**Original research article**

# DIAGNOSTIC POTENTIAL OF NEWBORN FOOT LENGTH TO DETERMINE GESTATIONAL AGE AND ITS COMPARISON WITH NEW BALLARD SCORE

**[1]Dr. Basavanappa, [2]Dr. Arvind K Trishul, [3]Dr. Arshiya Kouser. J., [4]Dr. P Ramu, [5]Dr. Dilip Kumar,**

[1,2]Post Graduate, Department of Paediatric, Dr B.R Ambedkar Medical College and Hospital, Bangalore, Karnataka, India

[3]Assistant Professor, Department of Community Medicine, Dr. B.R. Ambedkar Medical College and Hospital, Bengaluru, Karnataka, India

[4]Assistant Professor, Department of Community Medicine, Viswabharathi Medical and General Hospital, Kurnool, Andhra Pradesh, India

[5]Associate Professor, Department of Paediatrics, Dr B R Ambedkar Medical Collage and Hospital, Bangalore, Karnataka, India

**Corresponding Author:**
Dr. P Ramu

**Abstract**

**Background:** Foot length (FL) measurement is an easy and highly efficient anthropometric parameter used as a proxy method for assessing a newborn's gestational age (GA) in low-resource settings. The present study aimed to determine the diagnostic accuracy of postnatal FL measurement in predicting GA in newborns and compare it with other methods of GA assessment, particularly the New Ballard Score (NBS).

**Methods:** This single-institution-based cross-sectional study was conducted at the Dr. BR Ambedkar Medical College and Hospital, Karnataka, India, from December 2018 to May 2020 to include 102 live newborns. Prenatal GA was assessed by ultrasonography (USG), while postnatal GA was estimated using the NBS. Demographic details and anthropometric measurements of the infants, including gender, birth weight (BW), mode of delivery, head circumference (HC), crown-heel length (CHL), and right FL, were recorded.

**Results:** The mean FL of the study subjects was 6.57 ± 1.01 cm. We found that FL could significantly predict prematurity at a cut-off value of ≤ 6.8 cm (sensitivity=93.9%; specificity=92.5%; $p$=<0.0001). The mean GA (NBS) was 35.23 ± 3.59 weeks, and FL could measure GA as per the following equation: GA = 16.752 + 2.811*FL (cm), i.e., GA increased by 2.811 weeks with a 1 cm increase in FL ($p$<0.0001). A significant positive correlation was observed between FL and GA (NBS), HC, CHL, and BW ($p$ < 0.000 each).

**Conclusion:** Newborn FL is a highly sensitive tool to diagnose prematurity in neonates within the first seven days of life.

**Keywords:** Hospitals, gestational age, newborn, pregnancy, birth weight

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 04, 2024

**Introduction**

Gestational age (GA) denotes the period from the conception of pregnancy to birth and is a crucial factor in determining an infant's survival and prognosis. Based on the GA, newborns may be categorized as preterm (born at < 37 weeks), full-term (at 37-41 weeks), or post-term (at > 42 weeks) [1]. Every year, around 13 million babies are born prematurely, with a prevalence rate of 47.5-137 per 1000 live births [2, 3]. Preterm birth and the associated complications make up a massive 28% of all neonatal deaths worldwide [4], while India alone accounts for around 35% of these deaths.[5] Furthermore, more than 80% of infant deaths occur in low birth weight (LBW, < 2500 g) infants either because they are prematurely born or are small for gestational age (SGA) [6]. The prevalence of SGA births is considerably high in low and middle-income countries (LMICs), with approximately three-quarters belonging to South Asia and sub-Saharan Africa [7].

