Original Research Article

# Assessment of gestational age using anthropometric parameters: an observational study in India

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## Abstract

**Introduction**: The gestational age of newborn is assessed by standard method New Ballard's score but it can also be assessed by some other simple parameters which are less time consuming and significantly correlate with gestational age. **Material and Methods:** The study population included 209 consecutive live born singleton newborn of 28-40 weeks of gestation. Data were recorded and analyzed by applying correlation and regression analysis. Regression equation was derived to predict gestational age from foot length and mid upper arm circumference (MUAC). **Result:** The foot length, MUAC and nipple to umbilicus distance correlated very well with gestational age with $R^2$=0.7843, 0.7832 and 0.6630 respectively and when used in combination i.e. foot length and MUAC as $R^2$= 0.833.The quadratic regression equation obtained was $Y=0.006X^2 – 0.174X + 5.081$ (Y is gestational age and X is the mean of foot length and MUAC). **Conclusion:** Foot length is an easy parameter and can be used as a proxy measure for New Ballard's score. Foot length and MUAC when used in combination can be used as a better and reliable guide for gestational age assessment of newborn. Also, the foot length, MUAC and nipple to umbilicus distance at cut-off value of 7 cm, 7 cm and 8 cm respectively can be used as ready reference for gestational age assessment of newborn at 34 weeks.

**Key words**- Anthropometry; Equation; Gestational age; New Ballard's score; Newborn

## Introduction

Prematurity is a significant contributor of morbidity and mortality in India and other developing countries. Conventionally, gestational age was calculated by Naegele's formula and antenatal ultra sonography or by using New Ballard's assessment and scoring in neonates [1]. Gestational age estimates based on Naegele's formula have lower accuracy in setting within rural settings with low literacy [2].

The assessment of gestational age of newborn is based on New Ballard's score [3], for which a paediatric specialist is needed. In developing countries like India, this method can be useful for assessment of gestational age in remote places with limited resources and manpower and preterm babies can be referred earlier for better care. Although New Ballard's score is a standard method for assessment of gestational age of newborn but assessment of gestational age of newborns using New Ballard's score may have inter-observer variation [4] in the condition of neonates like severe birth asphyxia and excessive sedation. In addition, it is a complex score, which requires the skills of a paediatric specialist.

Also we know that in developing countries like India, where resources are limited and paediatrician and obstetrician are not available in remote areas, in that condition deliveries are conducted at home by Dais, Aanganwadi workers or untrained relatives, so in that situation neonatal morbidity and mortality increases because they are not aware, which baby has to be referred to higher centre for neonatal care. All these factors thus underline the importance of

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early identification and reference to higher centre, if the baby is referred earlier then the morbidity or mortality can be decreased.

Anthropometry of newborn especially birth weight, has been used in the past to predict the gestational age of the neonates in peripheral health facilities where a trained paediatrician is often not available. Since decades, attempts have been made to find an alternative for gestational age assessment of newborns. These alternative measurements should be reliable, have a close correlation with both birth weight and gestational age in all groups of newborn babies such as preterm, term, and post-term as well as in the small-for-gestational age (SGA), appropriate-for-gestational age (AGA) and large-for-gestational age (LGA) groups of babies.

The alternative measurements including anthro-pometric parameter or group of parameters should be easy to conduct even by inexperienced health care staff and should have very little intra and inter observer variability. Thus, there is need to develop a simple, inexpensive and practical method to identify these highly-vulnerable preterm newborns soon after birth [5,6].

We conducted this study to devise a mathematical model to predict the gestational age of neonate, using anthropometric estimates, like foot length (FL), MUAC and nipple to umbilicus distance (NUD), using this parameter alone or in combination.

## Material and Methods

In this study we have collected the data by using predesigned and pretested proforma which was fulfilling the objective of study. Anthropometric measurements like FL, MUAC, NUD, weight, length, and head circumference (HC) were recorded.

