International Journal of Contemporary Pediatrics
Tenali ASL et al. Int J Contemp Pediatr. 2019 Mar;6(2):477-481
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20190684

Original Research Article

Study of foot length as an alternate measurement for assessment of gestational maturity in neonates

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Received: 14 February 2019
Accepted: 19 February 2019

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ABSTRACT

Background: The aim was to study neonatal foot length as a simple method for quick gestational age assessment which can be done by basic healthcare personnel overcoming the technicality required by other assessment methods.
Methods: Prospective descriptive study was done. Live born neonates at Saveetha Medical College, Kanchipuram from June 2016 to June2017 were enrolled. Gestational age was assessed by New Ballard's Scoring and footlength was measured using the paddle blades of automated digital Vernier calipers within 24 hours while birth weight was taken within 72 hours of birth. Based on gestational age, babies were grouped into preterm, term and post term and were subclassified as small for gestational age (SGA), appropriate for gestational age (AGA) and large for gestational age (LGA) based on Lubchenco's intrauterine growth chart. Correlation and regression analysis and Scattergram was done.
Results: Out of 300 neonates, term, preterm and post-term were 70.3%,28.3% and1.3% while SGA, AGA, and LGA babies were 9%, 88% and 3%. Mean foot length was 7.728cm±0.59 with a range of 5-8.8cm. Foot length strongly correlated with gestational age in Preterm AGA, SGA and Term AGA babies (<0.001). Correlation coefficient of foot length with gestational age was higher in preterms (r=0.95). Gestational age in 54% of study population could be calculated with the derived regression equation derived.
Conclusions: Foot length maybe useful for quick estimation of gestational age in preterm and term neonates for early referral of newborns requiring special care and can even be done by basic healthcare personnel.

Keywords: Foot length, Gestational age, Neonate, New Ballard score, Preterm

INTRODUCTION

Neonatal period, defined as the first 28 days of life, is the most vulnerable time for the survival of a child.[1] WHO and maternal and Child Epidemiology Estimation Group (MCEE), 2015 states that 45% of under 5 deaths occur in neonatal period.[2] In India, complications due to Preterm birth (43.7%) constitute majority of neonatal deaths.[3] AAP policy defines Gestational age as the time elapsed between the first day of the last menstrual period and the day of delivery.[4] Gestational age can be broadly classified into preterm, term, and post term categories. Pre-term neonates are those with gestational age of less than 37 completed weeks; neonates within gestational age 37 weeks to 41 weeks 6 days are considered Term neonates. Neonates with gestational age of 42 weeks or more are termed as Post term babies.[5,6] In each gestational age, a neonate can be further sub-classified into Appropriate for Gestational Age (AGA), Small for Gestational Age (SGA) and Large for Gestational Age (LGA) by weight based gestational age classification. The intra uterine growth charts commonly used for this classification are

Lubchenco charts and Fenton's charts. Less than 10th percentile is considered as SGA and more than 90th percentile is considered as LGA.[6]

Gestational age (GA) is a critical factor in the decision-making and management of newborns. It is also important for prognostication and follow-up of newborn infants, especially preterm. Conventionally; gestational age of neonates is computed based on Naegele's formula, by ultrasonic evaluation during pregnancy, or by New Ballard assessment and scoring after birth but each have their own limitations.[7,8]

Gestational age assessment based on Naegele's formula have less accuracy in settings with low literacy and is likely to be affected by variation in ovulation and breastfeeding. Use of Ultrasonography as a tool for assessment of gestational age, is a limiting factor especially in developing countries like India where not all women undergo the recommended number of at least 3 antenatal visits. Postnatally, The New Ballard Score (NBS) has evolved as standard for postnatal gestational maturity assessment but it may not be always reliable as its accuracy depends on the skill of the examiner and the condition of the neonate more so in asphyxiated neonates.[5]

Anthropometric measures such as birth weight are commonly used measures of growth in neonates and they do correlate fairly with maturity, but weight measurements are significantly affected by changes in water, carbohydrate, fat, protein, and mineral levels. Postnatal Foot length measurement is a recently evolving method used to assess gestational age. Various studies have stated that foot length is the least affected anthropometric measurement in intra uterine growth restricted babies.[9]

Preterm infants have a higher risk of morbidity therefore are considered as babies at risk. The potential to reduce neonatal morbidity on a significant level is attributed to varied reasons like early identification of babies at risk in medical facilities, especially at the peripheries and community level. Accurate assessment of gestational maturity is not possible in all newborn neonates especially when they are sick and in need of intensive care support. But even in such babies, the foot of the newborn is usually readily accessible for measurement.

