Utility of anthropometric measures to identify small for gestational age newborns: A study from Eastern India

Saba Annigeri1, Arindam Ghosh1, Sunil Kumar Hemram1, Ritayan Sasmal2, Mythri J P3

1Department of Paediatrics, Midnapore Medical College, West Bengal, 2Department of Gynaecology and Obstetrics, Egra Sub-Divisional Hospital, Purba Medinipur, West Bengal, 3Department of Community Medicine, Bangalore Medical College and Research Institute, Karnataka, India

ABSTRACT

Introduction: Small-for-gestational-age (SGA) is one of the important factors for neonatal mortality. Early identification and necessary intervention of these newborns is crucial to increase their chances of survival and reduce long-term disabilities. However, in low- and middle-income countries a large portion of pregnant women are unaware of their accurate gestational age (GA) due to the limited availability of ultrasonography. The purpose of our study was to build an alternative tool to identify SGA.

Methods: A institutional-based, prospective observational study was conducted from August-2018 to February-2020, with 1451 live singleton-newborns of 30-40 weeks of gestation. Ultrasonography was used to evaluate accurate GA in early pregnancy and a reference chart for the Asian population, constructed by the National Institute of Child Health and Human Development (NICHD) Fetal Growth Studies was used to classify newborns as SGA. Neonatal anthropometry was measured within 48 hours of birth. Receiver operating characteristic curves were developed to identify the best cut-off point for each anthropometric parameter and the area under the curve (AUC) was estimated to assess the overall precision.

Results: Prevalence of SGA was 34.3%. The AUC was 0.888 for head circumference (HC), 0.890 for chest circumference (CC), and 0.865 for mid-upper arm circumference (MUAC). The optimal cut-offs to classify SGA were ≤32.45 cm for HC, ≤29.75 cm for CC and ≤8.55 cm for MUAC with sensitivities of 85.9%, 86.9% and 85.4%, specificities of 75.5%, 85.1% and 72.1%, positive predictive values of 0.64, 0.75 and 0.61 and negative predictive values of 0.91, 0.93 and 0.90 respectively. Conclusion: All three anthropometric measurements could be used to identify SGA but, overall CC is the best.

Keywords: Chest circumference, low- and middle-income countries (LMICs), neonatal anthropometry, small-for-gestational-age
not LBW. A large proportion of around 53% of SGA infants were born in South Asia. Acknowledging the large burden of preterm and SGA babies born, WHO emphasized its reduction by 2025. Small-for-gestation arises in fetuses with prolonged in-utero nutrient deprivation and results in the readjustment of blood supply from peripheral structures to central vital organs. These modify physical features and neurological maturity of SGA newborns and cause hindrance to accurate gestational age assessment by neonatal New-Ballard scoring system. These newborns are prone to have high perinatal morbidity and mortality if not intervened timely, as well as to develop long-term metabolic, neurologic, and cardiovascular-related complications as a result of a process called fetal programming. Identification of SGA babies requires a valid estimation of gestational age (GA) by ultrasound (USG) in early gestation but, in LMICs access to USG is limited, and traditionally sonography done in late gestation is usually imprecise for calculating GA by ± 4 weeks. This highlights the importance to find a valid alternative tool that is readily available, affordable, and easy-to-use for the identification of these SGA babies in resource-limited settings.

Previous studies have shown that various anthropometric parameters can be used as a diagnostic tool for the identification of premature and LBW newborns, but there are limited studies on the usage of these anthropometric parameters to identify SGA newborns. To the best of our knowledge, this is the first study from Eastern India comparing head circumference (HC), chest circumference (CC), and mid-upper arm circumference (MUAC) among SGA and appropriate-for-gestational age (AGA) newborns.

**Materials and Methods**

**Study design**
This prospective observational study was conducted at a tertiary care teaching hospital of Eastern India from August-2018 to February-2020. This hospital gives services to the majority of the rural population along with the neighboring twin cities of this district and conducts more than 200 deliveries per month. We enrolled pregnant mothers from the antenatal clinic (ANC) after consideration of inclusion and exclusion criteria and followed-up till delivery. Eligible live-born babies, with GA between 30-40 weeks were included after getting informed consent from parents/guardians [Figure 1].

