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Original Research Article

Correlation of neonatal gestational age with foot length and right nipple to umbilicus distance

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ABSTRACT

Background: India contributes to one fifth of global live births and more than a quarter of neonatal deaths. A systematic analysis of global, regional and national causes of child mortality in 2013 identified preterm birth complications and infections to be the two major causes of neonatal deaths in India. So, there is need of a simple, easy to use and reliable screening tool for assessment of gestational age at peripheral level for early referral of a neonate to a tertiary care hospital, thereby reducing neonatal mortality.
Methods: A hospital based observational cross-sectional study included 350 live new-borns within 48 hours of birth, from September 2018 to February 2019. Gestational age assessed by new ballard score, birth weight, foot length and right nipple to umbilicus distance were noted. Babies categorised as per the gestational age profile as small, appropriate and large for gestational age using fenton charts. Data analysis done, correlation coefficient, and p value calculated to obtain results.
Results: Out of 350 babies, males (185) outnumbered females (165); 154 were LBW, 89 VLBW and 76 were ELBW. AGA neonates were 193, and 157 belonged to SGA. There were no post-term and large for gestational age newborns. Both foot length and right nipple to umbilicus distance correlated well with gestational age in all age groups ($p<0.001$).
Conclusions: Foot length as well as right nipple to umbilicus distance can be used as a reliable tool for assessment of gestational age and birth weight of newborns by any health care professional to identify and refer high risk neonate.

Keywords: Foot length, Gestational age, New ballard score, Right nipple to umbilicus distance

INTRODUCTION

The neonatal period-the first 28 days of life, carries the greatest risk of mortality per day than any other period during childhood. India contributes to one fifth of global live births and more than a quarter of neonatal deaths. Nearly, 0.75 million neonates died in India in 2013, the highest for any country in the world. A systematic analysis of global, regional and national causes of child mortality in 2013, identified preterm birth complications and infections to be the two major causes of neonatal deaths in India.[1] In developing country like this, most of the deliveries are conducted at peripheral level, where accurate assessment of gestational age is very difficult because of non-availability of weighing machines, ultrasonography and trained personnel leading to failure to identify preterm/low birth weight babies requiring urgent referral to higher centre for new-born care.[2]

One of the first steps to assist these new-borns is inventing an inexpensive, fast, easy to use, and acceptable screening tool for health workers to identify at-risk babies. Foot length is one such measurements which is easily accessible, rapid to perform, can be

measured easily even in critically ill new-borns nursed in incubators and receiving intensive care. Also, these are not influenced by subcutaneous fat and biological sex.[3]

Gestational age estimates based on Naegele's formula have lower accuracy in settings with low literacy and are likely to be affected by variation in ovulation and also by breastfeeding. Ultrasound, as a tool to assess gestational age, is a limiting factor, particularly in developing countries, like India where only 51% of women undergo the recommended number of at least 3 antenatal visits. Postnatally, assessment of gestational age of new-borns using New Ballard Score (NBS) may not be reliable as its accuracy depends on the skill of examiner and the condition of the neonate. It cannot be used in asphyxiated neonates, there is need of a simple, easy to use and reliable screening tool for assessment of gestational age at peripheral level, soon after birth for early referral of a neonate to a tertiary care hospital, thereby reducing neonatal mortality.[4]

METHODS

This observational cross-sectional study was conducted on 350 new-borns admitted in Paediatric wards, neonatal intensive care unit (NICU) from 1st September 2018 to 28th February 2019 (6 months) at Shri. Vasantrao Naik Government Medical College, Yavatmal, India.

Neonates within 1st 48 hours of life whose parents have given written informed consent were included in this study.

Conventionally, subjects' right foot length was measured twice using metric scale, on a foot length measuring device, by placing the heel against the platform and the head of the first metatarsal and medial aspect of the heel aligned parallel with the edge of the instrument.

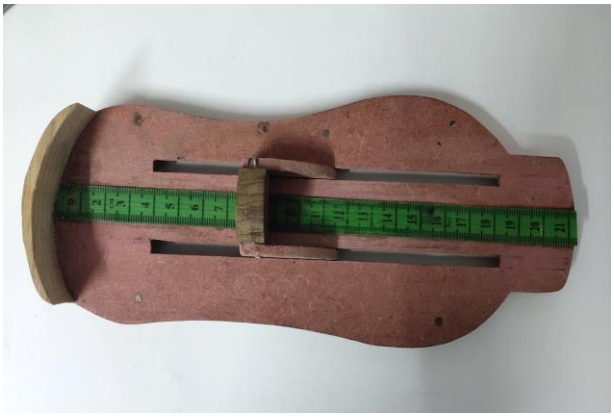

Figure 1: Foot length measuring instrument.

