INSIGHTS-JOURNAL OF
HEALTH AND RESEARCH REHABILITATION

CORRELATION BETWEEN FETAL FOOT LENGTH AND HUMERUS LENGTH FOR THE ESTIMATION OF GESTATIONAL AGE IN SECOND AND THIRD TRIMESTER

Original Research

Gul Bahader[1]*, Muhammad Haseeb Jafar[2], Babar Issac[3], Fiaz Ahmad[4], Muhammad Ibrahim[5]
[1]Consultant Sonologist, Irfan General Hospital, Peshawar, Pakistan.
[2]Medical Diagnostic Sonographer, Bashir Diagnostic Center, Toba Tek Singh, Punjab, Pakistan.
[3]Consultant Sonologist, Abdul Haq General Hospital, Khyber, Pakistan.
[4]Consultant Sonologist, Ayesha Sadiqa Hospital, Lahore, Pakistan.
[5]Sonologist, Ibraheem Health Care Centre, Nowshera, KPK, Pakistan.
Corresponding Author: Gul Bahader, Consultant Sonologist, Irfan General Hospital, Peshawar, Pakistan. gulbahader777@gmail.com
Acknowledgement: The authors extend their gratitude to Bashir Diagnostic Hospital, Toba Tek Singh, for their support and facilitation of this research.

Conflict of Interest: None   Grant Support & Financial Support: None

ABSTRACT

Background: Gestational age (GA) is a critical parameter in obstetric care, guiding clinical decision-making, fetal monitoring, and estimating the expected date of delivery (EDD). Various biometric parameters, including biparietal diameter (BPD), femur length (FL), head circumference (HC), and abdominal circumference (AC), are conventionally used for GA estimation. However, alternative fetal measurements such as fetal foot length (FFL) and fetal humerus length (FHL) have shown potential in improving GA assessment, particularly in the second and third trimesters.

Objective: To determine the correlation between fetal foot length and fetal humerus length with gestational age during the second and third trimesters using ultrasonographic assessment.

Methods: A cross-sectional study was conducted at Bashir Diagnostic Hospital, Toba Tek Singh, over a duration of nine months. A total of 383 pregnant women with singleton pregnancies and known last menstrual period (LMP) were included using a convenient sampling method. Ultrasonographic measurements of FFL and FHL were obtained using a Toshiba Aplio XG ultrasound machine. Gestational age was estimated based on LMP, BPD, AC, and FL, and correlations with FFL and FHL were analyzed using Pearson's correlation coefficient. A significance level of $p < 0.01$ was considered statistically significant.

Results: A strong positive correlation was observed between GA by LMP and FHL ($r = 0.901$, $p < 0.01$) and GA by LMP and FFL ($r = 0.895$, $p < 0.01$). GA by BPD correlated significantly with FHL ($r = 0.909$, $p < 0.01$) and FFL ($r = 0.915$, $p < 0.01$). GA by AC showed significant associations with FHL ($r = 0.900$, $p < 0.01$) and FFL ($r = 0.894$, $p < 0.01$). Similarly, GA by FL exhibited strong correlations with FHL ($r = 0.899$, $p < 0.01$) and FFL ($r = 0.891$, $p < 0.01$).

Conclusion: Fetal humerus length and fetal foot length demonstrated strong correlations with gestational age and can be effectively utilized for GA estimation in the second and third trimesters. These parameters serve as reliable alternatives when conventional measurements may be limited, contributing to improved prenatal assessment and fetal growth monitoring.

Keywords: Abdominal circumference, biparietal diameter, fetal femur length, fetal foot length, fetal humerus length, gestational age, head circumference.

