r-value) was highly positive for GA and birth weight, 0.78 and 0.84, respectively which indicates strong positive association between them.

In the present study, in pre-term LGA neonates, foot length correlated significantly ($p < 0.05$) with gestational age and birth weight. Correlation coefficient (r-value) was highly positive for GA and birth weight, 0.84 and 0.89, respectively which indicates strong positive association between them. Maximum correlation of foot length with birth weight and gestational age was observed in this group.

In term neonates also, foot length correlated significantly ($p < 0.05$) with gestational age and birth weight. Correlation coefficient (r-value) was highly positive in term AGA, term SGA and term LGA groups for birth weight, 0.64, 0.75 and 0.16, respectively and for gestational age 0.54, 0.66 and 0.11, respectively.

Foot length positively correlated very well with gestational age assessed by LMP in the present study with a significant r value of 0.80. Average foot length at 27 weeks was 4.80 cm and 8.28 cm at 42 weeks. The results obtained were similar to that of Kulkarni et al Mean foot length at 28 weeks and 41 weeks were 5.6 centimeter and 7.5 centimeters respectively [7]. Daga et al through their study suggested that foot length measurement of 6.5 cm be made cut off for identifying a newborn at risk of being born within 34 weeks [9]. In the present study average foot length corresponding to 34 weeks was 6.7 cm. All these values suggest that foot length can be reliably used in gestational age assessment. When gestational age was plotted against mean foot length, a linear association was obtained. As the study group included many small for gestational age and growth restricted babies, the linear association graph showed a dip in age groups where SGA babies were predominant, as foot growth was also affected in such babies due to growth restriction.

Statistically significant linear correlation was obtained between foot length and gestational ages assessed by ultrasound and NBS with an r value of 0.81 and 0.83 respectively, in this study. A study done by Mukherjee et al proved that for identification of preterm babies, foot length of 7.75 cm had a sensitivity and specificity of 92.3 % and

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86.3 % [10]. Average foot lengths corresponding to 37 weeks in the present study were 7.71 and 7.44 cm respectively, when LMP and ultrasound were used to determine the gestational age. Hence the results obtained were comparable. Fetal foot length measurement using ultrasound is a good marker for gestational assessment. Platt et al concluded that foot length correlated with menstrual age with an r value of 0.94 [11].

In this study, a positive linear correlation was observed between foot length and birth weight with an r value of 0.88 which is significant. Foot length correlated with age in appropriate for gestational age, small for gestational age and large for gestational age babies. Similar results were obtained in various studies like James et al, Gohil JR et al and Shambhu Sharan, et al [8,6,1].

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LIMITATIONS

There is a lack of ethnical representivity, and a larger study is required to determine if the Merz model is applicable to areas where more Indian and Caucasian infants are prominent. This study's sample size precluded further analyses to define the effect of antenatal steroids, multiple pregnancies and SGA/ LGA on foot length. Moreover, our study was done in a hospital-based setting, so the prevalence of preterm was higher than in a community setting in which the incidence of IUGR is higher. Number of babies was also not equal in all gestational groups. There were no babies in post- term SGA and LGA groups.

CONCLUSION

Significant correlation was observed between foot length and gestational age assessed by all three methods, namely, LMP, USG, and NBS, in different groups of newborns (preterm AGA, preterm SGA, preterm LGA, term SGA, term AGA, tern LGA, post-term AGA). Foot length also correlated well with birth weight significantly.

The correlation of foot length with gestational age and birth weight was higher in preterm neonates than in term neonates. Term SGA babies showed higher correlation (r value) of foot length with gestational age and birth weight than term AGA babies. The foot length is an efficient screening tool in identifying preterm and low birth weight babies.

The highest correlation (r value) of foot length was with gestational age in preterm LGA

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babies (r = 0.8459) and with birth weight in preterm LGA babies (r = 0.8975). Term AGA (r= 0.6420) and term SGA (r = 0.7528) babies showed higher correlation of foot length with birth weight. As the post-term group was very small in number to be statistically significant, statistical analysis of this group was not done.

Overall in study, the highest correlation (r value) was observed between foot length and birth weight (r = 0.88). Out of the three methods of gestational age assessment, highest correlation was observed with New Ballard score (r = 0.834) followed by early USG (r = 0.819) and then with LMP (r = 0.802).

Foot length is a quite simple, quick, reliable and easy anthropometric measurement which can be used as an alternative parameter to predict gestational age and birth weight especially in sick and pre-term neonates receiving intensive care. It can be easily measured by traditional birth attendants in the community and hence can be used as a screening tool to identify preterm and low birth weight babies in remote areas.

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REFERENCES

1. Shah SS, Shrestha PS, Gami FC. Detection of low birth weight newborns by footlength as a proxy measure of birth weight. Archives of Disease in Childhood 2005;90(Suppl 2):A9-A10.
2. Huque F, Hussain Z. Detection of low birth-weight new born babies by anthropometric measurements in Bangladesh. The Indian Journal of Pediatrics. 1991 Mar 1;58(2):223-31.
3. Hossain MM, Habib H, Dupont HL. Association between birth weight and birth arm circumference of neonates in rural Egypt. Indian Journal of Paediatrics 1994;61:81-7.
4. Kamaladoss T, Abel R, Sampathkumar V. Epidemiological correlates of low birth weight in rural Tamilnadu. Indian Journal of Paediatrics 1992;59:299-304.
5. Mathur A, Tak SK, Kothari P. 'Foot Length'—a Newer Approach in Neonatal Anthropometry. Journal of tropical pediatrics. 1984 Dec 1;30(6):333-6.
6. Gohil JR, Sosi M, Vani SN, Desai AB. Footlength measurement in the neonate. The Indian Journal of Pediatrics. 1991 Sep 1;58(5):675-7.
7. Kulkarni ML, Rajendran NK. Values for foot length in newborns. Indian Pediatr. 1992 Apr 1;29(4):507-9.
8. James DK, Dryburgh EH, Chiswick ML. Foot length--a new and potentially useful measurement in the neonate. Archives of disease in childhood. 1979 Mar 1;54(3):226-30.
9. Daga SR, Daga AS, Patole S, Kadam S, Mukadam Y. Foot length measurement from foot print for identifying a newborn at risk. Journal of Tropical Pediatrics 1988 Feb;34(1):16-19.

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10. Mukherjee S, Roy P, Mitra S, Samanta M, Chatterjee S. Measuring new born foot length to identify small babies in need of extra care: a cross-sectional hospital based study. Iranian Journal of Pediatrics. 2013 Oct;23(5):508.
11. PLATT LD, MEDEARIS AL, DeVORE GR, HORENSTEIN JM, CARLSON DE, BRAR HS. Fetal foot length: relationship to menstrual age and fetal measurements in the second trimester. Obstetrics & Gynecology. 1988 Apr 1;71(4):526-31.