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Original Research Article

Association of foot length and gestational maturity in neonates: a single centre study

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ABSTRACT

Background: As the prematurity is one of the important causes of neonatal mortality/ morbidity in a developing country like India. It is important to differentiate between preterm and term babies and timely refer them to higher centre. But it's difficult to assess the Gestation age (GA) in rural areas by existing methods like New Ballard score, and Antenatal ultrasound (due to lack of equipment and experienced person). So that shows the importance of the alternative, reliable, and easy to use method for identification of term, preterm and post-term babies. The present study carried out to find out the importance of Foot length in the assessment of GA.
Methods: It is a hospital-based prospective observational study, 253 newborns were included in the study. The GA assessment was done by using New Ballard score. Foot length measured by using Digital sliding calliper and birth weight were recorded. Correlation of Fetal foot length with GA and birth weight was made by using appropriate statistical tests.
Results: Among 253 neonates distribution of term, preterm, male and female were 65%, 35 %, 55%, 45% respectively. In this study positive Correlation between foot length and gestational age was found with the "r" value of 0.77. The study also showed a correlation between foot length and weight with the "r" value of 0.74.
Conclusions: To conclude most of the newborn in our study have a good correlation of Foot length with gestational maturity and Birthweight. Derived equation from this study can be used as an alternative to New Ballard score in the estimation of gestational age in poor sources situations like in rural areas and also in emergencies by ASHAs (Accredited Social Health Activist) & Anganwadi workers.

Keywords: Foot length, Gestational age, New Ballard score, Prematurity

INTRODUCTION

Neonatal death is one of the major contributors to under-five child death in the world. About 99% of neonatal deaths occur mainly in five countries China, India, Pakistan, Nigeria, and the Democratic Republic of Congo.[1] India is a country in the world with the highest number of neonatal mortalities. Mortality in the first 4 weeks of life constitutes 50% of the under-five mortality and around 70% of the infant mortality.[2] Complications arise due to preterm delivery and prematurity is the major cause of neonatal death (43.7%) in India.[3] Usually Gestational age(GA) or Fetal age of neonates are calculated based on Last day of Menstrual period(LMP), Antenatal USG, and till 72hrs of life by using New Ballard Score(NBS).[4] And at the same time, we cannot use the New Ballard Score in asphyxiated and extremely preterm babies.[5] As in the developing country like India,

due to low female literacy and lack of equipment in the remote areas are constraints in the assessment of GA and timely referral of preterm neonates. Assessment of the neonatal GA using the "New Ballard Score" although does not require any instrument but its accurateness depends on the experience and ability of the examiner and the condition of the new-born. So that shows the importance of the alternative method for identification of term, preterm, and post-term babies. At the same time that method should be easy to do, reliable, and easily conducted by health care staff.

Even In the World Health Organization's 2012 'Born too soon', it was stated that 'simplified approaches to identify preterm babies such as foot size' were required for the early identification and management of preterm babies.[6] Keeping in mind the necessity of such a method, the present study carried out to know the usefulness of Foot length in the assessment of GA.

METHODS

It is a hospital-based prospective observational study, was carried out at Teerthankar Mahaveer Medical College and Research Centre, Moradabad (UP) India. A total of 253 neonates with variable GA, admitted in NICU, and postnatal ward within 72 hours of birth was enrolled in the study. The study period was from October 2018 to March 2019.

Inclusion criteria

All newborns of different GA within 72 hours of birth, admitted in NICU and post-natal ward

Exclusion criteria

- Babies who had skeletal deformities of the foot.
- Babies suffered birth asphyxia, and are extremely premature

After the inclusion of babies in the study, anthropometric parameters (weight and foot length) were recorded, the gestational age assessment was done by using the New Modified Ballard score. All the babies were examined by the same observer for GA assessment by using the New Modified Ballard score. All babies were categorised into Small for gestational age (SGA), appropriate for gestational age (AGA), and large for gestational age (LGA) group by using Fenton's intrauterine growth curves (Figure 1 and 2).

Foot length measured as the distance from the heel to the greater toe of the right foot by using Digital slide caliper (Figure 3). Measurements were taken parallel to the long axis of the foot, and by the same observer to avoid the inter-observer bias. Correlation of foot length with other anthropometric data like the birth weight of newborn and gestational age of preterm and term neonates was made.

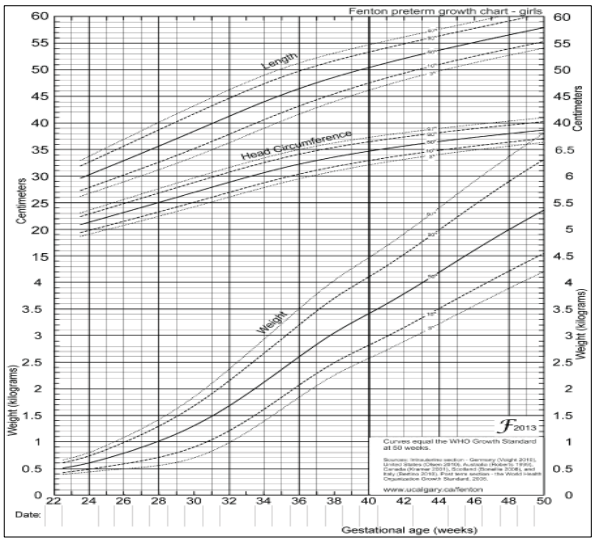

Figure 1: Fentons growth chart for girls.