INTRODUCTION

Gestational age (GA) plays a fundamental role in guiding clinical decision-making, therapeutic interventions, and prognostic evaluations, particularly in the context of preterm births. Accurate estimation of GA is essential for optimizing neonatal outcomes and ensuring appropriate prenatal care. It aids in assessing fetal development, diagnosing intrauterine growth restriction (IUGR), and advising expectant mothers regarding potential perinatal complications(1). Ultrasonography has emerged as the primary modality for GA assessment due to its precision and non-invasive nature, especially when clinical indicators such as uterine size and menstrual history prove unreliable. Despite advancements in obstetric imaging, challenges persist in accurately estimating GA, particularly in resource-limited settings where early pregnancy ultrasound is often inaccessible. Many neonatal centers in such regions rely on postnatal physical and neurological assessments, which may introduce significant inaccuracies in GA determination(2, 3). A variety of biometric parameters have been employed to estimate GA through ultrasonography, including crown-rump length (CRL), biparietal diameter (BPD), femur length (FL), abdominal circumference (AC), and gestational sac (GS) diameter. While these metrics have proven valuable, they are not without limitations. For instance, cranial deformities can affect BPD and head circumference (HC) measurements, necessitating alternative approaches for GA estimation. The first-trimester ultrasound, particularly CRL measurement between 6 and 12 weeks of gestation, is widely regarded as the most accurate method for dating pregnancy(4). However, as fetal development progresses into the second and third trimesters, GA estimation becomes increasingly complex due to anatomical variability and rapid fetal growth. Although ultrasound-based dating between 20 and 22 weeks is considered the gold standard with an error margin of less than 10 days, its accuracy diminishes as pregnancy advances. Bias may arise when standard biometric models are applied to fetuses that are symmetrically larger or smaller than reference populations(5, 6).

Given these challenges, there is a pressing need to explore additional biometric parameters that could enhance the accuracy of GA estimation in later pregnancy. Emerging evidence suggests that fetal foot length (FFL) may serve as a reliable indicator of gestational maturity, particularly in the second and third trimesters. Unlike traditional cranial and abdominal measurements, which may be influenced by fetal growth abnormalities, FFL demonstrates a relatively consistent growth pattern across gestation. Similarly, humerus length (HL) has been proposed as a supplementary parameter for refining GA assessment. Investigating the correlation between FFL and HL could provide a novel approach to improving GA estimation, particularly in cases where conventional measurements are suboptimal(7, 8). This study aims to evaluate the correlation between fetal foot length and humerus length for the estimation of gestational age in the second and third trimesters. By establishing a predictive relationship between these parameters, the research seeks to enhance the accuracy and reliability of GA assessment, thereby contributing to improved prenatal care and neonatal outcomes(9, 10).

METHODS

This cross-sectional analytical study was conducted at Bashir Diagnostic Center, Toba Tek Singh, to assess the correlation between fetal foot length and humerus length in estimating gestational age during the second and third trimesters of pregnancy. A total of 383 pregnant females with singleton pregnancies were included through a convenient sampling method. Participants were selected based on age criteria, including women aged 15 years and above, without any gender-based discrimination, as all participants were pregnant females. Women with uncertain last menstrual period (LMP), irregular menstrual cycles, or discrepancies in their estimated date of delivery were excluded to ensure precision in gestational age estimation(11). Ultrasonographic measurements were performed using a Toshiba Aplio XG ultrasound machine, following standardized protocols to obtain fetal foot length and humerus length measurements. All assessments were conducted by experienced and certified sonographers to minimize inter-observer variability and ensure accuracy. Measurements were taken in accordance with established obstetric ultrasonographic guidelines, ensuring consistency across all participants(12).

Data collection involved recording demographic and obstetric details, followed by statistical analysis to determine correlations between fetal foot length, humerus length, and gestational age. Ethical approval was obtained from the institutional review board before the commencement of the study, ensuring adherence to ethical research guidelines. Written informed consent was obtained from all participants, emphasizing voluntary participation and data confidentiality(13). Statistical analysis was performed using specify statistical software, e.g., SPSS version X or any other software. Descriptive statistics were applied to summarize demographic and clinical

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

variables. Pearson's correlation analysis was used to determine the strength of the relationship between fetal foot length, humerus length, and gestational age. Additionally, linear regression modeling was employed to develop predictive equations for estimating gestational age. The significance level was set at mention threshold, e.g., $p < 0.05$, ensuring robust statistical interpretation(14).