The newborns were grouped into preterm (PT), late preterm (LPT), and full term (FT) categories but no cases were seen in post term category. All the three groups of babies were categorized into SGA, AGA, and LGA. This classification was made on the basis of Fenton TR growth chart centiles [7] for weight (kg), length (cm), and head circumference (cm). The baby was weighed in nude and pre-feed condition using a digital electronic scale to nearest 5gm. The crown- heel length (CHL) was recorded using an infantometer to the nearest 1.0mm by standard method. The MUAC was measured at the midpoint between the tip of acromion and olecranon process of the left upper arm. The HC was measured between glabella anteriorly and along the most prominent point posteriorly by cross over technique, measured over parietal eminence. The NUD was measured between right nipple to 12 o'clock position of the rim of the umbilicus. The MUAC, CHL, and NUD were measured by using a non-stretchable measuring tape to the nearest 1.0mm. The FL was measured as the distance from the heel to the longest toe (either great toe or first toe) of the right foot using Vernier calliper.

This observational study was conducted in the Sultania-Zanana- Hospital and special newborn care unit (SNCU) of Kamla Nehru, Hamidia Hospital, Gandhi Medical College, a tertiary care centre in Bhopal M.P. India. We assessed consecutive live born singleton neonates within 24 hours of birth from the beginning of the January 2015 to the end of December 2015 with inclusion criteria's (like single birth, normal without any complication and within 24 hours of birth). Neonates for whom reliable information about gestational age was not available (mother not knowing her last menstrual period i.e.

LMP; irregular menstrual cycles prior to pregnancy; bleeding during first trimester) and those with gross congenital anomalies and severe birth asphyxia were excluded from the study. Gestational age of newborn was calculated by using Naegele's formula [8] and by NBS which was regarded as gold standard for our study. A detailed anthropometric assessment was performed for each of the newborn within 24 hours of birth. To avoid inter-observer bias, the anthropometric estimation and the assessment of gestational age by NBS were carried out by only one investigator.

All the measurements were done 3 times, and the mean value was used in analysis. All anthropometric parameters were recorded in predesigned proforma. Neonates were categorized as small, large and appropriate for gestational age, using Fenton's TR reference chart but there was no case of large for gestational age seen in our study. Also we derived a cut-off value of different parameters which were included in our study like foot length, nipple to umbilicus distance and MUAC for gestational age below 34 weeks because above this gestational age

newborn will be able to breast feed until or unless there were any complication/s. All study subjects were recruited after obtaining written consent from parents/guardians. Scientific and ethical clearance has always been taken from the institutional committee of Gandhi medical college.

**Statistical analysis:** Statistical analysis was done using computer software (SPSS version 20). The qualitative data were expressed in proportion and percentages and the quantitative data expressed as mean and standard deviations. The difference in proportion was analyzed by using chi square test and the difference in means was analyzed by using student T Test [unpaired]. Correlation analysis was performed using Pearson correlation coefficient. Significance level for tests was determined as 95%. Test is considered significant if p value <0.05.

## Result

A total of 209 neonates, ranging in weight from 700gm to 3500gm were included. The gestational age varied from 28 to 40 weeks, with 99 neonates (47.4%) were PT, 26(12.4%) LPT and 84(40.2%) FT babies. There was no case of post term seen. Only 9.57% of neonates found to be extremely low birth weight (ELBW) i.e. <1000gm, 29.67% were very low birth weight (VLBW) i.e. 1000-<1500gm, 16.75% of neonates' low birth weight (LBW) i.e. 1500-<2500gm and rest 44.01% were normal birth weight babies. Out of 100 percent cases, 62.7% cases were found AGA; 37.3% cases were SGA; and no case seen for LGA, when classified according to Fenton TR chart. The mean, standard deviation and percentiles for FL, MUAC and NUD were tabulated with respect to gestational age.

The FL had best linear correlation with gestational age i.e. 0.886 followed by MUAC and NUD i.e. 0.879, 0.814 respectively and all three parameters were statistically significant i.e. p<0.001. Also, the standard error of estimate (SEE) for FL, MUAC and NUD were 1.5711, 1.5783 and 1.9637 respectively. The coefficient of determination ($R^2$) for FL was maximum i.e. 0.7843 followed by MUAC i.e. 0.7832 and least for NUD i.e. 0.6630. Hence FL and MUAC were included in final quadratic regression equation.

Also the sensitivity, specificity and negative predictive value for combined quadratic regression was higher than individual parameter. The equation had a sensitivity of 98.4%, specificity of 90.3% and negative predictive value of 99.2%.