Regular assessment of GA is a major component of the antenatal examination because birth, either before or after the completion of full-term, is a high-risk factor for the neonate's health. Preterm babies often suffer from developmental delays resulting in several life-long complications on their health and overall growth. These babies are more prone to hypoglycemia, hypothermia, necrotizing enterocolitis (NEC), hypotension, anemia of prematurity, hearing and visual disorders, central nervous system (CNS) injury, and a wide range of respiratory disorders, including apnea due to respiratory distress syndrome (RDS), and bronchopulmonary dysplasia [8]. In contrast, infants born post-term are more likely to develop respiratory difficulty as a result of meconium aspiration syndrome (MAS).[9] Therefore, establishing the GA accurately not only helps in identifying LBW, preterm birth, and SGA babies but also prepares the parents and pediatrician for the probability of developing serious clinical conditions in the newborn and promptly adopting appropriate treatment plans.

GA can be estimated by several methods, such as using the date of the last menstrual period (LMP) [10, 11], calculating the estimated date of delivery (EDD) by Naegele's formula [12], antenatal ultrasonography (USG) [13], clinical examination of the mother, biochemical evaluation of amniotic fluid, and vaginal wall cytology. The modified or New Ballard Score (NBS) is one such valid and reliable tool for GA assessment that uses a standardized postnatal scoring system based on a variety of physical and neuromuscular criteria [14].

In developing countries, the majority of deliveries take place at peripheral centers. Besides the limitations associated with individual GA estimation methods, it is often difficult to take accurate infant measurements in such peripheral centers because of the unavailability of sensitive weighing and ultrasound machines and trained personnel. Simple anthropometric alternatives to birth weight (BW), such as measurement of head and chest circumference and crown-heel length (CHL), have been investigated earlier to assess GA [15-18]. Newborn foot length (FL) has also been studied as an alternative tool for screening low-weight babies and estimating GA [1, 5, 19-21]. Measuring FL with a standard well-graded tape or ruler is relatively simple and requires no expertise. Additionally, the foot is easily accessible, even in preterm babies or in those requiring special support in neonatal intensive care units (NICUs) or incubators. Thus, newborn FL measurement is a potentially simple and inexpensive method to predict GA in clinical settings for recognizing high-risk newborns due to either preterm birth or LBW

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 04, 2024

[21, 22]. The present study attempts to ascertain the diagnostic value of newborn FL measurement in predicting GA by determining the correlation between the FL and NBS-based GA.

## Materials and Methods

### Study Design and Subjects

A single-center cross-sectional study was conducted from December 2018 to May 2020 to include neonates from the postnatal ward and NICU, Department of Pediatrics, Dr. B. R. Ambedkar Medical College and Hospital, Bangalore, Karnataka, India. The study sample was selected using random sampling after applying the relevant inclusion and exclusion criteria (Table I).

Dagnew *et al*. (2020) reported the sensitivity and specificity of FL for predicting prematurity as 98.5% and 96.3%, respectively [20]. Using these as reference values, to achieve an acceptable precision of 8% with the power of study as 90% and a 5% level of significance of 5%, a target sample size of 96 patients was determined. To further decrease the margin of error, we increased the total sample size to 102 in the present study.

Written informed consents were obtained from the parents or the legal guardians of all children included in the study. Ethical clearance was obtained from the local Institutional Ethical Committee.

### Instrumentation

We used a non-stretchable measuring tape and ruler to record the FL, a flexible, non-stretchable measuring tape for measuring the HC, an Infantometer for measuring CHL, and an electronic weighing scale for measuring the BW.

### Data Collection

All data for the study participants were recorded using the standard predesigned proforma as per the study objectives (Annexure I). Before birth, the GA of the newborn was assessed by antenatal scans (using USG) carried out before 18 weeks of gestation. After delivery, details, such as gender, mode of delivery, BW, CHL, and HC of the newborn study subjects were recorded. Measurements of the right foot were taken for the FL-the length was measured from the most distal point on the heel to the tip of the longest toe (great toe or 2$^{nd}$ toe) using a measuring tape and a ruler. Fenton's chart was used to include only AGA babies.