Foot length is simple to measure and does not require much expertise. Therefore, it may be used as a simple, practical method of quick gestational age assessment to identify babies in need of special care. Therefore, it will be worthwhile to determine if foot.

METHODS

This prospective descriptive study was conducted at Saveetha Medical College, Kanchipuram from June 2016 to June 2017.

Inclusion criteria

- All live born babies during this period were enrolled in the study.

Exclusion criteria

- Neonates with congenital skeletal deformities of foot, lower limb edema or foot asymmetries, neonates with congenital abnormalities of head and neonates with chromosomal abnormalities were excluded from enrollment.

For all the newborns in this study, gestational age was assessed by New Ballard's Scoring within 1st day of life.

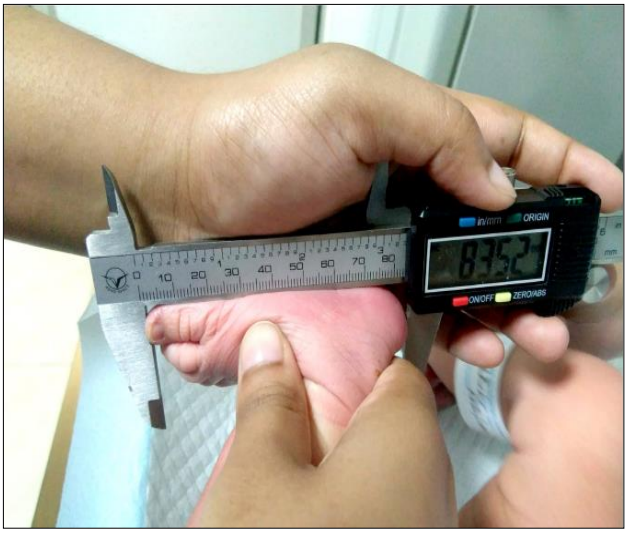

Figure 1: Measurement of foot length using digital Vernier calipers.

Under aseptic precautions, foot length was measured using automated digital Vernier calipers from posterior most prominence of the foot to the tip of the longest toe, using the paddle blades of the sliding calipers. The measurements were recorded in centimeters. For the sake of uniformity, measurements were taken of the Right foot within 24hrs of birth. Babies were weighed naked on digital scale (CIBI) with ±5g accuracy within 24hrs of life. Weight was recorded in kilograms. From the data collected, neonates were grouped into preterm, term and post term. These babies were further sub-categorised into small for gestational age (SGA), appropriate for gestational age (AGA), large for gestational age (LGA). This sub-categorisation was based on Lubchenco chart (intra uterine growth chart).[10]

Statistical analysis

Categorical data were expressed as absolute counts and percentage. Correlation and Regression Analysis and Scattergram was done with SPSS Software version 17 for windows. Data were considered statistically significant at $p< 0.05$.

RESULTS

A total of 300 newborns were included in the study. The sex distribution was 55% males and 45% females. AGA, SGA, LGA babies were 88%, 9%, 3% respectively. They were further distributed based on gestational maturity.

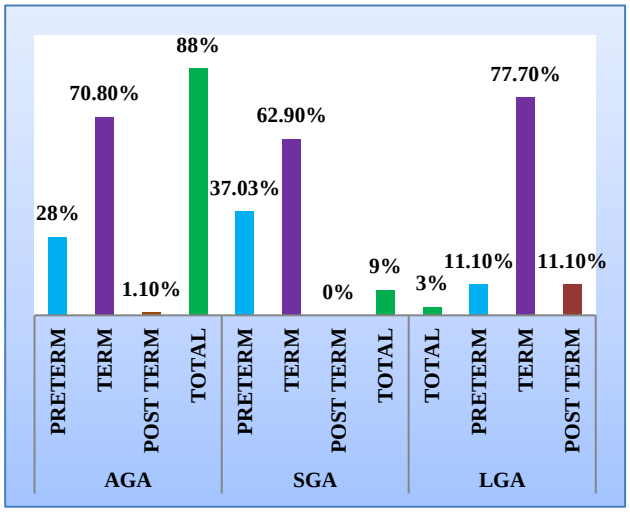

Figure 2: Distribution of preterm, term and post term neonates in AGA, SGA, and LGA groups.

The neonates included in the study underwent clinical assessment of gestational maturity by New Ballard Scoring and were grouped into gestational age ranges of 2 weeks interval. The mean gestational age of present study population was 37.99±1.67 weeks. The mean foot length in centimeter (cm) in present study was 7.728±0.59.

Authors found that foot length correlates with all anthropometric measures in both preterm AGA and SGA. Whereas with term newborns authors find that foot length correlates with other anthropometric measures only in AGA babies.