**Inclusion criteria**
- a. Pregnant mothers of ≤24 weeks of gestation (GA was calculated from crown-rump length (CRL) measurement before 14 weeks of gestation and biparietal diameter measurement between 14 to 24 weeks of gestation by USG)
- b. Ultrasound showing singleton fetus and no major congenital malformation.

**Exclusion criteria**
- a. Mothers aged ≤18 years and ≥35 years
- b. Body mass index (BMI) ≤18.5 kg/m² and ≥30 kg/m²
- c. Chronic smoker, severe anemia (hemoglobin <7 g%)"
Annigeri, et al.: Anthropometric measures to identify SGA newborns

This study was permitted by Institutional Review Board (IRB). Enrolled mothers gave written informed approval (or thumbprints from illiterate) for participation in the study. Newborns were included after obtaining consent from parents/guardians. All procedures contributing to our work comply with the ethical standards of the relevant national guidelines in human experimentation and Helsinki Declarations.

Statistical analysis
The collected statistics were written in a Microsoft Excel spreadsheet and the statistical package for social sciences (SPSS) version-25 was used for analysis. Data was scrubbed and edited for final analysis. The Pearson and Spearman correlation coefficients for birth weight and gestational age with different anthropometric measurements were calculated, as applicable. Variables with a $P$ value $< 0.05$ were taken as statistically significant. Continuous variables were expressed as means and standard deviations (SD), and categorical variables as the numbers and percentage of subjects in each sub-division. Receiver operating characteristic (ROC) curves were developed to identify the best cut-off points for each of the anthropometric indicators for identifying LBW (BW $<2500$ grams), SGA, and preterm ($<37$ weeks of gestation) newborns. The sensitivity, specificity, positive predictive value (PPV), and negative predictive values (NPV) were determined at the corresponding cut-off points while the area under the curve (AUC) was estimated to assess the overall precision. Finally, we assessed our aim of identifying the best anthropometric parameter to indicate SGA newborns.

Ethical consideration
This study was permitted by Institutional Review Board (IRB). Enrolled mothers gave written informed approval (or thumbprints from illiterate) for participation in the study. Newborns were included after obtaining consent from parents/guardians. All procedures contributing to our work comply with the ethical standards of the relevant national guidelines in human experimentation and Helsinki Declarations.

Results
Profile of study population
A total of 1774 eligible pregnant mothers were enrolled, out of which 1662 women gave birth to live newborns in this hospital. Among these, 1451 eligible newborns fulfilling the inclusion criteria were included in this study.

There were 733 males and 718 female newborns giving a sex ratio of 1: 0.98. In total, 498 (34.3%) were born SGA, 539 (37.1%) were LBW and 449 (30.9%) were born preterm. The mean (SD) birth weight of newborns was 2567 (± 624) grams. The median GA was about 38 weeks [interquartile range (IQR): 36-40 weeks].

The proportionate of SGA newborns were found to be slightly higher among females than males (51.9% vs 48.1%) in contrast LBW and preterm were almost similar in male and female newborns (50.2% vs 49.8% and 50.7% vs 49.3%, respectively). The profile of mothers and their newborns are summarized in Table 1.

Statistical correlation between anthropometric variables
All the studied anthropometric parameters showed a significant, linear, positive correlation with both BW and GA ($P < 0.001$). The highest correlation was attained by the CC (Pearson correlation for BW: 0.939 and Spearman correlation for GA: 0.880) while MUAC attained the lowest (Pearson correlation for BW: 0.865 and Spearman correlation for GA: 0.744) [Figure 2].

The mean values of the three anthropometric measurements were significantly lower ($P$-value $< 0.001$) among the babies born SGA, LBW, or preterm when compared to those born AGA, with normal birth weight and at term respectively [Table 2].