### New Ballard Score

The postnatal GA of the newborn was examined within 72 hours of life using the NBS method by trained medical personnel. The modified Ballard's maturational assessment system consists of six physical and six neuromuscular maturity signs. The score of each variable ranges from -1 to 5; the total maturity score is the sum of scores for each maturity sign and ranges between -10 and 50. NBS allows estimating GA in the range of 20-44 weeks from the corresponding total maturity score of the infant (Figure 1.) [14, 23].

**Statistical Analysis**

The categorical variables were described using frequency and percentages (%) and continuous variables as mean ± standard deviation (SD) or median values. The Kolmogorov-Smirnov test was used to check for data normalcy. The correlation between FL and other anthropometric measurements (BW, CHL, and HC) and the GA of the babies was assessed using the Spearman rank correlation coefficient. Bland Altman plots were used to compare GA determined by USG and NBS. The cutoff value for FL to predict prematurity was assessed by computing the receiver operating characteristic (ROC) curve. Additionally, a univariate linear regression was performed, considering FL as an independent variable to predict GA. All statistical analyses were done using the Statistical Package for Social Sciences (SPSS) software (version 21.0, IBM Inc., NY, USA). A *p*-value of $< 0.05$ was considered statistically significant.

**Results**

**Demographic Characteristics of the Newborns**

We included a total of 102 babies (54 males (52.94%) and 48 females (47.06%)) (Figure 2a). A majority of the neonates (n = 71, 69.61%) were delivered by normal vaginal delivery (NVD), while 30.39% (n = 31) were delivered by lower segment cesarean section (LSCS) (Figure 2b). The mean BW (kg) of the neonates was 2.37 ± 0.92 kg [Median weight: 2.5 (1.525-3.2)]. Most of the babies (n = 45, 44.12%) had a BW in the range of 2.5-3.5 kg (Figure 2c). The mean CHL (cm) was 44.84 ± 5.77 cm (median (IQR): 46 (41-49.75) kg) (Figure 2d), and the mean HC (cm) was 30.21 ± 3.57 cm (median (IQR): 31 (27.625-33) cm) (Figure 2e).

**Foot Length Measurement**

The mean FL of the neonates was 6.57 ± 1.01 cm with a median (IQR) value of 7 (6-7.2) cm (Figure 2f).

**Assessment of Gestational Age**

a) **Based on USG:** The mean GA of the 102 neonates based on USG assessment was 35.22 ± 4.3 weeks (median (IQR): 37 (32-38.57) weeks). About 51.96% of the study subjects had a GA (USG) of >37 weeks, followed by 24.51% being born at 32 weeks-36 weeks (± 6 days), and 17.65% were born at 28 weeks-31 weeks (± 6 days) of GA (USG). Six babies (5.88%) were born at a GA (USG) of < 28 weeks (Figure 3a).

b) **Based on the NBS:** The mean GA (NBS) was found to be 35.23 ± 3.59 weeks (median (IQR): 36 (32-38) weeks). Out of the 102 newborn babies, 50 (49.02%) had a GA(NBS) of >37 weeks, followed by 34 (33.33%) neonates having a GA(NBS) of 32 weeks-36 weeks (± 6 days), 17 neonates (16.67%) having a GA(NBS) of 28 weeks-31 weeks (± 6 days), and only one case of (0.98%) GA(NBS) <28 weeks (Figure 3b).

**Correlation of Newborn FL with other Anthropometric Measurements**

The FL value had a statistically significant positive correlation with BW ($\rho = 0.92$), CHL ($\rho = 0.881$), and HC ($\rho = 0.881$) ($p < 0.0001$ each) (Table II).

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 04, 2024

**Correlation of Newborn FL and GA (NBS)**

A significant positive correlation was observed between newborn FL and GA (assessed using the NBS ($\rho = 0.863$; $p < 0.000$) (Figure 4).

**Comparison of GA by USG and NBS**

Using the Bland-Altman plot, we observed that the average of the differences in mean GA assessed using USG and the NBS was 0.0098 weeks. The limits of agreement were estimated as an interval of -0.3283 to 0.3479 weeks (Figure 5).