Authors found that gestational age as assessed with Ballard score, correlates with foot length in both preterm AGA and SGA. Whereas with term newborns authors find that Ballard score correlates with foot length only with respect to AGA babies.

For the data collected a linear regression analysis was done and Regression equation was obtained to identify various groups such as preterm, term, post term, AGA, LGA and SGA using foot length. The R^2 value is the ability of the regression equation to predict the gestational age.

Table 1: Pearson correlation between foot length and other measurements.

Pair	Preterm		Term		
	SGA	AGA	SGA	AGA	LGA
Foot length vs birth weight	0.689 (0.028)*	0.468 (0.000)**	0.282 (0.272)	0.469 (0.000)**	0.123 (0.79)
Foot length vs gestational age	0.799 (0.006)**	0.606 (0.000)**	0.210 (0.420)	0.390 (0.000)**	0.336 (0.461)

Table 2: Pearson correlation of gestational age with other measurements.

Pair	Preterm		Term		
	SGA	AGA	SGA	AGA	LGA
Gestational age vs birth weight	0.849 (0.002)*	0.698 (0.000)**	0.385 (0.127)	0.345 (0.000)**	0.667 (0.102)
Gestational age vs foot length	0.799 (0.006)*	0.606 (0.000)**	0.210 (0.420)	0.390 (0.000)**	0.336 (0.461)

Table 3: Regression analysis of each category in the study population.

Variable	Regression equation (y)	R^2 value
Overall	21.84+2.09 (FL)	0.548
Maturity status		
Preterm	18.696+2.439 (FL)	0.55
Term	33.764+0.616 (FL)	0.14
Post term	43.053+0.110 (FL)	0.438
Weight for gestational age		
SGA	12.480+3.444 (FL)	0.682
AGA	23.238+1.907 (FL)	0.523
LGA	7.618+3.829 (FL)	0.490

For the overall sample, the gestational age has been expressed as an equation of 21.84±2.09 (FL). Here, 2.09 indicate the slope of the equation and 21.84 is constant. The slope value infers that as 1cm increase in the FL means 2.09 weeks increase in gestational age.

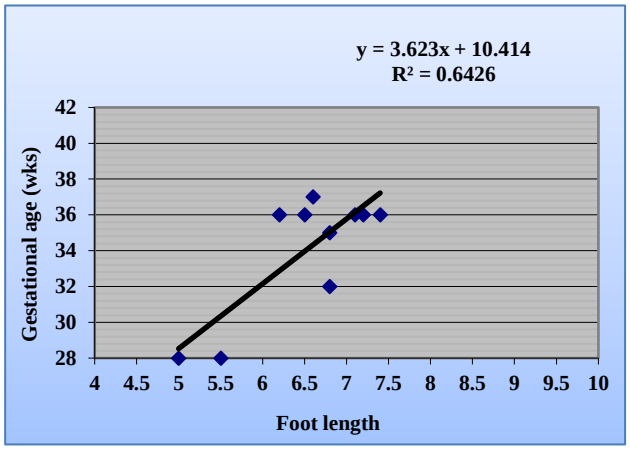

Figure 3: Scattergram showing the correlation between foot length and Ballard score in preterm SGA.

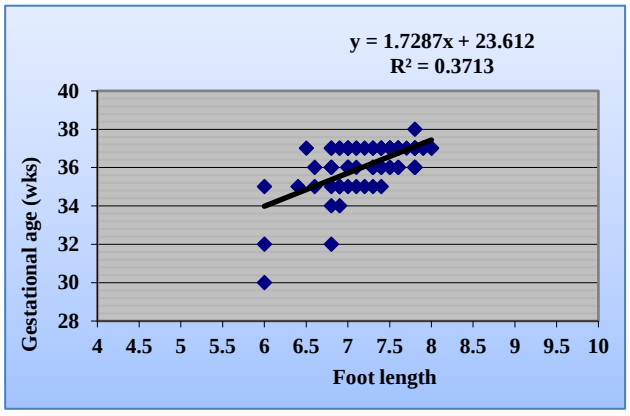

Figure 4: Scattergram showing the correlation between foot length and Ballard score in preterm AGA.

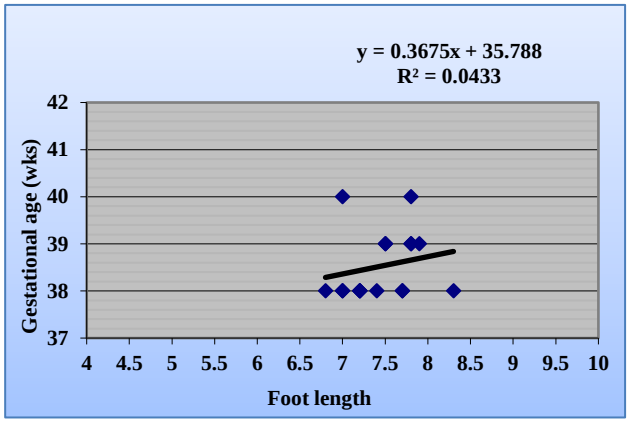

Figure 5: Scattergram showing the correlation between foot length and Ballard score in term SGA.