**Table-1: Mean values, standard deviation (SD) and their centiles for foot length with gestational age.**

| GA | No of cases | Mean FL | SD | 2 SD | Mean + 2SD | Mean - 2 SD | 3rd | 5th | 10th | 25th | 50th | 75th | 90th | 95th | 97th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **28 weeks** | 10 | 5.13 | 0.36 | 0.72 | 5.85 | 4.41 | 4.80 | 4.80 | 4.80 | 4.80 | 4.95 | 5.43 | 5.77 | | |
| **30 weeks** | 23 | 5.81 | 0.48 | 0.95 | 6.76 | 4.86 | 4.90 | 4.98 | 5.34 | 5.40 | 5.80 | 6.10 | 6.42 | 6.98 | |
| **32 weeks** | 31 | 5.83 | 0.30 | 0.60 | 6.42 | 5.23 | 5.40 | 5.40 | 5.40 | 5.60 | 5.80 | 5.90 | 6.10 | 6.60 | |
| **34 weeks** | 35 | 6.34 | 0.45 | 0.89 | 7.23 | 5.45 | 5.50 | 5.50 | 5.72 | 6.00 | 6.30 | 6.70 | 6.90 | 7.10 | 7.10 |
| **36 weeks** | 26 | 6.90 | 0.35 | 0.70 | 7.60 | 6.20 | 6.30 | 6.30 | 6.44 | 6.60 | 6.85 | 7.20 | 7.40 | 7.40 | |
| **38 weeks** | 71 | 7.46 | 0.33 | 0.65 | 8.11 | 6.80 | 6.72 | 6.80 | 6.92 | 7.30 | 7.40 | 7.70 | 7.90 | 7.90 | 7.98 |
| **40 weeks** | 13 | 7.52 | 0.33 | 0.67 | 8.19 | 6.85 | 6.90 | 6.90 | 6.98 | 7.25 | 7.60 | 7.80 | 7.92 | | |

Above table reflects various centiles and mean for FL for different gestational age. The value of Pearson correlation co-efficient (r) of FL with gestational age calculated was 0.886, p<0.001. This shows significant positive correlation. Which indicates that foot length is better correlated with gestational age of newborn.

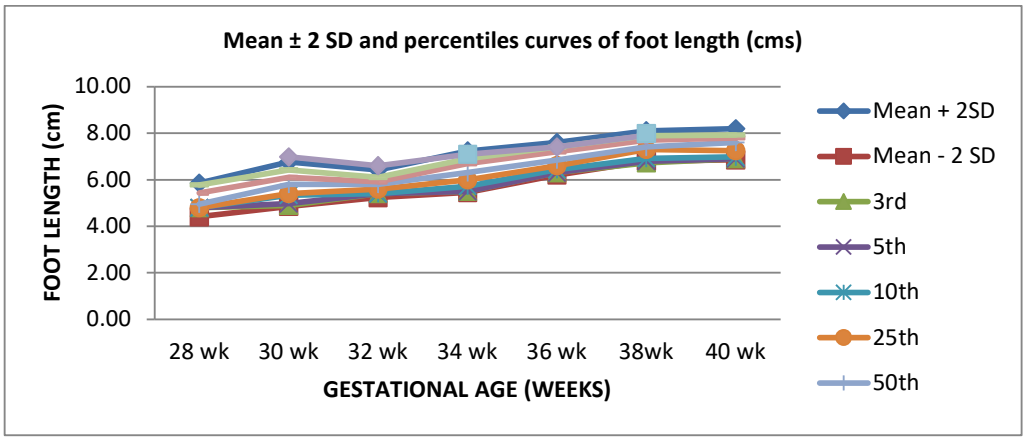
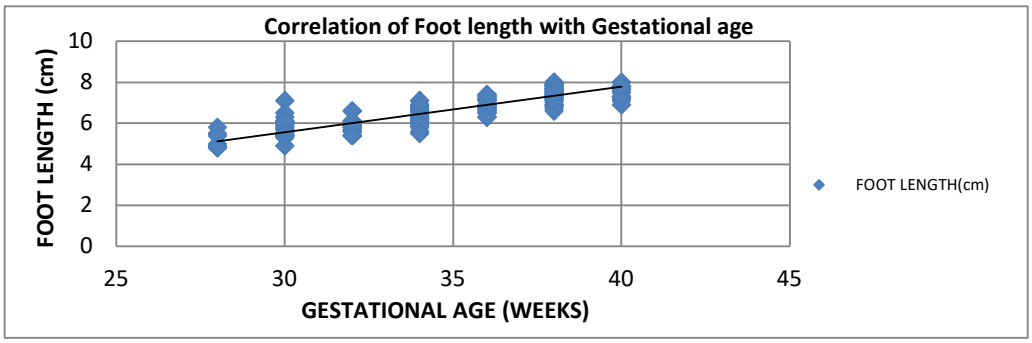