RESULTS

A total of 383 pregnant females were included in the study, with a mean ± SD age of 25.72 ± 3.36 years, ranging from 19 to 36 years. The majority of participants (74.7%) were in the second trimester, while 25.3% were in the third trimester. Primigravida cases accounted for 71.5% of the study population, whereas 18.3% were multigravida. Parity distribution showed that 63.2% of participants had a parity of one, while 18.8% had a parity of two. Gestational age estimation was analyzed using multiple biometric parameters. The mean ± SD gestational age calculated by the last menstrual period (LMP) was 24.81 ± 5.13 weeks, by biparietal diameter (BPD) was 24.94 ± 5.12 weeks, by femur length (FL) was 24.68 ± 5.23 weeks, and by abdominal circumference (AC) was 24.73 ± 5.21 weeks. The fetal humerus length had a mean ± SD of 30.70 ± 7.28 mm, whereas fetal foot length had a mean ± SD of 46.61 ± 13.45 mm.

Statistical analysis demonstrated strong correlations between gestational age and fetal biometric measurements. A significant positive correlation was observed between gestational age determined by LMP and humerus length ($r = 0.901$, $p < 0.01$), as well as between LMP and fetal foot length ($r = 0.895$, $p < 0.01$). Similarly, BPD showed a strong correlation with both humerus length ($r = 0.909$, $p < 0.01$) and fetal foot length ($r = 0.915$, $p < 0.01$). The correlation between AC and humerus length was significant ($r = 0.900$, $p < 0.01$), as was the correlation between AC and fetal foot length ($r = 0.894$, $p < 0.01$). Additionally, a strong association was found between FL and humerus length ($r = 0.899$, $p < 0.01$), and between FL and fetal foot length ($r = 0.891$, $p < 0.01$). The findings indicate that fetal humerus length and fetal foot length exhibit strong correlations with gestational age across different biometric estimation methods. These results suggest that both parameters may serve as reliable indicators for estimating gestational age, particularly in cases where conventional measurements such as BPD or AC may be challenging to obtain accurately.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