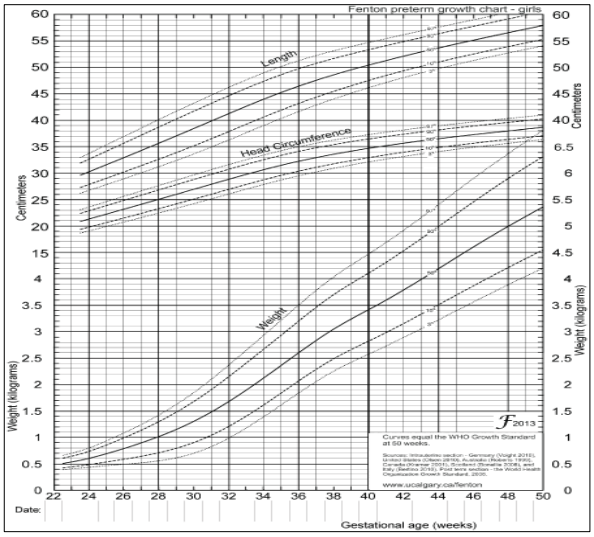

Figure 2: Fentons growth chart for boys.

Figure 3: Foot length measurement using digital slide calliper.

Data analysis

The collected data was compiled using MS Excel 2007 and statistical analysis was done using SPSS software (version 15). Appropriate statistical methods like Pearson correlation analysis, regression analysis and scatter diagram were used.

RESULTS

In this study ratio between male to female babies was 1.2:1(138 male and 115 female). Out of 253 babies, 163(64.4%), 87(34.4%), 3(2%) were term, preterm and post-term respectively. In our study around two-third of the babies (68%) were delivered by Caesarean section, while one third (32%) by normal vaginal delivery. When babies were classified as appropriate for gestational age (AGA) and small for gestational age (SGA), 196(77.4%) were AGA and 53(21%) were SGA, while only 4 (1.5%) were LGA (Large for Gestation). Distribution of cases according to the birth weight given in Table 1.

Table 1: Distribution of cases according to birth weight.

	Frequency	Percentage(%)
1-1.29kg	5	2
1.3-1.59	11	4.3
1.6-1.89	23	9.1
1.9-2.19	27	10.7
2.2-2.49	28	11.1
2.5-2.79	65	25.7
2.8-3.09	38	15
3.1 and above	56	22.1
Total	253	100

Table 2: Correlation between the gestational age and foot length.

Variable	Mean	SD	Correlation coefficient (r value)	p value
GA (wks)	37.14	2.596	0.77	0.001*
Foot length(mm)	74.7428	6.51072		

Table 3: Correlation between the birth weight and foot length.

Variable	Mean	SD	Correlation coefficient (r value)	p value
Birth Weight (Kg)	2.5831	0.63433	0.74	0.001*
Foot length(mm)	74.7428	6.51072		

On analysis of the correlation between foot length and gestational age, we found a positive correlation (p= 0.001) with 'r' value of 0.77 (Table 2). Between foot length and birth weight on correlation analysis, we found a positive correlation (with 'r' value of 0.74 (p=0.001) (Table 3). Simple linear regression was performed to know the effect of gestational age and birth weight on foot length. The regression coefficient of gestational age was found to be 1.937 (95% CI of 1.739; 2.135) p-value <0.001. This coefficient represents the mean increase of foot length in millimeters for every additional one week in gestational age, that means if the gestational age increases by 1 week the average foot length increases by 1.937 millimeters.

The derived equation by simple linear regression is, Foot length (mm) = 2.814+1.937× GA (Wks.) The R^2 value is found to be 0.59 indicating that 59% of variation in the foot length is explained by GA (Figure 4). Simple linear regression was performed to establish the effect of birth weight on foot length. The regression coefficient was found to be 7.60, (95% CI 6.744; 8.459) with p value of 0.001(p <0.05). The estimated simple linear regression equation, Foot length (mm)=55.10+7.60 Birth Weight (Kg). R^2 =0.54, indicate 54 % variation in the foot length can be explained by birth weight. On correlation of gestational age and foot length, this study reviled positive correlation among preterm (r =0.77, p = 0.001), SGA (r = 0.82, p =0.001), AGA (r = 0.78, p=0.001), and term babies (r=0.53, p= 0.001) (Table 4).