**Figure-1: Indicates foot length is better correlated with gestational age of newborn**




**Graph 1:** Scattered diagram showing Simple regression of Foot length for Ballard's Score of newborns.

**Table-2: Mean values, standard deviation (SD) and their centiles for Nipple to umbilicus distance with gestational age.**

| GA | No of cases | Mean NU length | SD | 2 SD | Mean + 2SD | Mean - 2 SD | 3rd | 5th | 10th | 25th | 50th | 75th | 90th | 95th | 97th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **28 weeks** | 10 | 7.01 | 0.28 | 0.56 | 7.57 | 6.45 | 6.40 | 6.40 | 6.44 | 6.95 | 7.00 | 7.13 | 7.47 | | |
| **30 weeks** | 23 | 7.13 | 0.36 | 0.71 | 7.85 | 6.42 | 6.50 | 6.50 | 6.54 | 6.90 | 7.10 | 7.50 | 7.56 | 7.76 | |
| **32 weeks** | 31 | 7.42 | 0.60 | 1.19 | 8.61 | 6.23 | 6.20 | 6.38 | 6.54 | 7.10 | 7.30 | 7.90 | 8.18 | 8.40 | |
| **34 weeks** | 35 | 8.03 | 0.73 | 1.45 | 9.48 | 6.58 | 6.02 | 6.24 | 7.16 | 7.50 | 8.20 | 8.50 | 8.80 | 9.00 | 9.00 |
| **36 weeks** | 26 | 8.50 | 0.61 | 1.22 | 9.72 | 7.29 | 7.20 | 7.31 | 7.85 | 8.10 | 8.50 | 8.93 | 9.50 | 9.50 | |
| **38 weeks** | 71 | 9.34 | 0.65 | 1.31 | 10.65 | 8.03 | 8.03 | 8.20 | 8.80 | 9.00 | 9.20 | 9.60 | 10.20 | 10.94 | 11.00 |
| **40 weeks** | 13 | 9.47 | 0.60 | 1.20 | 10.66 | 8.27 | 8.50 | 8.50 | 8.58 | 8.90 | 9.50 | 10.10 | 10.16 | | |

Above table depicts that the various centiles and mean for nipple to umbilicus distance for different gestational age. The value of Pearson correlation co-efficient (r) of Nipple to umbilicus length with gestational age calculated was 0.814, $p<0.001$. It is significant positive correlation. Which indicates that nipple to umbilicus distance is better correlated with gestational age of newborns.