The R^2 value infers that the regression equation correctly predicts the gestational age; 54% of the time. From the above table, authors find that the regression equation derived, correctly predicts the gestational age 55% in pre terms and 68% in SGA babies.

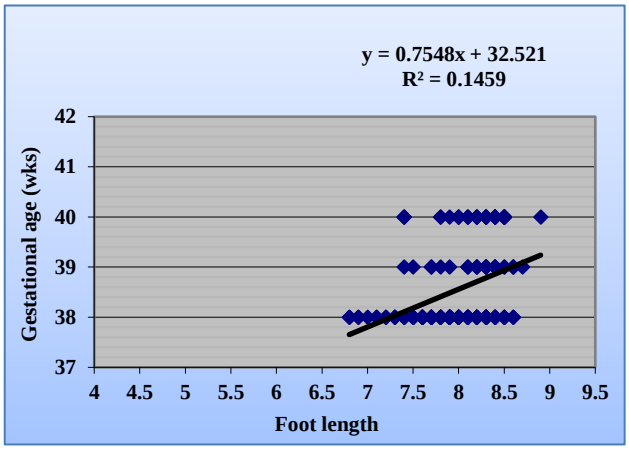

Figure 6: Scattergram showing the correlation between foot length and Ballard score in term AGA.

From Figure 3, 4, 5 and 6, authors see that all categories correlate well with foot length but seen best in preterm SGA, AGA and term AGA.

DISCUSSION

In this study, after categorization of neonates into term, preterm and post term and sub categorization into AGA, SGA, LGA, it was found that Term SGA, AGA and LGA was 8%, 89% and 3% respectively whereas preterm SGA, AGA and LGA was 12%, 87%, and 1% respectively. Srivastava A et al, showed term AGA 75% , SGA 24.7% and preterm AGA, SGA was 74.6% and 24.3%.[11] Shah SS et al study showed term AGA, SGA and LGA as 78.4%, 12.5% and 2%, respectively.[12] As the post-term group was small in number to be statistically significant, statistical analysis of this group was not done in any of the studies including the present study.

Though the mean foot length of all the mentioned studies showed that there is a positive linear relationship between foot length and gestational age, the correlation coefficient of Foot Length and gestational age was different in different studies. The extent of correlation was different for different gestational age groups.

In the study done by James et al, they found that there was a positive linear correlation between foot length and other measures in SGA and AGA babies of all gestational ages.[13] However, the correlation was more significant in premature babies, between Foot length and birth weight (r=0.95) and foot length and gestational age (r=0.96) which is comparable to the present study. Gohil JR et al, study showed significant relationship between foot length and other body parameters in both preterm and term neonates.[14] In his study the foot length in term SGA and

AGA babies had significant correlation with other measures but in the present study, strong correlation between foot length and other parameters was limited to only term AGA babies.

In the present study, foot length strongly correlates in preterm AGA, SGA and Term AGA babies with gestational age, birth weight, ($P<0.001$).

The studies of James et al, and Gohil JR et al, showed that although there is a positive correlation between Foot Length and other measures like gestational age and birth weight in all categories, better correlation was seen in preterm babies, a finding similar to the present study.[13,14]

In the present study, the possibility to predict the gestational age with foot length by using regression equation was 54% ($R^2=0.548$) of the overall population, 55% in pre terms and 68% in SGA babies while in Rakappan et al, study, 65% (0.65) and Yadav R et al, study it was 76% ($R^2=0.765$).[15,16]

Limitations of this study include that it was a single centre study. The numbers of neonates in each gestational age category were unequal. Though obstetric dating was done by Naegli's formula, there are chances of mild over or under estimation of gestational age.

CONCLUSION

In conclusion, it can be said that foot length can be used as an alternate method for estimation of gestational age assessment especially in the case of preterm neonates. It is easy to perform without necessity of any technical training and would help in early referral of newborns requiring special care.

ACKNOWLEDGEMENTS

Authors would like to thank Department of Pediatrics, HOD, guide and co guides, Saveetha Medical College for their support.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Tenali ASL, Tenali RK. Study of foot length as an alternate measurement for assessment of gestational maturity in neonates. Int J Contemp Pediatr 2019;6:477-81.