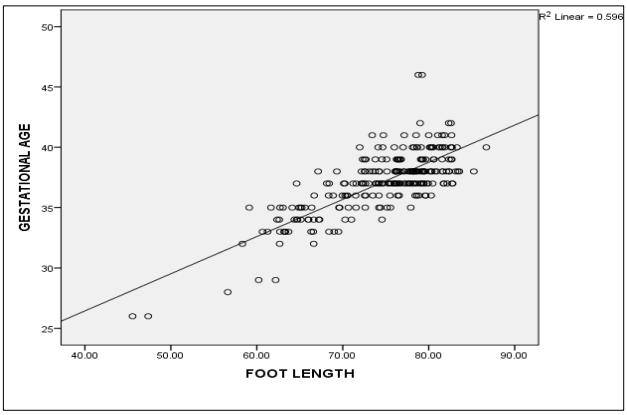

Figure 4: Simple linear regression function to determine the effect of gestational age on baby foot length.

Table 4: Correlation between foot length and GA in term, Preterm, SGA, AGA babies.

Group	variables	Values		Correlation coefficient(r)value	p value
		Mean	SD		
Preterm babies	GA (wks.)	34.5506	2.01419	0.77	0.001*
	Foot length (mm)	69.3990	6.50155		
Term babies	GA (wks.)	38.1847	1.55387	0.53	0.001*
	Foot length (mm)	77.4742	4.45080		
SGA	GA (wks.)	37.0167	2.65277	0.82	0.001*
	Foot length (mm)	74.6975	6.57091		
AGA	GA (wks.)	36.9850	2.47284	0.78	0.001*
	Foot length (mm)	74.7887	6.54722		

*significant relationship ($p < 0.05$)

DISCUSSION

In the present study, a positive correlation was found between GA and FL, with mean GA of 37.14(SD= 2.596), r value 0.77 (p= 0.001). these findings are in line with other study done previously like James DK et al, Gohil JR et al.[7,8]

Table 5: Previous studies that show correlation between foot length and gestational age.

Study	"r" value
Present study	0.77
Kim HJ, moon JH[16]	0.79
Lizelle van wyk [17]	0.919
Srivastava A et al[18]	0.87
Madhulika et al[19]	0.94
Hadush MY et al[20]	0.85

The birth weight of 253 neonates range from 0.741kg-4.4kg with a mean of 2.5831kg, and SD 0.63433, comparable with Akukwu et al, Nigerian shown birth weight range from 0.85kg-4.5kg , Gowri et al, showed 0.7kg-3.8kg.[9,10] In the present study majority of the babies are term 64.4% (163) while preterm is 34.4% (87). This is comparable to James et al, shown term (76.5%), preterm (39.6%).[7] Shahbu Saran et al, showed preterm (15.5%), term (76.4%)38 and Gohli et al, shown term (89.5%) and preterm (10.4%).[11,8] Above two studies shown preterm babies are lesser in number than the present study. These differences may be due to poor maternal nutrition, poverty and geographical factors. Among 253 neonates 53(21%), 196 (77%), 4 (1.5%) were SGA, AGA, LGA babies respectively. this is very comparable to Ilangovan Rakkappan et al, shown 85% AGA, 14.3% SGA, 0.6% LGA babies, also comparable to Shahbu Saran et al, shown AGA 84.8%, SGA 13.2%, LGA 2.1%.[11,12] SGA babies are little high in number in this region when compared to other regions. In 1920 Streeter et al, revealed that the fetal foot length has a distinguished relationship with the gestational age and fetal foot length can be used for determination of the GA.[13] Since then a number of studies done to find out the correlation between FL and GA (Table 5). In this study, a strong positive correlation was found with r-value of 0.77($p<0.001$).

In present study simple linear regression analysis yielded the equation:

FL (mm) =2.814+1.937 × GA (wks). The R^2 value is found to be 0.59 indicates 59% variation in the foot length explained by gestational age. From this, if the gestational age increases by 1 wk, the average foot length increased by1.937 mm. Drey EA et al, also proposed the equation for estimation of foot length:[19]

FL = -30.3 days of gestation 0.458 (R^2 value of 0.92)

Srivastava A et al proposed[16]

FL (mm)=2.4 × GA (wks)-15.1

In previous studies by linear regression analysis cut-off points of foot length derived to know the prematurity/preterm. For example, the study was done by Kim HJ et al, Srivastava A et al, found the 74.5mm and 73.6 mm of foot length respectively corresponds to 37 wks of GA, babies having foot length less than that value can be classified as preterm.[14,15] In this study, the cut-off value was found of 74.5mm corresponds to 37 wks of GA.

Authors acknowledge this study's various weakness like no comparison of foot length with the best estimate of GA (LMP confirmed by ultrasonography), no comparison of GA by foot length Vs GA by LMP. GA correlation was based on the New Ballard score, that has a high chance of error and need expertise.

Even with various weakness of the study, its useful as previously many similar studies in a different part of the world showed a promising outcome. Specially usefulness of foot length for early identification and timely referral of premature babies in remote areas.

CONCLUSION

To conclude most of the new-borns in our study have a good correlation of Foot length with gestational maturity and Birthweight. Derived equation from this study can be helpful in the estimation of gestational age in poor sources situations like in rural areas and also in emergencies by "ASHAs and Anganwadi workers" for calculation of gestational age when they give home visit & refer the preterm newborns to higher centres for further management as early as possible to prevent long & short term complications of prematurity.

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