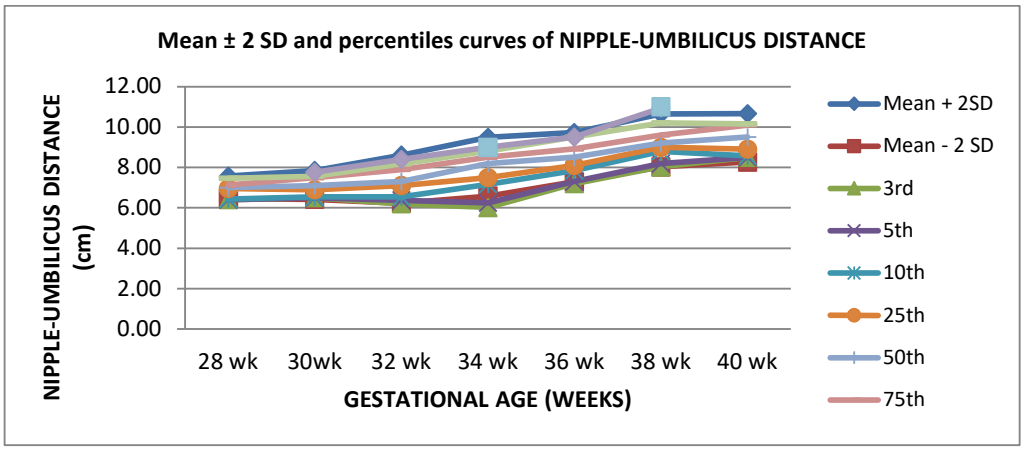
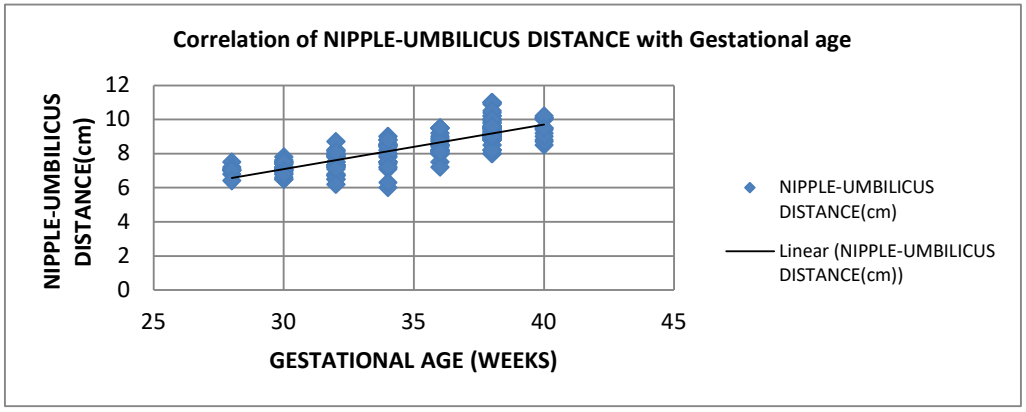



**Figure-2: Indicates Nipple to Umbilicus distance for Ballard's Score of new-borns.**




**Graph 2:** Scattered diagram showing Simple regression of Nipple to Umbilicus distance for Ballard's Score of newborns

**Table- 3: Mean, standard deviation (SD) and their centiles for MUAC with gestational age.**

| GA | No of cases | Mean | SD | 2 SD | Mean + 2SD | Mean - 2 SD | 3rd | 5th | 10th | 25th | 50th | 75th | 90th | 95th | 97th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **28 weeks** | 10 | 6.12 | 0.81 | 1.63 | 7.75 | 4.49 | 5.00 | 5.00 | 5.05 | 5.50 | 5.80 | 7.00 | 7.09 | | |
| **30 weeks** | 23 | 6.54 | 0.51 | 1.02 | 7.56 | 5.51 | 5.50 | 5.52 | 5.68 | 6.10 | 6.60 | 7.10 | 7.10 | 7.10 | |
| **32 weeks** | 31 | 7.17 | 0.53 | 1.05 | 8.23 | 6.12 | 6.00 | 6.06 | 6.26 | 6.60 | 7.30 | 7.50 | 7.60 | 8.00 | |
| **34 weeks** | 35 | 7.65 | 0.90 | 1.79 | 9.44 | 5.85 | 5.09 | 5.88 | 6.42 | 7.10 | 7.80 | 8.10 | 8.82 | 9.00 | 9.00 |
| **36 weeks** | 26 | 8.69 | 0.74 | 1.47 | 10.17 | 7.22 | 7.00 | 7.18 | 7.57 | 8.10 | 9.00 | 9.15 | 9.59 | 9.80 | |
| **38 weeks** | 71 | 9.62 | 0.56 | 1.11 | 10.73 | 8.51 | 8.50 | 8.56 | 9.00 | 9.10 | 9.80 | 10.10 | 10.20 | 10.44 | 10.75 |
| **40 weeks** | 13 | 10.05 | 0.48 | 0.95 | 11.00 | 9.10 | 9.10 | 9.10 | 9.26 | 9.65 | 10.20 | 10.50 | 10.50 | | |

Above table shows that various centiles and mean value for different gestational age. The value of Pearson correlation co-efficient (r) of MUAC with gestational age calculated was 0.879, $p<0.001$. It is significant positive correlation. Which indicates that MUAC better correlated with gestational age of newborns.