**Analysis of the ROC Curve of FL for Predicting Prematurity**

The ROC curve above the diagonal line shows that FL has a reasonable discriminating ability to predict prematurity. Furthermore, the area under the ROC curve (AUC) estimation revealed that the performance of FL (cm) was outstanding (AUC: 0.969; 95% Confidence Intervals, CI: 0.914 to 0.993). An FL value of ≤ 6.8 cm was found to be the cutoff value for significantly predicting prematurity, with a 96.90% chance of predicting prematurity correctly (sensitivity = 93.9%, specificity = 92.5%; $p$ <0.000) (Figure 6 and Table III).

At this cutoff FL value, the positive predictive value (PPV) or probability of prematurity was 92%, while the negative predictive value (NPV) was 94.2%, i.e., if FL is > 6.8 cm, there is a 94.2% chance that the child is not premature. The diagnostic accuracy of newborn FL to predict prematurity was found to be 93.14% (Table III).

Lastly, GA was estimated through linear regression analysis of FL, using the formula GA = 16.752 + 2.811*FL (cm). According to this formula, an increase of 1 cm in FL depicted an increase of 2.811 gestational weeks ($p < 0.000$) (Table IV).

**Table I:** Selection criteria for enrolling study participants

| |
|---|
| **Inclusion Criteria**<br>Neonates alive and born at appropriate gestational age (AGA) belonging to different gestational ages (preterm, full-term, post-term) within 72 hours of birth. |
| **Exclusion Criteria**<br>Babies who were:<br>• Syndromic.<br>• With limb dysplasia or skeletal foot abnormalities.<br>• SGA/large for GA (LGA). |

**Table II:** Correlation between newborn FL and other variables

| Variables | Birth weight (kg) | Length (cm) | Head circumference (cm) |
|---|---|---|---|
| Foot length (cm) | | | |
| Correlation coefficient | 0.92 | 0.881 | 0.881 |
| P value | <0.0001 | <0.0001 | <0.0001 |

**Table III:** Diagnostic study results

| Prematurity | Foot length(cm) |
|---|---|
| Area under the ROC curve (AUC) | 0.969 |
| Standard Error | 0.0197 |
| 95% Confidence interval | 0.914 to 0.993 |
| P value | <0.0001 |
| Cut off | ≤6.8 |
| Sensitivity (95% CI) | 93.88% (83.1-98.7%) |
| Specificity (95% CI) | 92.45% (81.8-97.9%) |
| PPV (95% CI) | 92% (80.8-97.8%) |
| NPV (95% CI) | 94.2% (84.1-98.8%) |
| Diagnostic accuracy | 93.14% |

**Table IV:** Univariate linear regression of FL to predict GA

| Variable | Beta coefficient | Standard error | Standardized coefficient | *P*-value | Lower-bound (95%) | Upper bound (95%) | $R^2$ |
|---|---|---|---|---|---|---|---|
| Foot length (cm) | 2.811 | 0.318 | 0.662 | <0.0001 | 2.179 | 3.443 | 43.78% |

**Discussion**

Premature birth (before 37 weeks of pregnancy) is one of the major factors contributing to neonatal deaths amongst children < 5 years of age and accounts for 15.9% of the global mortality rate [24]. It has been reported that infants born preterm have a 6.8-fold higher risk of neonatal mortality than those born at full-term [25]. Therefore, to reduce mortality from preterm birth, it is important to accurately determine GA within 48 hours after birth and allow the health workers to identify preterm at-risk babies and treat them with potential life-saving interventions. Several surrogate measures of neonatal anthropometries, such as head and chest circumference, mid-upper arm, CHL, and BW, have been used to diagnose preterm status and GA in newborns [5, 18, 26]. However, these methods require a long time and availability of equipment and operating personnel, usually putting the neonate at s risk of hypothermia. Additionally, they are governed by the baby's gender and the presence of subcutaneous fat. In contrast, measuring a newborn's FL is an easy and cost-effective anthropometric screening tool to efficiently identify preterm and critically-ill newborns, even in settings that lack infrastructure and trained manpower [27, 28]. There is a dearth of literature from India evaluating the correlation of FL with other anthropometric variables. Accordingly, the present study was undertaken to assess the diagnostic potential and utility of FL in predicting GA and prematurity.