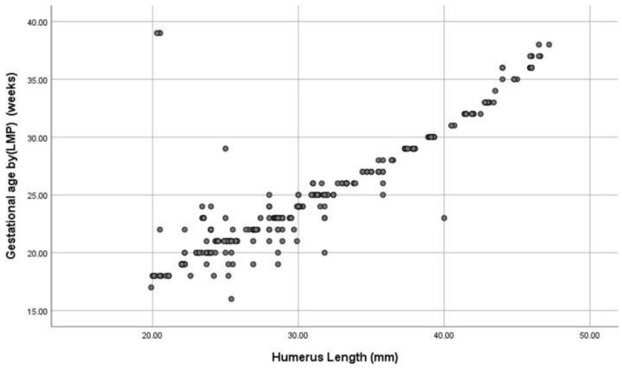


Figure 1 Correlations between Gestational age by (LMP) and Fetal Humerus Length

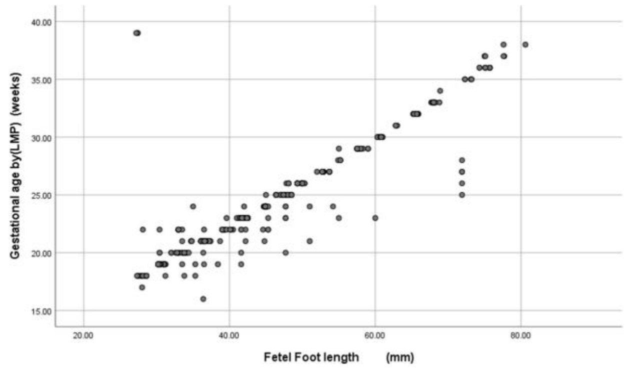


Figure 2 Correlations between Gestational age by (LMP) and Fetal Foot Length

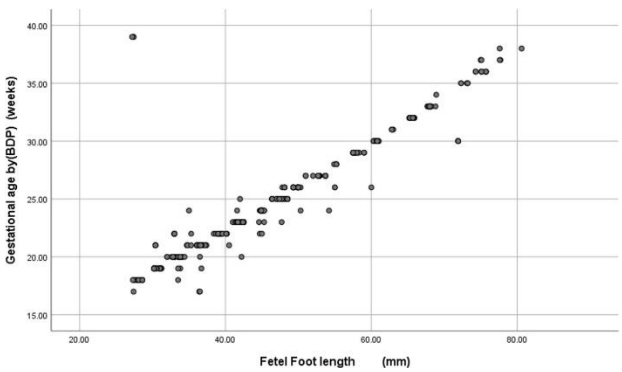


Figure 3 Correlations between Gestational age by (BPD) and Fetal Foot Length

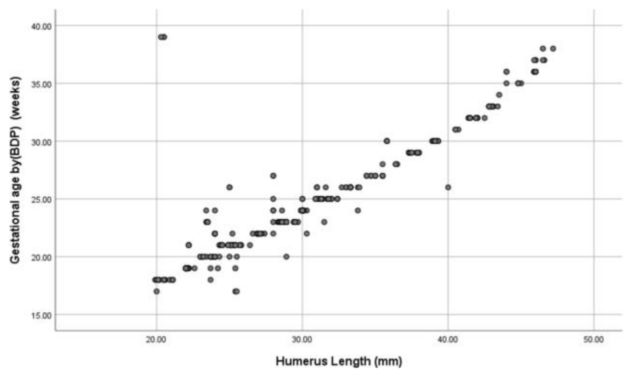


Figure 4 Correlations between Gestational age by (BPD) and Fetal Humerus Length

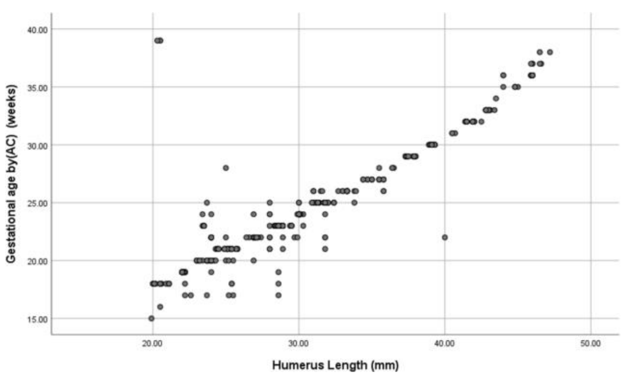


Figure 5 Correlations between Gestational age by (AC) and Fetal Humerus Length

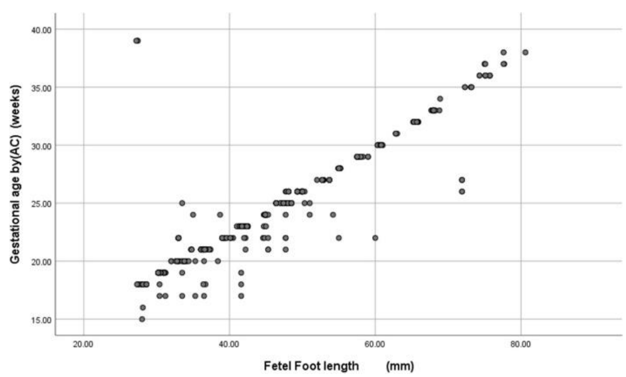


Figure 6 Correlations between Gestational age by (AC) and Fetal Foot Length

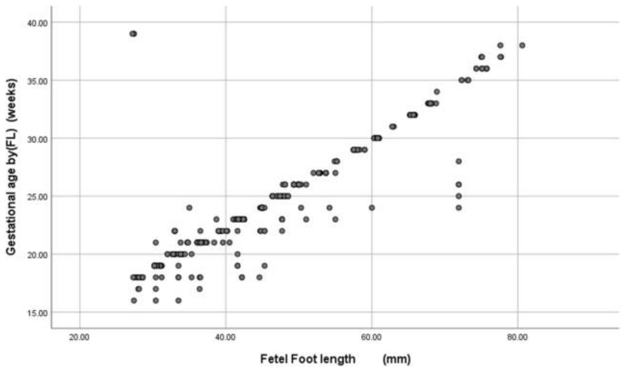