ROC curve exploration to determine specific cut-off points
ROC analysis was done to test how efficiently the three anthropometric parameters could predict SGA, LBW, and prematurity. The highest observed AUC (0.983) was for CC detecting LBW while MUAC detecting SGA had the lowest AUC (0.865) [Figure 3]. AUCs for all three anthropometric parameters were comparable for both males and females for all three outcomes.

The operational cut-off points of the three anthropometric measures for SGA yielding the highest average of sensitivity and specificity were determined as ≤32.45 cm for HC (sensitivity at 85.9%, specificity at 75.5%), ≤29.75 cm for CC (sensitivity at 86.9%, specificity at 85.1%) and ≤8.55 cm for MUAC (sensitivity at 85.4%, specificity at 72.1%). The separate operational cut-off points for male and female SGA babies producing the highest sensitivity and specificity were similar to the combined operational cut-off point. The predictive validity for each of the separate cut-off points of SGA babies were calculated which produced high NPVs (0.90-0.93), whereas the PPVs were reasonably lower for all three measures (0.61-0.75). The best predictive power was observed when using CC with PPV of 0.75 and NPV of 0.93. The main target of our study was to assess the ability of HC, CC and MUAC in identifying SGA. Prematurity and LBW are closely related to SGA so sensitivity, specificity, PPV and NPV at the same operational cut-off points of SGA, but using LBW or prematurity as outcome parameters were also assessed [Table 3]. To determine the best operational cut-offs for detecting preterm and LBW babies, a separate cut-off point...
balancing the highest values of sensitivity and specificity along with PPV and NPV was also calculated [Table 4]. The operational cut-offs identified for both preterm and LBW for all the three anthropometric measures were almost comparable in outcome to when using them for the cut-off points defined based on SGA.

**Discussion**

The birth weight and gestational age of newborns are two important determinants of neonatal mortality and morbidity.[12] In LMICs, the majority of LBW have IUGR rather than being preterm.[13,14] Ultrasound dating scan in early pregnancy is the most precise method to calculate GA. In LMICs, the availability of USG is limited and GA is frequently unknown. GA estimation by Naegele's method based on the last menstrual period (LMP) is often unreliable, due to high rates of maternal illiteracy.[13,14] Appropriate GA estimation is crucial to identify preterm and SGA newborns and provide them with effective interventions. In this study, we aim to find out an alternative method to identify SGA newborns.

The study showed the prevalence of preterm, LBW, and SGA as 30.9%, 37.1%, and 34.3% respectively. These are much higher than the estimated national values[15] but are similar to other Indian studies.[16‑21] The high prevalence can be attributed to the fact that it included mainly illiterate mothers belonging to low socioeconomic status.

The study had a mean BW of 2567 grams and the male: female sex ratio of 1:0.98 was comparable to other Indian, Bangladesh, and Yemen studies with birth weights of 2400‑2900 grams and male: female ratio of 0.95:1 to 1.2:1.[17‑20,22,23] HC, CC and MUAC had a statistically significant association with both birth weight and GA, however, CC showed the best correlation among the three parameters. It is also keeping