We found that an FL ≤6.8 cm can accurately differentiate between preterm and term newborns. Furthermore, FL could significantly predict prematurity with a 96.90% chance of a correct diagnosis ($p$<0.0001). In a similar study, Dagnew *et al*. (2020) reported that the optimal threshold FL of ≤7.35 cm could predict preterm status in newborns with high sensitivity (98.5%) and specificity (96.3%) [20]. Likewise, a recent Indian study by Shukla *et al*. (2020) reported that the FL = 7.2 cm had a sensitivity and specificity of 94.4% and 95.6%, respectively ($p$<0.0001), identifying preterm babies [29]. Folger *et al*. (2020) systematically reviewed 19 studies that showed high sensitivity of FL to diagnose low BW infants [21].

On the other hand, Lee *et al*. (2016) reported contrasting findings, i.e., they reported that newborn FL of < 7.5 cm had a low sensitivity (64%) and specificity (35%) for diagnosing preterm status in newborns [30]. The difference in operational cutoff FL value observed in each study and country may be attributed to the racial, genetic, geographical, and measurement variations. Thus, the authors recommend that every hospital should determine its own FL cutoff value for subjects within a particular country.

The mean FL of our study subjects was 6.57 ± 1.01 cm. Furthermore, it was observed that the FL could be used to estimate GA using the regression equation: GA = 16.752 + 2.811*FL (cm), i.e., there was an increase of 2.811 weeks GA for every 1 cm increase in FL ($p$<0.0001). This is similar to many equations laid down in the existing literature. A previous Indian study described the following equation: GA = 3.8*FL + 7.68 [31], while Shukla *et al*. (2020) gave the equation, GA = 6.669 + 4.0601*FL (cm) [29]. Dagnew *et al*. (2020) provided the equation GA = 4.5*FL + 3.61 for estimating GA based on FL [20]. Although different equations have been provided; these findings suggest that accurate GA assessment by measuring a simple parameter, such as FL, could help various hospitals, especially peripheral care centers, which are not fully equipped with sophisticated and expensive setups to scrutinize potential preterm birth babies.

To further support the evidence regarding the use of FL in determining GA, we also determined the correlation between FL and other anthropometric measures. We found that FL was strongly and positively correlated with HC, BW, and CHL ($p$<0.000 each). Rakkappan *et al*. (2016) found that there was a strong positive correlation between FL and other anthropometric variables, such as BW (r = 0.92) and HC (r = 0.85) [19]. Gohil *et al*. (1991) reported that in neonates, FL had the highest correlation with CHL and BW in preterm babies and with HC in term babies [32]. These results suggest that FL can be a useful adjunct to the established anthropometric measures in determining the GA in newborns.

Conventionally, the GA of neonates may be computed by USG during pregnancy and using NBS assessment and scoring after the birth [33]. In our study, the mean GA(USG) of the study subjects was 35.22 ± 4.3 weeks, and the mean GA(NBS) was 35.23 ± 3.59 weeks. On average, the GA(NBS) overestimated the maturity or measured 0.0098 weeks more than the GA(USG), i.e., the GA(NBS) was found to be 0.3283 weeks below or 0.3479 weeks above the GA(USG) value. Previous studies have shown that compared with USG, the Ballard score tends to overestimate GA by 0.4 weeks [34]. However, on applying a paired t-test, we found no significant difference between GA(USG) and GA(NBS); this implies that there was a congruency in both the methods while determining the GA, which corroborates the validity of our study. However, determining the GA with the NBS method requires a skilled professional and is accurate only when used within the first seven days of life [35]. In this study, we observed a significant positive correlation between FL and GA(NBS) (ρ = 0.863, $p$<0.0001), indicating that FL increases with increasing GA. This finding strongly concurs with the results of previous studies depicting a positive correlation between FL and GA [5, 20, 22, 31, 36]. Therefore, our data successfully demonstrates the ability of FL to predict GA and, thus, recognize high-risk babies with prematurity.