Figure 7 Correlations between Gestational age by (FL) and Fetal Foot Length

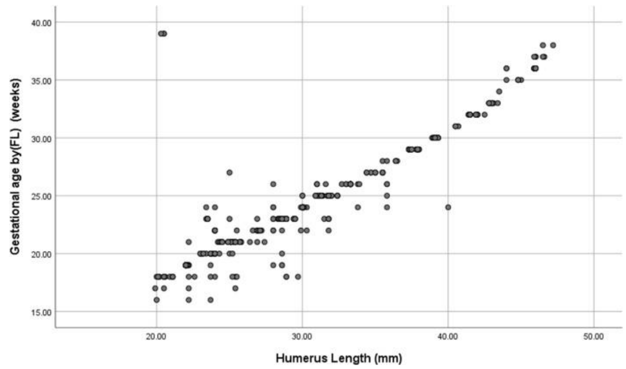


Figure 8 Correlations between Gestational age by (FL) and Fetal Humerus Length

Table 1: Correlation Between Gestational Age, Humerus Length, and Fetal Foot Length Using Different Methods

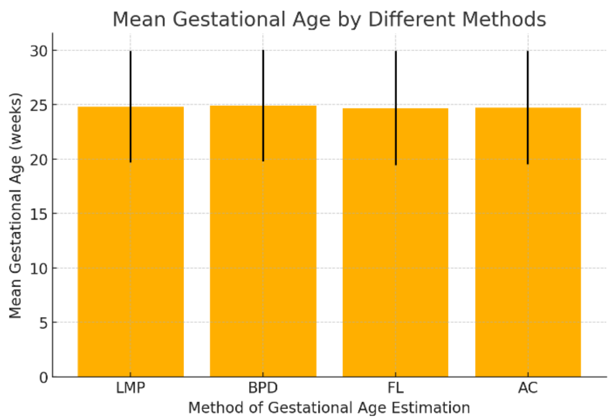
Gestational Age Method	Humerus Length (Pearson Correlation)	Fetal Foot Length (Pearson Correlation)	Sig. (2-tailed)
LMP	0.901	0.895	0.0
BPD	0.909	0.915	0.0
AC	0.9	0.894	0.0
FL	0.899	0.891	0.0

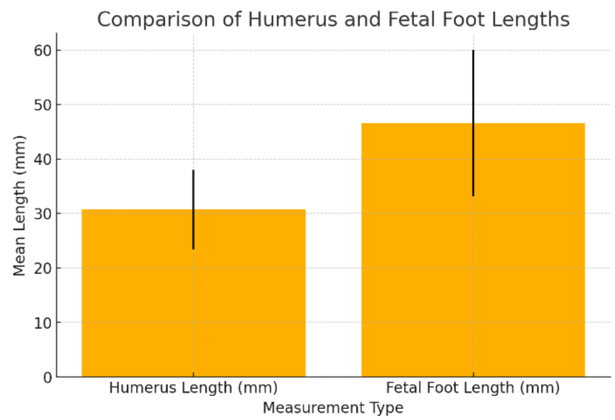
Category	Frequency	Percent (%)
Trimester 2	286	74.7
Trimester 3	97	25.3
Primigravida	274	71.5
Multigravida	70	18.3
Nulliparous	69	18
Parity 1	242	63.2
Parity 2	72	18.8
Total	383	100