The instrument is made up of wood, with a support at the back of heel, and a slider that can be adjusted according to the foot length of baby, by a measuring tape placed over the platform where baby's foot is placed (Figure 1).

Foot length is the maximum distance along the line joining the heel to the longest toe of the right foot.

Nipple to umbilicus distance is measured from right nipple to 12'0 clock position of rim of umbilicus using a non-stretchable measuring tape in centimeters.

The measurements were done twice, and the mean value was used in analysis.

Birth weight was taken on a digital weighing machine of Mediox Company, in grams. Weight for gestational age determined using TR FENTON chart, and accordingly neonates were categorised as small, appropriate and large for gestational age.[5] Systematic random sampling technique is used.

Inclusion criteria

- All live new-borns admitted in Paediatric ward and NICU during the specified period.
- Neonates born within 1st 48 hours whose parents have provided written informed consent.

Exclusion criteria

- Congenital anomalies of new-born.
- Sick new-borns (requiring ventilator care, haemodynamically unstable, birth-asphyxia).
- Gross discrepancy between gestational ages calculated by LMP and Modified Ballard score by >2 weeks.
- Parents who refused to give consent.

Authors derived regression equations to obtain gestational age from foot length and nipple to umbilicus distance.

Data collected was entered into a Microsoft excel sheet and analysed using statistical package for social studies (SPSS) software version 16. The Pearson correlation coefficient was calculated and p value of <0.05 was considered statistically significant.

Informed consent and ethical committee clearance was obtained. No harm was done to the subjects, their care was given priority over the data collection. Confidentiality of the data obtained from the patients was maintained.

All expenses were borne by the principal investigator.

RESULTS

A total of 350 neonates ranging in weight from 710 grams to 3800 grams and gestational age of 26 weeks to 42 weeks were included. Male newborns outnumbered the females in this study, and the male: female ratio was 1.1: 1. Maximum number of neonates (44%) belonged to

low birth weight category, followed by very low birth weight i.e. 25.4% and those with normal birth weight were 21.7% whereas the least number belonged to ELBW group (8.9%). There were 193 appropriate for gestational age neonates, and 157 were small for gestational age. There were no large for gestational age neonates in this study.

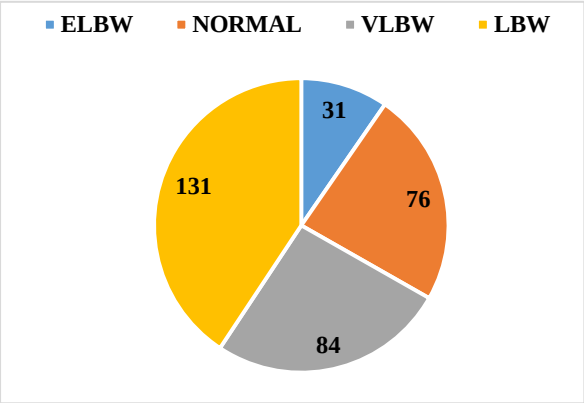

Figure 2: Frequency distribution of neonates as per the birth weight category.

As per this figure, maximum number of neonates belonged to low birth weight category, followed by very low birth weight, normal birth weight and lastly extremely low birth weight (Figure 2).

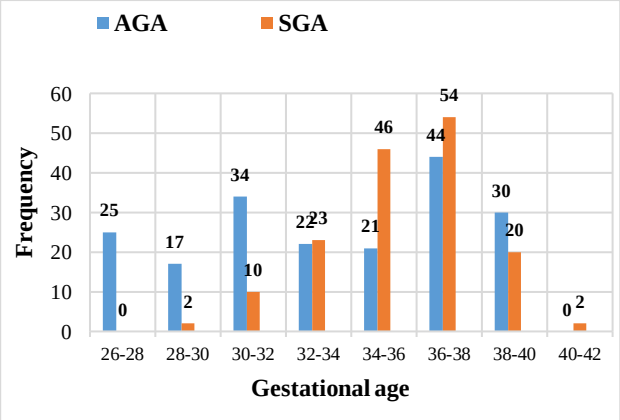

Figure 3: Distribution of neonates as per the weight for gestational age.

Comparing each gestational age range, appropriate for gestational age (AGA) neonates are more in 26-28 weeks, 28-30 weeks, 30-32 weeks, and 38-40 weeks gestational age, and small for gestational age (SGA) neonates predominate in the remaining gestations (Figure 3).