### Table 1: Profile of study population

| Parameters | Value | Parameters | Value | P |
|------------|-------|------------|-------|---|
| Age (yrs)-mean (SD) | 24.2 (4.9) | Sex | 733 (30.52) | 718 (49.48) | - |
| Residence (freq, %) | Rural 921 (63.45) | Birth Weight (kg)-mean (SD) | 2.59 (0.52) | 2.54 (0.51) | 0.0647 |
| Urban 530 (36.55) | ≤2.5 kg (n=539) | 271 (50.20) | 268 (49.80) | - |
| ≥2.5 kg (n=912) | 462 (50.66) | 450 (49.34) | - |
| Educational Status (freq, %) | Illiterate 691 (47.63) | Chest Circumference in cm-mean (SD) | 30.15 (2.47) | 29.89 (2.76) | 0.0587 |
| Primary 404 (27.86) | 32.81 (1.69) | 32.65 (1.61) | 0.0651 |
| Secondary 229 (15.76) | Higher 127 (8.75) | | | | |
| Socioeconomic Class * (freq, %) | Upper (I) 77 (5.34) | Head Circumference in cm-mean (SD) | | | |
| Upper Middle (II) 160 (11.01) | Lower Middle (III) 356 (24.53) | | | | |
| Upper Lower (IV) 365 (25.18) | Lower (V) 493 (33.94) | | | | |
| Maternal BMI-mean (SD) | 20.06 (1.53) | MUAC in cm-mean (SD) | 8.57 (0.99) | 8.51 (1.01) | 0.2605 |
| Gravidity (freq, %) | ≤2 55 (31.36) | Small for gestational age (n=498) | 240 (48.1) | 258 (51.9) | - |
| >2 996 (68.64) | | | | | |
| Parity (freq, %) | ≤2 761 (52.46) | Appropriate for gestational age (n=953) | 493 (51.73) | 460 (48.27) | - |
| >2 690 (47.54) | | | | | |
| GA (wks) at Inclusion-median (IQR) | ~11 (8‑14) | Preterm (n=449) | 228 (50.7) | 221 (49.3) | - |
| GA (wks) at Delivery-median (IQR) | ~38 (36‑40) | Term (n=1002) | 505 (50.40) | 497 (49.60) | - |
| Mode of Delivery (freq, %) | Caesarean 231 (15.93) | | | | |
| Vaginal 1220 (84.07) | | | | | |

### Table 2: Comparative analysis of anthropometric parameters among three categories

| Category | Head Circumference | Chest Circumference | MUAC | P |
|----------|---------------------|---------------------|------|---|
|          | Mean (SD)           | Mean (SD)           | Mean (SD) | P |
| SGA      | 31.19 (2.04)        | <0.001              | 7.88 (1.05) | <0.001 |
| AGA      | 33.83 (1.44)        | <0.001              | 9.20 (0.88) | <0.001 |
| LBW      | 30.89 (1.91)        | <0.001              | 7.73 (0.99) | <0.001 |
| NBW      | 34.13 (0.95)        | <0.001              | 9.36 (0.67) | <0.001 |
| Preterm  | 30.62 (1.96)        | <0.001              | 7.62 (1.09) | <0.001 |
| Term     | 33.96 (1.08)        | 32.64 (1.51)        | 9.26 (0.71) | <0.001 |

SGA - Small for gestational age; AGA - Appropriate for gestational age; LBW - Low birth weight; NBW - Normal birth weight; MUAC - Mid upper arm circumference; SD - Standard deviation.

balancing the highest values of sensitivity and specificity along with PPV and NPV was also calculated [Table 4]. The operational cut-offs identified for both preterm and LBW for all the three anthropometric measures were almost comparable in outcome to when using them for the cut-off points defined based on SGA.

[1] Annigeri, et al.: Anthropometric measures to identify SGA newborns

[2] Journal of Family Medicine and Primary Care 3128

Volume 11 : Issue 6 : June 2022

[3] Balancing the highest values of sensitivity and specificity along with PPV and NPV was also calculated [Table 4]. The operational cut-offs identified for both preterm and LBW for all the three anthropometric measures were almost comparable in outcome to when using them for the cut-off points defined based on SGA.

**Discussion**

The birth weight and gestational age of newborns are two important determinants of neonatal mortality and morbidity.[12] In LMICs, the majority of LBW have IUGR rather than being preterm.[13]

[Unparsed content]
Annigeri, et al.: Anthropometric measures to identify SGA newborns

in findings from studies done in India,[19,22,24,25] Nepal[26] and Bangladesh[27] which have reported a similar good correlation among three anthropometric parameters with birth weight and GA.