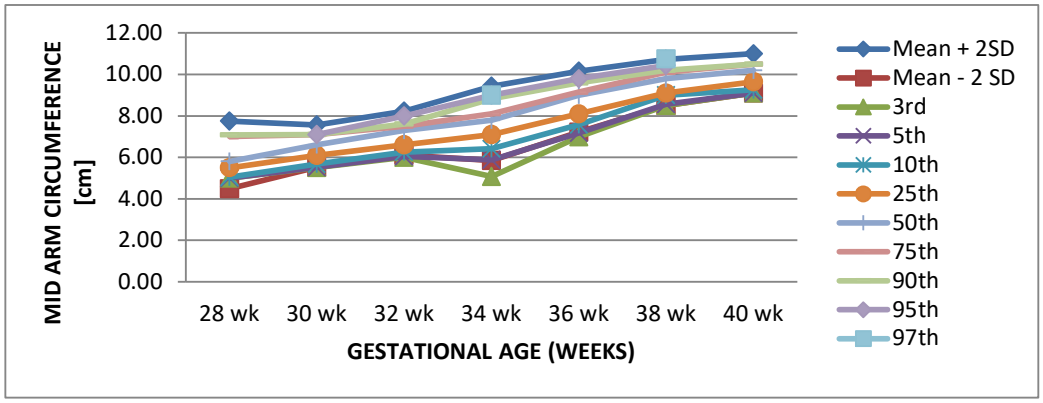
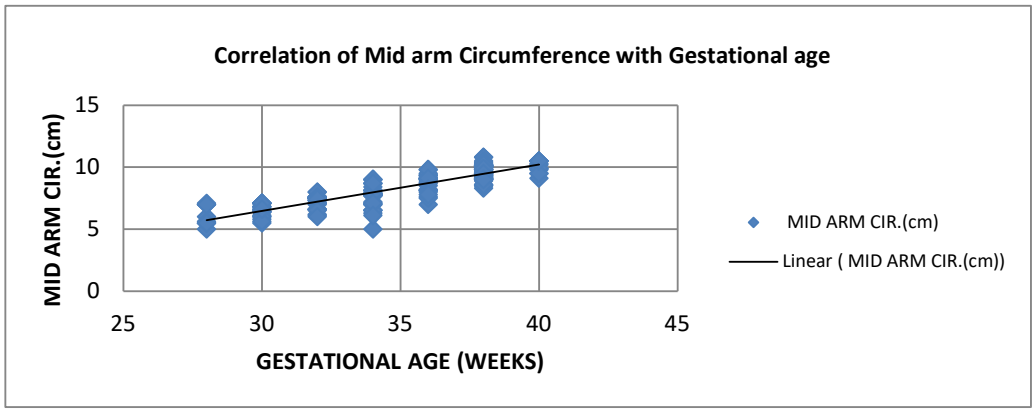



**Figure-3: Indicates Mid-upper-arm Circumference for Ballard's Score of newborns.**




**Graph3:** Scattered diagram showing Simple regression of Mid-upper-arm Circumference for Ballard's Score of new-borns.

## Discussion

In present study the percentage of SGA was 37% in which, it has maximum percentage for preterm babies accounting to about 80%, followed by late preterm and term babies i.e. 15.8% and 3.84% respectively. This was in contrast to the study done by Thawani et al found that the percentage of SGA was almost equal in preterm, late preterm and term babies [9]. In present study, Pearson correlation coefficient (r) of FL with gestational age was found to be r=0.886. The study also showed that the centiles and mean value of FL linearly increases with increasing gestational age.

The p value was also significant which indicates that FL can correlate with gestational age. The correlation coefficient of foot length with gestational age was almost similar to present study in the studies done by Shilpi et al[10] in 2014 (r=0.94 and r=0.934 respectively). Also in this study, the sensitivity of foot length for the prediction of gestational age below 34 weeks with cut off value of 7 cm was 94.76% and specificity was 94.30%. The positive predictive value and negative predictive value were 81.55% was 98.54% respectively. In present study, sensitivity and negative predictive value were higher than this study i.e. 98.4% and 98.9% respectively

In present study, cut-off value of FL below 34 weeks of gestational age was 7, with sensitivity of 98.4%, specificity of 61.4%, positive predictive value of 52.9% and negative predictive value of 98.9% for the prediction of gestational age below 34 weeks.

S Mukherjee et al [11] according to the study, foot length < 7.75cm had 92.3% sensitivity and 86.3% specificity for identification of preterm neonates. Nabiwemba et al [12] found that the operational cut-off for foot length to detect small babies was 7.6 cm.