A large percentage of newborns belonged to 1000-<2000 grams, while least numbers weighed >3000 grams. The number of preterm neonates in this study, excluding those with gestational age of 36-38 weeks was 200. Since the gestational age by Modified Ballard Score was obtained in a range of 2 weeks as shown in the table below, the total number of preterm neonates couldn't be estimated, taking into account WHO definition of prematurity.

Table 1: Numbering of category of gestational age category in ascending order.

Gestational age by ballard (weeks)	Category number assigned
26-28	1
28-30	2
30-32	3
32-34	4
34-36	5
36-38	6
38-40	7
40-42	8

Gestational age categories are numbered from 1 till 8 as gestational age is obtained in a range of 2 weeks (Table 1).

The mean foot length ranged from 5.3 - 7.95 cm (S.D=0.823 cm) and the mean right nipple to umbilicus distance from 6.6-8.8 cm (S.D=0.7 cm) in the study sample.

The foot length (in cm) as well as nipple umbilical distance (in cm) showed a significant positive correlation with gestational age by New Ballard Score in the whole study group, p value being <0.001, which is statistically significant.

The above table shows that as the gestational age increases, the mean foot length and nipple-umbilicus distance both increases, which signifies their linear correlation with the gestational age (Table 2).

Pearson correlation coefficient of gestational age with foot length was found to be 0.799 and that with nipple to umbilicus distance was 0.782, both of which show a positive linear correlation. Thus, comparing Pearson correlation coefficient obtained in this study, it is seen that the correlation of gestational age with foot length (r=0.799), is better than that with nipple to umbilicus distance (r=0.782).

The equation for estimating gestational age from foot length is Y = -6.593 + 1.713 X where, Y= gestational age category, X=foot length in cm, constant = -6.593. The correlation of the estimated gestational age, derived by using the regression equation and actual gestational age babies is found to be strong (r =0.994). Similarly, authors derived another regression equation to predict gestational age from nipple umbilicus distance, Y = -5.583 + 1.25 X, where Y= gestational age category, X= nipple to umbilicus distance in cm, constant= -5.583

The correlation of the estimated gestational age, derived by using the above regression equation (using nipple

umbilicus distance) and actual gestational age of babies was also found to be strong (r=0.940).

Table 2: Mean values of foot length and nipple-umbilicus distance obtained in various gestational age categories.

Descriptives									
	G.A	N	Mean	S.D	Standard Error	95% CI		Minimum	Maximum
						Lower Bound	Upper Bound		
Foot length	26-28	25	5.3	0.248	0.05	5.2	5.4	5	6
	28-30	19	5.54	0.361	0.083	5.36	5.71	5	6
	30-32	44	6.12	0.51	0.077	5.96	6.27	5	7
	32-34	45	6.19	0.561	0.084	6.02	6.36	5	8
	34-36	67	6.63	0.503	0.061	6.51	6.76	5	8
	36-38	98	7.1	0.507	0.051	7	7.2	6	8
	38-40	50	7.55	0.493	0.07	7.41	7.69	6	8
	40-42	2	7.95	0.071	0.05	7.31	8.59	8	8
Nipple-umbilicus distance	26-28	25	6.636	0.67384	0.13477	6.3579	6.9141	5.2	8.4
	28-30	19	6.926	0.7415	0.17011	6.5689	7.2837	5.3	8.2
	30-32	44	7.573	0.5888	0.08876	7.3937	7.7517	6.5	8.6
	32-34	45	7.547	0.73472	0.10953	7.3259	7.7674	5.5	9
	34-36	67	8.257	0.62407	0.07624	8.1045	8.4089	6.8	9.5
	36-38	98	8.908	0.63175	0.06382	8.7815	9.0348	7.5	10.1
	38-40	50	9.59	0.74265	0.10503	9.3789	9.8011	7.2	10.8
	40-42	2	8.8	0.70711	0.5	2.4469	15.1531	8.3	9.3

Table 3: Regression equations to predict gestational age.

Variable used to predict gestational age (Y)	Regression equation	Correlation of estimated G.A with actual G.A
Foot length (X)	Y = -6.593 + 1.713 X	0.994
Nipple to umbilicus distance (X)	Y = -5.583 + 1.25 X	0.940

It is clear from the above table that, foot length was a better variable in predicting gestational age than the nipple umbilical distance (Table 3).

The foot length showed a higher correlation with nipple umbilical distance in AGA group (r=0.912), as compared to that in SGA group (r=0.823).

DISCUSSION

This study has been conducted at a hospital where most of the patients come from nearby villages from poor families. It was carried out to find the correlation of gestational age with foot-length and nipple to umbilicus distance in neonates, so that by such simple measurements, gestational age of neonate can be easily estimated in peripheral health centres, and hence high risk preterm neonates are identified and immediately referred to higher centre for further care.