The mean values of HC, CC and MUAC between newborns born SGA, preterm, and LBW were found to be lower and statistically significant in difference when compared to AGA, normal weight and term newborns, which is in line with findings in other studies.[8,28,29]
Our study showed that all three anthropometric parameters are effective tools for detecting preterm, LBW and SGA. However, AUC for SGA was lower when compared to preterm and LBW. These were comparable to the findings from previous studies showing higher AUC for preterm and LBW\cite{6,26}. The operational cut-off points for LBW in the present study were comparable with other studies reporting cut-offs of 31.5-33.5 cm for HC\cite{20,30,31}, 8.9-9.8 cm for MUAC\cite{7,27,31,32} and 28.5-31.2 cm for CC\cite{27,31}. When identifying prematurity, the cut-off for CC as 30.4-31.4 cm\cite{30} and MUAC as 9-10 cm\cite{6,7} were comparable to the current study. The current study did not find any difference in cut-offs for males and females separately as seen in another study from East Africa.\cite{8}

HC, CC and MUAC have been used to screen for prematurity and LBW in many studies conducted in different parts of the world.\cite{20,27,30,31} These anthropometric parameters have been used in very few studies to differentiate SGA from AGA.\cite{8,9} As this is a different way of using anthropometric parameters in newborns, it needs to be confirmed by conducting further studies.

Our study has found the sensitivity of 85.4-85.9% and specificity of 72.1-85.1% for the operational cut-off points for identifying SGA newborns. The study also showed high NPVs (0.90-0.93), whereas PPVs were lower (0.61-0.75). Among three parameters, CC gave good results showing the highest values of sensitivity, specificity, PPV, and NPV. CC >29.75 cm would 93% correctly identify AGA newborns, whereas among newborns with CC ≤29.75 cm almost 25% would be wrongly categorized as SGA. Despite that, in India with a high neonatal mortality rate, the consequences of wrongly classifying a newborn as SGA will result only in providing extra attention. However, the consequences of misinterpreting the SGA as AGA will result in increased neonatal mortality. Hence, high NPV is more significant in this context than the PPV, as found in our study.

As a single best parameter, we recommend the use of a CC for identifying SGA rather than other anthropometric measures studied, not only based on our study findings but also due to varied logistic reasons. CC is easy to measure as the nipple line acts as a fixed landmark. Unlike on the head caput produced as a result of the molding process during delivery, there are
no significant soft tissue edematous changes that can happen on the chest. Moreover, the use of HC alone can potentially miss asymmetric IUGR newborns who have normal head circumference.

In India, still, a significant number of births occur outside of hospital facilities, and family physicians may be the first point of contact for these newborns. Family physicians, as well as trained community-based health workers, can use these anthropometric measures as valid tools for early identification of SGA newborns so that they can refer these at-risk newborns to appropriate health facilities, that provide immediate interventions and special care for reducing neonatal mortality.

The strength of our study was the approximate GA assessment using standard USG in early gestation (≤24 weeks) and the use of an Asian population-specific fetal growth chart developed by NICHD Fetal Growth Studies, as standard to classify SGA newborns.[19]

The drawbacks of our study were the small sample size and AUC, sensitivity, specificity, PPV and NPV of the three anthropometric parameters-based identification of SGA newborns were lower when compared to using them to identify prematurity and LBW. This could, therefore, imply that the SGA group might be more difficult to be recognized by anthropometric measurements and the results being biased due to the wide range of distribution of SGA newborns across all the gestational age groups lowering sensitivity and specificity. Nonetheless, we believe that HC, CC, and MUAC could be used as a simple alternative tool for screening purposes to identify SGA newborns. Future studies in larger populations from different Indian settings are deemed necessary to develop GA-specific cut-offs for each anthropometric parameter, instead of single cut-offs determined by the current study. All the governorates of India should take necessary initiatives urgently for appropriate documentation of these parameters in each delivery, which can then be utilized to construct a ready-to-use reference nomogram for the identification of SGA newborns in resource-limited areas where standard weighing scales are likely not to be available.