Table 2: Descriptive Statistics for Patient Age and Gestational Age Parameters

Parameter	N	Minimum	Maximum	Mean	Std. Deviation
Patient Age (years)	383	19	36	25.72	3.36
Gestational Age by LMP (weeks)	383	16	39	24.81	5.13
Gestational Age by BPD (weeks)	383	17	39	24.94	5.12

Parameter	N	Minimum	Maximum	Mean	Std. Deviation
Gestational Age by FL (weeks)	383	16	39	24.68	5.23
Gestational Age by AC (weeks)	383	15	39	24.73	5.21
Humerus Length (mm)	383	19.9	47.2	30.7	7.29
Fetal Foot Length (mm)	383	27.2	80.6	46.61	13.46





DISCUSSION

The findings of this study demonstrated a strong correlation between fetal foot length, humerus length, and gestational age when assessed using different biometric methods, including last menstrual period (LMP), femur length (FL), biparietal diameter (BPD), and abdominal circumference (AC). A significant positive relationship was observed between fetal biometric parameters and gestational age, indicating that both fetal foot length and humerus length increased proportionally as gestation progressed. The results align with previous research, which established a strong association between fetal foot length and gestational age measured through ultrasonography, reinforcing the potential of these measurements as reliable indicators of fetal maturity(15). Gestational age determination traditionally relies on standardized biometric parameters such as BPD, FL, and AC, with femur length widely accepted as a robust marker for fetal age estimation. Despite being less commonly utilized, humerus length and fetal foot length were found to be highly correlated with gestational age, exhibiting statistical significance comparable to conventional parameters. The correlation coefficients between gestational age and fetal foot length ($r = 0.895$, $p < 0.01$) and between gestational age and humerus length ($r = 0.901$, $p < 0.01$) were indicative of strong predictive accuracy. Similarly, BPD and AC demonstrated significant correlations with both humerus length and fetal foot length, supporting the reliability of these parameters in estimating gestational age(16).

Ultrasonographic assessment remains the gold standard for fetal biometric evaluation, allowing non-invasive and accurate measurement of fetal structures. The findings of this study reaffirm the applicability of humerus length and fetal foot length as supplementary parameters in gestational age estimation, particularly in scenarios where traditional biometric markers may be influenced by fetal growth variations or anatomical anomalies. Previous research has suggested that humerus length is a reliable metric for estimating gestational age, and its combined assessment with femur length is beneficial in identifying fetal skeletal abnormalities. The strong positive correlation between humerus length and gestational age in the present study further supports its clinical utility in obstetric practice(17). One of the strengths of this study is the inclusion of a sufficiently large sample size, ensuring statistical robustness in the correlation analysis. The selection of participants with confirmed LMP and singleton pregnancies minimized potential confounding variables, enhancing the reliability of the results. Furthermore, the use of standardized ultrasonographic techniques and biometric measurements ensured methodological consistency(18).

However, certain limitations must be acknowledged. The study relied on LMP as a primary reference for gestational age, which, despite being widely used, may be subject to recall bias in some cases. Additionally, while fetal biometric parameters exhibit strong correlations with gestational age, variations in fetal growth patterns due to genetic or environmental factors could influence measurement accuracy. The cross-sectional nature of the study also limits the ability to assess longitudinal changes in fetal growth over time(19). Future research should explore the predictive accuracy of fetal foot length and humerus length in a larger, more diverse population, including high-risk pregnancies where fetal growth abnormalities are prevalent. Longitudinal studies could provide further insight into the progression of these biometric parameters across different gestational stages. Moreover, incorporating advanced imaging techniques and artificial intelligence-based predictive models may enhance the precision of gestational age estimation using these parameters(20).

