

## Original Research Article

# Prediction of gestational age of newborn by measurement of foot length at birth

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### ABSTRACT

**Background:** Gestational age of the newborn can be assessed by various methods. Aim of this study was to estimate the gestational age using foot length of the neonate and to find the correlation between foot length and gestational age assessed by last menstrual period and first trimester ultrasound.

**Methods:** It was a hospital based prospective cross-sectional study done at Newborn ward, Department of Pediatrics, MGM Govt. hospital attached to KAP Viswanatham Govt. Medical College, Tiruchirappalli, involving 170 newborns with 10 babies in each gestational age ranging from 26 weeks to 42 weeks. Gestational age of all babies were assessed using last menstrual period, first trimester ultrasound and New Ballard Score soon after birth. Right foot length of each baby was measured from heel to tip of great toe or second toe whichever was longer, within 12-24 hours of life. Measurements were taken using a plastic ruler, measuring tape and by measuring the length of foot print ink impression. Gestational age obtained by various methods were assessed for their correlation with foot length.

**Results:** Positive correlation was obtained between foot length and gestational age determined by LMP ( $r=0.965$ ) and ultrasound ( $r=0.964$ ). Hence foot length could be reliably used to predict gestational age of newborn.

**Conclusions:** Foot length measurements can be used as a non-invasive alternative method to assess gestational age of newborn, especially by community health workers and thus can facilitate the early identification of preterm babies.

**Keywords:** Foot length, Gestational age, Preterm

### INTRODUCTION

Most vulnerable period of life is neonatal period. Neonatal deaths account for 45% of all deaths among children under five. 75% of all neonatal deaths occur in the first week of life and among them 25% to 45% occur within the first 24 hours. The main cause of neonatal mortality is prematurity. Other causes are low birth weight, neonatal infections, birth asphyxia, birth trauma, congenital anomalies, maternal diseases and unexplained neonatal deaths. About 1/3 of low birth weight (LBW) babies are born preterm and remaining 2/3 are born at term as Small for Gestational Age (SGA) babies. Nearly 30% of neonate, almost around seventy-five lakhs are

born with LBW in India. Identifying these SGA and preterm babies at the earliest and referring them to higher centers for further management will help in decreasing neonatal mortality and morbidity.<sup>1,2</sup>

Majority of newborn deaths occur in developing countries where access to health care is very low in comparison to developed nations. Most of them die at home or at primary health centers with minimal facilities. Only forty seven percent of Indian women have routine antenatal follow up and among them only about fifty percent of them deliver with assistance from a trained health worker. Most often these deliveries occur at peripheral centers where often assessment of gestational

age is not possible because of non-availability of weighing machines, ultrasonography and trained personnel. Identifying SGA and preterm at the earliest and referring them to higher center for further management would definitely increase their chances of survival. Simple alternatives which does not require sophisticated equipment or trained personnel to identify SGA and preterm babies will help to reduce the number of neonatal deaths.

In a developing country like India, especially in rural areas, access to proper health care facilities and trained medical professionals is limited. Various anthropometric alternatives to measure gestational age have been investigated in different settings to help identify LBW and Preterm babies. Some research studies have investigated newborn foot length (FL) as a screening tool for identification of preterm/LBW babies.<sup>3-5</sup>

Foot length is quite simple to measure where the only requirement is a well calibrated ruler or tape and does not require much expertise. A ruler is small, does not take up space, can be taken to deliveries outside a hospital premises i.e. in remote areas, and can be adequately cleaned and sanitized. It is also easy to acquire a well calibrated ruler.

FL measurements can thus be used in remote areas to identify high risk newborn babies. In this study, relation between newborn foot length and gestational age assessed by various methods were studied in both preterm and term babies and the utility of newborn FL as screening tool to identify preterm babies was verified.

**METHODS**

This is a hospital based prospective cross-sectional study conducted at Newborn ward, Department of Pediatrics, MGM Govt. Hospital attached to KAP Viswanatham Government Medical College, Tiruchirappalli, Tamil Nadu, India. 620001.

The study was conducted from January 2016 to June 2017. With an alpha error of 0.05, beta error of 20% and expected correlation of 0.8, the sample size required was 170 with 10 samples in each gestational age from 26 to 42 weeks.

**Inclusion criteria**

- Babies whose mothers with documented LMP & dating USG done at 1<sup>st</sup> trimester.

**Exclusion criteria**

- Babies with congenital anomalies of lower limbs (eg. CTEV).

Following parameters were recorded:

- Foot length at birth,
- Gestational age by LMP,
- Gestational age by first trimester ultrasound,
- Gestational age by New Ballard Score

Antenatal gestational age was assessed based on LMP and first trimester USG and post-natal gestational age assessment was done using New Ballard score. Right foot length of each baby was measured from heel to tip of great toe or 2nd toe (whichever is longer) using three techniques;

- Using a plastic stiff transparent ruler,
- Measuring tape,
- Length of neonatal foot print taken with the help of ink pad with toes held in extension.