**Conclusion**

In a setting with limited availability of ultrasonography for accurate gestational age estimation, the studied anthropometric parameters with high NPV could be utilized to preclude newborns being SGA at specific cut-off points determined by this study (>32.45 cm for HC, >29.75 cm for CC and >8.55 cm for MUAC). Of the three, CC is the most appropriate surrogate given its high correlation, sensitivity and specificity in detecting SGA babies. The results of this study are encouraging. Many life-saving decisions regarding essential newborn care could be made easier, faster, and even more efficiently by using these anthropometric parameters at the community level and a simple measuring tape is the only tool required which is readily available, affordable, and easily replaceable when damaged.

Newborns who fall at or below the stated cut-off point should be considered as high risk and referred early to the appropriate health facilities where they can get better service and improve chances of survival.

**Key messages**

- Identification of SGA requires a valid estimation of gestational age by USG in early pregnancy. However, in LMICs a large portion of pregnant women are unaware of their accurate gestational age due to the limited availability of ultrasonography
- Previous studies have used anthropometric parameters as a valid tool to identify preterm and LBW, but there are limited studies on identifying SGA newborns using these anthropometric measures especially from eastern India.
- All the studied anthropometric measures had reasonable diagnostic accuracy to screen SGA newborns at specific cut-off points determined by this study (≤32.45 cm for HC, ≤29.75 cm for CC and ≤8.55 cm for MUAC) but, overall CC is the best.
- Family physicians and trained community-based health workers should be encouraged for routine use of these parameters as valid tools to screen SGA newborns in resource-limited settings.

**Acknowledgements**

The researchers would like to thank parents/guardians for giving consent to take part in this study and Ms.Meghna Mukherjee, MSc, Statistician cum Tutor, IPGMER & SSKM Hospital, Kolkata, India for her potential inputs in statistical analysis.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and anonymity cannot be guaranteed.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. WHO Expert Committee on Physical Status. Physical Status: The Use of and Interpretation of Anthropometry, Report of a WHO Expert Committee, Geneva: World Health Organization; 1995. Available from: https://apps.who.int/iris/handle/10665/37003.
2. Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, et al. National and regional estimates of term and preterm babies born small-for-gestational-age in 138 low-income
and middle-income countries in 2010. Lancet Global Health 2013;1:e26–36.

3. Yoshida S, Martines J, Lawn JE, Wall S, Souza JP, Rudan I, et al. Setting research priorities to improve global newborn health and prevent stillbirths by 2025. J Glob Health 2016;6:010508. doi: 10.7189/jogh.06.010508.

4. MacDonald MG, Seshia MM. Avery’s Neonatology, Pathophysiology and Management of Newborn. 6th ed. Wolters Kluwer India Pvt Ltd; 2005. p. 490–522.

5. Committee opinion no 611: Method for estimating due date. Obstet Gynecol 2014;124:863–6.

6. Thi HN, Khanh DK, Thu HLe, Thomas EG, Lee KJ, Russell FM. Foot length, chest circumference and mid upper arm circumference are good predictors of low birth weight and prematurity in ethnic minority newborns in Vietnam: A hospital- based observational study. PLoS One 2015;10:e0142420.

7. Gidi NW, Berhane M, Girma T, Abdissa A, Lim R, Lee K, et al. Anthropometric measures that identify premature and low birth weight newborns in Ethiopia: A cross-sectional study with community follow-up. Arch Dis Child 2020;105:326-31.

8. Paulsen CB, Nielsen BB, Msemo OA, Møller SL, Ekmann JR, Theander TG, et al. Anthropometric measurements can identify small for gestational age newborns: A cohort study in rural Tanzania. BMC Pediatr 2019;19:120.

9. Chaves MV, Ximenes CV, Borba SK, Figueiroa JN, Alves JG. Foot length in newborns small for gestational age. Trop Doct 2016;46:156-9.

10. Tergestina M, Chandran S, Kumar M, Rebekah G, Ross BJ. Foot length for gestational age assessment and identification of high-risk infants: A hospital-based cross-sectional study. J Trop Pediatr 2021;67:fma010.