This study included 350 neonates ranging from birth weight of 710 grams to 3700 grams, with gestational age ranging from 26 to 42 weeks. There are no post-term and large for gestational age neonates. The mean foot-length was obtained for all gestational ages, ranging from 5.3 cm for 26-28 weeks increasing progressively to 7.95 cm for 40-42 weeks. Similarly mean nipple-umbilicus distance was found to be 6.63 cm in 26-28 weeks, after which a mild dip was noted at 32-34 weeks and further dip at 40-42 weeks.

Both, foot length and nipple to umbilicus distance showed a positive correlation with gestational age, at a p-value <0.001.

In the study done by James et al, they found only a modest reduction (4.2-8.8%) of the mean foot length, body length, and OFC (occipito-frontal circumference) in LFD (light for date) babies compared with AGA babies.[6] A positive linear correlation between foot length and the other indices of body size was observed in AGA and LFD babies of all gestational ages similar to present study.

Daga et al, also found significant correlation between gestational age and different anthropometric parameters including foot length taken from foot.[7] The mean value for foot length was found to be 6.5 cm with standard deviation of 0.28 cm at 34 weeks of gestation, which correlates with present study wherein the mean value of foot length at 34-36 weeks is 6.63 cm with standard

deviation of 0.51 cm. They predicted the expected gestational age from the foot length, by regression equation, similar to this study.

Present study recorded findings similar to the study by Shilpi et al, which states that there was an increase in foot length with an increase in gestational age, except for the fall noted at 41 and 42 weeks, accounted by the fact that in the later gestational age growth slows down and a higher frequency of growth retardation is expected in the later weeks with consequently decreased foot length.[8] The correlation coefficient (r) of foot length with gestational age was found to be 0.934, while in this study correlation coefficient was 0.799, both of which shows a strong correlation.

Gavhane S et al, carried out similar study with larger sample wherein foot length correlated fairly well with gestational age (GA) (r=0.810) and other anthropometric parameters in preterm SGA group, and significantly with all the variables, including GA in term AGA group, maximum correlation being with birth weight.[9] In this study, there was a significant correlation of gestational age with foot length and nipple to umbilicus distance both.

Marchant et al, studied foot length of neonates on day 1 and day 5 of birth, and found that the mean foot length of all babies was 7.8 cm as opposed to 6.62 cm obtained in present study.[10] Gestational age was estimated using Eregie system of scoring while Modified Ballard score was used in present study.

There were few studies that used nipple umbilical distance as one of the parameters to determine gestational age, some of them are given below.

Thawani et al, studied neonatal anthropometric parameters to predict gestational age.[11] Four parameters had a better quadratic correlation with gestational age of which the quadratic correlation coefficients for birthweight, head-circumference, and mid-upper arm-circumference were the highest and, hence, included in the final equation. It was seen that both foot length as well as umbilical nipple distance, had a comparatively poor correlation so not included in the final equation, whereas authors found a significant correlation of gestational age with foot length as well as nipple umbilicus distance, as p value was <0.05 for both the variables.

Another study was done by Ananya Tenali et al, wherein mean foot length was 7.728±0.59 with a range of 5-8.8 cm, whereas present study obtained a mean foot length of 6.62 cm with a range of 5.3-7.95 cm.[4] Foot length strongly correlated with gestational age in preterm AGA, SGA and term AGA babies (<0.001); correlation being higher in preterm (r=0.95). In present study, foot length correlated well with gestational age in all gestational age groups, while there was overlap of preterm and term neonates in 36-38 weeks gestational age category, so exact number of preterm and term babies could not be calculated.

According to the study done by Kumar V et al, on 209 newborns, ranging from 28-40 weeks of gestation, for assessment of neonatal gestational age using foot length, mid-upper-arm circumference, and nipple to umbilicus distance, all the three variables correlated well with gestational age much the same as in this study.[12] The correlation coefficient of gestational age with foot length and nipple to umbilicus distance was 0.886 and 0.814 respectively, resembling the correlation coefficient obtained in present study.

Pratinidhi AK et al, found a significant correlation of foot length with birth weight (r=0.75) and gestational age (r=0.63), similar to this study (0.799).[13]

CONCLUSION

The foot length as well as right nipple to umbilicus distance correlated well with gestational age in all gestational ages.

The foot length and nipple umbilical distance also correlated well with the gestational age in both AGA and SGA neonates. But the correlation of gestational age with foot length was better than that with right nipple umbilical distance. Thus, both these parameters can be used by a peripheral health worker for assessment of gestational age, assisting in early referral to higher centre.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee Shri V.N.G.M.C, Yavatmal, Maharashtra, India.

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