All measurements were taken within 12 to 24 hours of birth after obtaining informed consent from the mother. Data was collected and recorded in the proforma during the whole study period and data was entered in Microsoft excel. Statistical analysis was done using SPSS software.

**RESULTS**

Out of the 170 newborn studied we had almost an equal distribution of male female ratio which was 89 and 81 respectively. 74% (n=126) of neonates were born through normal vaginal delivery with LSCS accounting for only approximately 26% (n=44). In present study group of 170 newborns majority were preterm babies (65%), 75% (n=127) of neonates were belong to AGA category and 24% (n=41) belongs to SGA category and 1% (n=2) belong to LGA.

**Table 1: Correlation between gestational age by LMP and foot length.**

	N	Mean	S.D	Mean	S.D	Correlation value	Statistical inference	T	Df	Statistical inference
GA-LMP	170	34.2059	4.91032	27.3788	3.74419	0.965	P=0.003	95.341	169	P=0.003
Average-FL	170	6.8271	1.22319							

P<0.05 is significant

Among term babies 70% [n=42] belong to AGA, 27% (n=16) belong to SGA and 3% (n=2) belong to LGA. Among preterm babies 77% (n=85) belong to AGA, 23% (n=25) belong to SGA. When the gestational age using LMP was compared with the average foot length using paired sample 't' test, a strong correlation among the two variables with correlation value (r = 0.965) was noticed. It was again supported by a statistically significant 'p' value of 0.003 (Table 1). Gestational age by USG and

foot length average was compared with paired sample 't' test. The 'r' value or correlation value was 0.964, which denoted a strong correlation among the two variables. The 'p' value was found to be 0.003 which was statistically significant. (Table 2). On comparing the gestational age by New Ballard Score with average foot length using paired sample 't' test, a positive correlation value ('r'=0.966) was noticed with a 'p' value of 0.002, which was statistically significant (Table 3).

**Table 2: Correlation between gestational age by USG and foot length.**

	N	Mean	S.D	Mean	S.D	Correlation value (r)	Statistical inference (p value)	T	Df	Statistical inference (p value)
GA-USG	170	34.0900	4.93845	27.2629	3.77411	0.964	P=0.003	94.185	169	P=0.003
Average-FL	170	6.8271	1.22319							

P<0.05 is significant

**Table 3: Correlation between gestational age by NBS and foot length.**

	N	Mean	S.D	Mean	S.D	Correlation value (r)	Statistical inference (p)	T	Df	Statistical inference(p)
GA-NBS	170	34.0241	4.95573	27.1971	3.78678	0.966	P=0.002	93.643	169	P=0.002
Average FL	170	6.8271	1.22319							

P<0.05 is significant

**Table 4: Correlation between birth weight and foot length.**

	N	Mean	S.D	Mean	S.D	Correlation value (r)	Statistical inference	T	Df	Statistical inference
BW	170	1.9601	0.83706	4.8670	0.51635	0.943	P=0.002	122.897	169	P=0.002
Average FL	170	6.8271	1.22319							

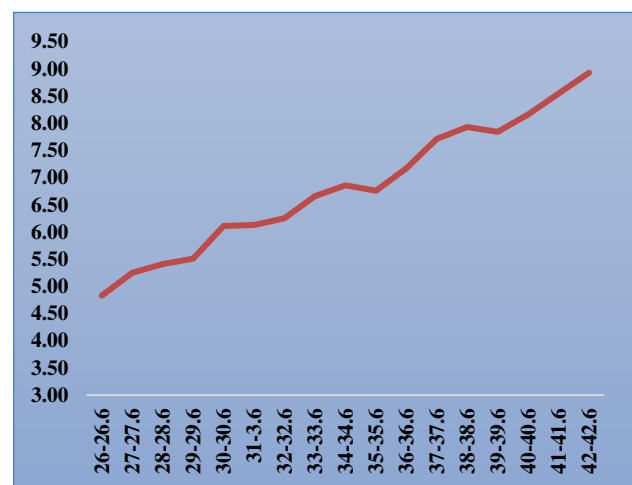
P<0.05 is significant

Birth weight and foot length were analyzed using paired sample 't' test.

The 'r' value (correlation value) was found to be 0.943 which meant a positive correlation between the two variables (foot length and birth weight), which was supported with a 'p' value (0.002) of statistical significance (Table 4).