11. Grantz KL, Hediger ML, Liu D, Buck Louis GM. Fetal growth standards: The NICHD fetal growth study approach in context with INTERGROWTH-21st and the World Health Organization Multicentre Growth Reference Study. Am J Obstet Gynecol 2018;218:564-5.

12. Pillar J, Belizán JM. The relative contribution of prematurity and fetal growth retardation to low birth weight in developing and developed societies. Am J Obstet Gynecol 1982;143:793-8.

13. Aliyu LD, Kurjak A, Watagana T, de Sá RA, Pooh R, Sen C, et al. Ultrasound in Africa: What can really be done? J Perinat Med 2016;44:119–23.

14. 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;187:1660-6.

15. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-5), 2019-20: India. Mumbai: International Institute for Population Sciences. Available from: http://rchiips.org/nfhs/index.shtml. [Last accessed on 2021 Oct 27].

16. Srivastava A, Sharma U, Kumar S. To study correlation of foot length and gestational age of new born by new Ballard score. Int J Res Med Sci 2015;3:3119-22.

17. Rai RK, Sudfeld CR, Barik A, Fawzi WW, Chowdhury A. Sociodemographic determinants of preterm birth and small for gestational age in rural West Bengal, India. J Trop Pediatr 2019;65:537-46.

18. Sebastian T, Yadav B, Jeyaseelan L, Vijayasevli R, Jose R. Small for gestational age births among South Indian women: Temporal trend and risk factors from 1996 to 2010. BMC Pregnancy Childbirth 2015;15:7.

19. Gupta A, Mehrotra G, Mulve S. Study of correlation between gestational age and new-born foot length and chest circumference. Int J Contemp Pediatr 2018;5:1875-82.

20. Taksande A, Vilhekar KY, Chaturvedi P, Gupta S, Deshmukh P. Predictor of low birth weight babies by anthropometry. J Trop Pediatr 2007;53:420-3.

21. 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. Iran J Pediatr 2013;23:508-12.

22. 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.

23. Ba-Saddik IA, Al-Asbahi TO. Anthropometric measurements of singleton live full-term newborns in Aden, Yemen. Int J Pediatr Adolesc Med 2020;7:121-6.

24. Das NK, Nandy S, Mondal R, Ray S, Hazra A. Gestational age assessment with anthropometric parameters in newborns. Oman Med J 2018;33:229-34.

25. Narendra KS, Madhu GN, Adarsha E. Relationship of anthropometric parameters of newborn with varying period of gestational age. J Evol Med Dental Sci 2014;3:5484-90.

26. Sreearamreddy CT, Chuni N, Patil R, Singh D, Shaky B. Anthropometric surrogates to identify low birth weight Nepalese newborns: A hospital-based study. BMC Pediatr 2008;8:16.

27. Das JC, Afrozoe A, Khanam ST, Paul N. Mid-arm circumference: An alternative measure for screening low birth weight babies. Bangladesh Med Res Cunc Bull 2005;3:11-6.

28. Hadush MY, Berhe AH, Medhanyie AA. Foot length, chest and head circumference measurements in detection of Low birth weight neonates in Mekelle, Ethiopia: A hospital based cross sectional study. BMC Pediatr 2017;17:111.

29. Ndu IK, Ibeziako SN, Obidike EO, Adimora GN, Edelu BO, Chinawa JM, et al. Chest and occipito-frontal circumference measurements in the detection of low birth weight among Nigerian newborns of Igbo ethnicity. Ital J Pediatr 2014;40:81.

30. Shastry R, Bhat P. Neonatal screening by chest circumference and a study of relationship between birthweight and other anthropometric parameters. Int J Biomed Res 2015;6:160-3.

31. SD J, Gopal K. Utility of anthropometric measurements to predict low birth weight newborns. Int. J Pediatr Res 2016;3:781-91.

32. Ahmed FU, Karim E, Bhuiyan SN. Mid-arm circumference at birth as predictor of low birth weight and neonatal mortality. J Biosoc Sci 2000;32:487-93.