The sensitivity of this was 96% and specificity was 76% for premature babies. The present study showed higher sensitivity. Mullany et al [13] in Nepal, studied that foot length measurement of <6.9 cm was 88% sensitive and 86% specific for identification of VLBW newborns. While in present study foot length <7cm were 98.4% sensitive and 61.4% specific for identification of newborn below 34 weeks gestational age.

In present study, MUAC also showed a linear correlation with the gestational age of newborn. The Pearson correlation coefficient (r) for MUAC was 0.879 and the p value was significant i.e. p <0.001. The cut off value of MUAC was 7 cm for gestational age below 34 weeks. The sensitivity and specificity were 46.8% and 95.8% respectively. The positive predictive value and negative predictive value were 83.33% and 80.3% respectively. The mean and SD value of NUD for different gestational age was also studied. The mean value of NUD gradually increased with increasing gestational age of newborns. The mean values of different parameters for various gestational ages were also calculated.

Through regression analysis, a linear regression equation Y=11.363+3.53X, where X is foot length in cm and Y is gestational age in weeks, was formulated. This simple equation can be applied to estimate the gestational age of newborn by foot length. For example, for a foot length of 6 cm the gestational age calculated will be 32 weeks, which is very close to the mean value of foot length obtained in this study which is 5.83 for 32 weeks.

Similarly the gestational age can also be calculated by known value of MUAC using the regression equation Y=17.58+2.08X, where 'X' is value of MUAC in cm and Y is gestational age in weeks. The equation for gestational age assessment from NUD is Y=13.67+2.54X, where 'X' is value of NUD in cm and Y is gestational age in weeks.

The present study also showed significant (p<0.001) correlation between each parameters with gestational age. However, FL and MUAC had more coefficient of determination ($R^2$) i.e. 0.7843 and 0.7832 respectively as compared to NUD which was $R^2$ =0.6630. Hence, NUD distance was not included in quadratic regression equation. So the final quadratic regression equation for calculation of gestational age of newborn was formulated to be $Y=0.006X^2-0.174X+5.081$, where X was the mean of FL + MUAC and Y was the gestational age in weeks. This equation had a sensitivity of 98.9%, specificity of 90.8%, positive predictive value of 81.8%, and negative predictive value of 99.2%.

The standard error of estimate (SEE) was low i.e. 1.39 for quadratic regression equation as compared to individual parameters like FL and MUAC which having 1.5711 and 1.5783 respectively. Also, the coefficient of determination ($R^2$) quadratic regression equation was 0.833 which was higher than individual parameter. This indicates that, all the statistical analysis for combined parameters (i.e. FL and MUAC) were more significant as compared to individual parameter like FL, MUAC and NUD. Thus, the quadratic regression equation can better predict gestational age of newborn in combination as compared to individual parameter. Considering the cut-off value of FL and MUAC to be 7 cm for gestational age below 34 weeks, the quadratic equation had 81.8% of positive predictive value, sensitivity of 98.4% and negative predictive value of 99.2% for the prediction of gestational age below 34 weeks.

Thus present study found a good linear correlation between gestational age and FL, MUAC and NUD. The quadratic correlations co-efficient for FL and MUAC were the highest and, hence included in the final equation. If we use single parameter like FL or MUAC, the calculation of gestational age was very close to the mean value but when we used these parameters in combination, the predictability of assessment of gestational age was high.

However, this remains a crude method as the slope of rise was too slow, making a large number of lengths normal for a range of gestation. Yet for approximation in field studies or where time was prohibitive, this could be useful.

Assessment of the gestational age by New Ballard's score or Dubowitz score is time consuming, observer dependent for neurological scoring, dependent on the condition of neonates and requires expertise. In such cases FL, MUAC and NUD can be used as single parameter or in combination to assess gestational age of healthy and sick newborns by health personnel in rural areas. It requires less handling and negates observer bias.

## Conclusion

The present study evaluates use of simple anthropometric measures like FL, MUAC, and NUD for easy assessment of gestational age of newborn. The present study showed statistical significant correlation of gestational age with each individual parameter like FL, MUAC and NUD as well as with combined parameters like FL and MUAC. In present study gestational age of newborn showed best correlation with the FL followed by MUAC and lastly with NUD. FL and MUAC when used as combined, quadratic regression equation showed higher sensitivity and specificity as compared to individual parameters and hence can be used as a better and reliable guide for gestational age assessment of newborn. The present study concluded that the FL, MUAC and NUD at cut off value of 7 cm, 7 cm and 8 cm respectively can be used as ready reference for gestational age assessment of newborn at 34 weeks. These measurements can guide early referrals from periphery for early intervention and better care in preterm newborns.