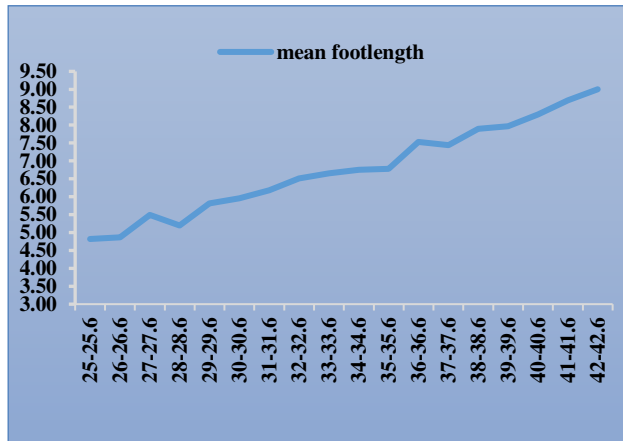
Study population of 170 newborn were divided into 17 groups according to their gestational age assessed by LMP. Minimum age group was 26 weeks and maximum was 42 weeks.

Average foot length for each gestational age group was calculated and a graph was plotted showing relation between gestational age and corresponding foot length (Figure 1).



**Figure 1: Gestational age by LMP and foot length**

170 neonates were divided according to gestational age groups based on first trimester USG findings. Mean foot length for each group was calculated and a graph was plotted showing the relation between gestational age assessed by USG with foot length. Minimum gestational age was 25 weeks and maximum was 42 weeks (Figure 2).



**Figure 2: Gestational age by USG and foot length.**

## DISCUSSION

Identification of low birth weight and preterm babies is crucial in providing proper newborn care. Early referral of such babies to higher centers helps in reducing neonatal mortality and morbidity. In a developing country like India majority of deliveries are conducted in peripheral hospitals and at home without the assistance of trained medical professionals. Estimation of gestational age in such cases might be difficult for community health care workers, especially in the absence of proper antenatal records. Foot length has been one of the parameters studied and found to correlate well with gestational age and birth weight.

### *Correlation between foot length and gestational age*

Foot length positively correlated very well with gestational age assessed by LMP in the present study with a significant  $r$  value of 0.965. Average foot length at 26 weeks was 4.8 centimeters and 8.9 centimeters at 42 weeks. The results obtained were similar to that of Kulkarni et al.<sup>6</sup> They studied eight hundred seventeen newborns between 26 to 42 weeks of gestation to identify the range of foot length values. Mean foot length at 28 weeks and 41 weeks were 5.6 centimeter and 7.5 centimeters respectively. Daga et al.<sup>7</sup> 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. In the present study average foot length corresponding to 34 weeks was 6.8 centimeter. 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 0.964 and 0.966 respectively, in this study. A cross sectional study done by Mukherjee et al<sup>8</sup> using 351 newborns to assess the reliability of foot length in predicting low birth weight babies proved that for identification of preterm babies, foot length of 7.75 centimeters had a sensitivity and specificity of 92.3 % and 86.3 %. Average foot length corresponding to 37 weeks in the present study were 7.71 and 7.44 centimeters 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 studied 120 patients with uncomplicated pregnancies and with known last menstrual period.<sup>9</sup> Ultrasonographic fetal foot length were measured in 12 to 28 weeks pregnant women. Foot length correlated with menstrual age with an  $r$  value of 0.94. Mercer et al in 1987 studied how gestational age can be assessed from the ultrasound measurement of fetal foot length.<sup>10</sup> Their study group involved 223 postpartum and 224 ultrasonographic measurements of foot length taken between 11 and 43 weeks of gestation. A strong correlation was demonstrable when curvilinear regression comparison was made between foot length and gestational age. In the present study ultrasound measurement of fetal foot length was not taken into account as a method to determine gestational age. This was because the antenatal USG for the pregnant mothers admitted at our hospital were done by different Radiologists with varying expertise and hence the accuracy was doubtful.

### *Correlation between foot length and birth weight*

Out of the 170 neonates studied, minimum birth weight recorded was 680 grams and maximum weight noted was 3750 grams. In this study, a positive linear correlation was observed between foot length and birth weight with an  $r$  value of 0.943 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 a study by James et al in neonates within gestational ages of 26-42 weeks ( $r=0.95$ ).<sup>11</sup>

They concluded that birth weight and crown rump length of babies could be estimated from foot length measurements, especially in preterm babies. Findings in this study are in agreement with study conducted by Shah SS et al where they concluded that foot length was a better indicator of birth weight among other anthropometric parameters studied with a statistically significant  $r$  value of 0.92.<sup>12</sup> New born foot length can be

measured with ease even by birth attendants and peripheral health workers and hence can reliably be used in determining gestational age of the neonate. It helps in identification of preterm and low birth weight babies in case of home deliveries and peripheral hospital deliveries and can thus facilitate the early referral of such babies to higher centers. The study sample may not be a representative of the general population as it was conducted in hospital with minimum participants. Various other anthropometric measurements like head circumference, length, chest circumference were not included in the study.

## CONCLUSION

There is significant correlation between foot lengths measured postnatally and birth weight. Gestational age assessed by all the three methods, namely LMP, first trimester USG, and New Ballard Score all correlated well with neonatal foot length.

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