## Limitations of the Study

Since this study was a single hospital-based study, the prevalence of preterm babies was greater as compared to that in a community setting. Another limitation was that SGA babies were excluded from the study, and the data may be biased to FL compared to the LBW newborn population with a greater incidence of intrauterine growth restriction.

## Conclusion

FL is a simple, quick, low-cost, as well as reliable anthropometric parameter that can be used as an alternative measure to GA and BW assessment using USG, particularly in sick and preterm neonates receiving intensive care. It may also be applied in various rural, remote settings devoid of facilities and infrastructure and allow medical practitioners to take preliminary measures to prevent prematurity complications in cases of unknown GA. However, further studies are required to validate FL in different community-based settings (with community health workers) to put it to clinical use.

## References

1. Farah M, Soebagyo B, Hidayah D. Diagnostic value of newborn foot length to predict gestational age. Paediatr Indones. 2017;57:181-186.
2. Gravett MG, Rubens CE, Nunes TM. Global report on preterm birth and stillbirth (2 of 7): discovery science. BMC Pregnancy Childbirth. 2010;10:1-6.
3. Mokuolu OA, Suleiman B, Adesiyun O, Adeniyi A. Prevalence and determinants of preterm deliveries in the University of Ilorin Teaching Hospital, Ilorin, Nigeria. Pediatr Rep. 2010;2:e3.
4. Lawn JE, Cousens S, Zupan J. Team LNSS. 4 million neonatal deaths: when? Where? Why? Lancet. 2005;365:891-900.
5. Selvendran C, Jagadeeswari S, Sundari S. Assessment of Gestational Age by Measuring Postnatal Foot Length of the Infant. J Res Med Dent Sci. 2021;9:294-305.
6. Lawn JE, Blencowe H, Oza S, *et al*. Every newborn: progress, priorities, and potential beyond survival. Lancet. 2014;384:189-205.
7. Blencowe H, Krasevec J, De Onis M, *et al*. National, regional, and worldwide estimates of low birthweight in 2015, with trends from 2000: a systematic analysis. Lancet Glob Health. 2019;7:e849-860.
8. Behrman RE, Butler AS. Mortality and acute complications in preterm infants. In Preterm Birth: Causes, consequences, and prevention. National Academies Press (US), 2007.
9. Cleary GM, Wiswell TE. Meconium-stained amniotic fluid and the meconium aspiration syndrome. An update. Pediatr Clin North Am. 1998;45:511-529.
10. Kramer MS, McLean FH, Boyd ME, Usher RH. The validity of gestational age estimation by menstrual dating in term, preterm and post-term gestations. J Am Med Assoc. 1988;260:3306-3308.
11. Neufeld LM, Haas JD, Grajéda R, Martorell R. Last menstrual period provides the

best estimate of gestation length for women in rural Guatemala. Paediatr Perinat Epidemiol. 2006;20:290-298.