The equation which was derived can be used as an alternative to New Ballard's score (NBS) in settings where antenatal Ultra-sonography and paediatrician to assess the gestational age of neonates within 24 hours of birth are not available. Thus, the present study puts forth an easy proxy method for gestational age assessment of newborn at community level.

**What this study adds to existing knowledge?**

The present study adds the importance of use of simple anthropometric measures like Foot Length, Mid Upper Arm Circumference, and Nipple to Umbilicus Distance for easy assessment of gestational age of newborn.

**Abbreviations**

FL - Foot length, MUAC- Mid-upper-arm circumference, NUD- Nipple to umbilicus distance, CHL- Crown to heel length, HC- Head circumference, PT- preterm, LPT-Late preterm, FT- Full term, SGA- Small for gestational age, AGA- Appropriate for gestational age, LGA- Large for gestational age, SD- Standard deviation.

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## References

1. March of Dimes. Born too soon: the global action report on preterm birth. Howson CP, Kinney MV, Lawn JE, editors. Geneva: world health organisation, 2012

2. Savitz DA, Terry JW Jr, Dole N, Thorp JM Jr, Siega-Riz AM, Herring AH. Comparison of pregnancy dating by last menstrual period, ultrasound scanning, and their combination. Am J Obstet Gynecol. 2002 Dec;187(6):1660-6.

3. Ballard JL, Khoury JC, Wedig K, et al: New Ballard's score. Infants. J Paediatric 1991; 119: 417-423.

4. Moraes CL, Reichenheim ME. [Validity of neonatal clinical assessment for estimation of gestational age: comparison of new ++Ballard+ score with date of last menstrual period and ultrasonography]. Cad Saude Publica. 2000 Jan-Mar; 16 (1):83-94.

5. Mullany LC, Darmstadt GL, Coffey P, Khatry SK, LeClerq SC, Tielsch JM. A low cost, colour coded, hand held spring scale accurately categorises birth weight in low resource setting. Arch Dis Child 2006; 91:410-13.

6. Sreeramareddy CT, Chuni N, Patil R, Singh D, Shakya B. Anthropometrics urrogates to identifylow birth weight Nepalese newborns: a hospital-based study. BMC Pediatr. 2008 Apr 25;8:16. doi: 10.1186 / 1471-2431-8-16.

7. Tanis R Fenton, Roseann Nasser, Misha Eliasziw, Jae H Kim, Denise Bilan, and Reg Sauve. Validating the weight gain of preterm infants between the reference growth curve of the fetus and the term infant BMC pediatrics 2013, 13:59. doi: 10.1186/1471-2431-13-92

8. Thomas F. Baskett,Fritz Nagele. Naegele's rule: a reappraisal. British Journal of Obstetrics and Gynaecology. November 2000; 107:1433-1435. 10. 1111/j. 1471-0528.2000.tb11661.x

9. Rajat Thawani, Pooja Dewan, Rajeev Kumar. Estimation of gestational ageusing neonatal anthro-pometry: A cross-sectional study in India. J Health Popul Nutr.2013 Dec; 31(4): 523-530.

10. Shilpi Singhal, Anurag Tomar, Rupesh Pasand, ALok Purohit. A simple tool for assessment of gestational age in newborns using foot length. J of Evolution of Med and Dent Sci. / Vol.3/ Issue 23/ June 09, 2014. P.6424-29.

11. Satarupa mukherjee, Prithvish, Souvik mitra and Sukanta chatterjee. Measuring newborn foot length to identify small babies in need of extra care: a cross sectional hospital based study. Iran J Pediatr.2013 oct; 23 (5):508-512.

12. In 2013, E. Nabiwemba, Merchant T, Namazzi G et al. identifying high-risk babies born in the community using foot length measurement at birth in Uganda. Child care health dev. 2013; 39 (1):20-6.

13. Mullany LC, Darmstadt GL, Khatry SK, et al. Relationship between the surrogate anthropometric measure, foot length and chest circumference and birth weight among newborns of Sarlahi, Nepal. Eur J clin Nutr. 2007; 61(1):40-46.

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