12. Lawson GW. Naegele's rule and the length of pregnancy-A review. Aust NZJ Obstet Gynaecol. 2021;61:177-182.
13. Chervenak FA, Skupski DW, Romero R, *et al*. How accurate is fetal biometry in the assessment of fetal age? Am J Obstet. Gynecol. 1998;178:678-687.
14. Ballard JL, Khoury JC, Wedig K, Wang L. New Ballard Score, expanded to include extremely premature infants. J Pediatr. 1991;119:417.
15. Bhatia BD, Tyagi NK. Birth weight: Relationship with other fetal anthropometric parameters. Indian Pediatr. 1984;21:833-8.
16. Hern WM. Correlation of fetal age and measurements between 10 and 26 weeks of gestation. Obstetr Gynecol. 1984;63:26-32.
17. Bhargava SK, Ramji S, Kumar A, *et al*. Mid-arm and chest circumference at birth as predictors of low birth weight and neonatal mortality in the community. Br Med J. 1985;291:1617-9.
18. Das NK, Nandy S, Mondal R, Ray S, Hazra A. Gestational Age Assessment with Anthropometric Parameters in Newborns. Oman Med J. 2018;33:229.
19. Rakkappan I, Kuppusamy N. Newborn foot length measurement to identify high-risk neonate. Int J Sci Stud. 2016;4:13-19.
20. Dagnew N, Tazebew A, Ayinalem A, Muche A. Measuring newborn foot length to estimate gestational age in a high-risk Northwest Ethiopian population. PLoS One. 2020;15:e023-8169.
21. Folger LV, Panchal P, Eglovitch M, *et al*. Diagnostic accuracy of neonatal foot length to identify preterm and low birthweight infants: a systematic review and meta-analysis. BMJ Glob Health. 2020;5:e002-976.
22. Srinivasa S, Manasa G, Madhu GN. Foot length of newborn: Its correlation with gestational age and various anthropometric parameters. Curr. Pediatr. Res. 2017;21:248-53.
23. Gabriel MAM, Moreiras JM, Fleixas GL, *et al*. Assessment of the new Ballard score to estimate gestational age. An Pediatr (Barc). 2006;64:140-145.
24. Liu L, Oza S, Hogan D, *et al*. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the sustainable development goals. Lancet. 2016;388:3027-3035.
25. Katz J, Lee AC, Kozuki N, *et al*. Mortality risk in preterm and small-for-gestational-age infants in low-income and middle-income countries: a pooled country analysis. Lancet. 2013;382:417-425.
26. Goto E. Meta-Analysis: identification of low birthweight by other anthropometric measurements at birth in developing countries. J Epidemiol. 2011;21:354-362.
27. Ashish K, Nelin V, Vitrakoti R, Aryal S, Målqvist M. Validation of the foot length measure as an alternative tool to identify low birth weight and preterm babies in a low-resource setting like Nepal: a cross-sectional study. BMC Pediatr. 2015;15:43.
28. Marchant T, Jaribu J, Penfold S, Tanner M, Schellenberg JA. Measuring newborn foot length to identify small babies in need of extra care: a cross sectional hospital-based study with community follow-up in Tanzania. BMC Public Health. 2010;10:624.
29. Shukla OS, Rathva JJ. A study of postnatal foot length to determine gestational

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 04, 2024

maturity in neonates. Int J Contemp Pediatr. 2020;7:1889-1893.

30. Lee AC, Mullany LC, Ladhani K, *et al*. Validity of newborn clinical assessment to determine gestational age in Bangladesh. Pediatrics. 2016;138:e2015-3303.
31. Chikkannaiah P, Gosavi M. Accuracy of fetal measurements in estimation of gestational age. Indian J Pathol. Oncol. 2016;3:11-3.
32. Gohil JR, Sosi M, Vani SN, Desai AB. Foot length measurement in the neonate. Indian J Pediatr. 1991;58:675-7.
33. Thawani R, Dewan P, Faridi MM, Arora SK, Kumar R. Estimation of gestational age, using neonatal anthropometry: a cross-sectional study in India. J Health Popul. Nutr. 2013;31:523-30.
34. Lee AC, Panchal P, Folger L, *et al*. Diagnostic accuracy of neonatal assessment for gestational age determination: a systematic review. Pediatrics. 2017;140:e2017-1423.
35. Sasidharan K, Dutta S, Narang A. Validity of New Ballard Score until $7^{th}$ day of postnatal life in moderately preterm neonates. Arch Dis Child Fetal Neonatal Ed. 2009;94:F39-F44.
36. Mukherjee S, Roy P, Mitra S, Samanta M, Chatterjee S. Measuring new born foot length to identify small babies in need of extra care: a cross-sectional hospital-based study. Iranian J Pediatr. 2013;23:508.