The findings of this study contribute to the growing body of evidence supporting the clinical utility of fetal foot length and humerus length in gestational age assessment. These parameters offer a reliable alternative for estimating fetal age and may be particularly useful in cases where conventional measurements are challenging to obtain or interpret(21).

CONCLUSION

The study highlights the significance of fetal humerus length and fetal foot length as reliable indicators for estimating gestational age, particularly in the second and third trimesters. These measurements demonstrated a strong correlation with gestational age, reinforcing their clinical utility when conventional biometric parameters may be less effective. The findings suggest that fetal foot length serves as a valuable tool for gestational assessment, while humerus length proves to be particularly accurate in later pregnancy. Incorporating these parameters into routine obstetric evaluations can enhance the precision of fetal age estimation, supporting improved prenatal care and clinical decision-making.

Author Contribution

Author	Contribution
Gul Bahader*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Haseeb Jafar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Babar Issac	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Fiaz Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Ibrahim	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

REFERENCES

1. Meena B, Chauhan RS. TO CORRELATE PLACENTAL THICKNESS WITH OTHER FETAL PARAMETER ON USG IN SECOND AND THIRD TRIMESTER OF PREGNANCY. Religion.54:55.5.

2. Tikmani SS, Mårtensson T, Khalid S, Uzair M, Ali Q, Rahim A, et al. Assessing the diagnostic accuracy of postnatal clinical scoring methods and foot length measurement for estimating gestational age and birthweight of newborns in low-and middle-income countries: a systematic review and meta-analysis. BMJ Paediatrics Open. 2024;8(1):e002717.

3. Abdelhamid ER, Kamhawy AH, Sherif LS, Ahmed HH, Saleh MT, Salem S. Association Between Cord Blood Placental Growth Factor Level, Fetal Doppler Parameters and Neonatal Growth Measures. Biomedical and Pharmacology Journal. 2024;17(1):171-80.

4. Desai RR, Ambali MP, Desai AR. Ultrasonographic estimation of gestation age and growth pattern of foetuses in second trimester of pregnancy by multiple growth parameters. parameters.6(S2):10169-79.

5. Qu S, Xie T, Giger ML, Mao X, Zaidi H. Construction of a digital fetus library for radiation dosimetry. Medical Physics. 2023;50(4):2577-89.

6. Murrin EM, Nelsen G, Apostolakis-Kyrus K, Hitchings L, Wang J, Gomez LM. Evaluation of first trimester ultrasound fetal biometry ratios femur length/biparietal diameter, femur length/abdominal circumference and femur length/foot for the screening of skeletal dysplasia. Prenatal Diagnosis. 2023;43(7):919-28.

7. Ferdousi A. Determination of gestational age by ultrasound: © University of Dhaka; 2023.

8. Agarwal P, Agarwal V. DETERMINATION OF GESTATIONAL AGE BY FETAL FEMUR LENGTH ESTIMATION. Int J Acad Med Pharm. 2023;5(4):1206-12.

9. Ugowe OJ, Adejuyigbe EA, Adeodu OO, Fajobi O, Ugowe OO. Accuracy of foot length, head, chest, mid-arm and calf circumference for the diagnosis of low birth weight in Ile-Ife. International Journal of Community Medicine and Public Health. 2022;9(8):3051.

10. Tummuri A, Siddiqui MS, Nelanuthala M, Joshi PM, Mahale JS, Dhule SS. Estimation of Kidney Size From Foot Length in Newborns: A Cross-Sectional Study. Cureus. 2022;14(3).

11. Mustafa MO, Ali QM, Haleeb M, Badawey K, Abdelmotalab MA. Ultrasonography of fetal kidney length as the approach for estimation of gestational age in Sudanese. Anatomy Journal of Africa. 2022;11(2):2167-74.

12. Garg A, Habeebullah S, Rathod S. Comparison of Ultrasonic Measurement of Fetal Kidney Length with Other Fetal Biometric Indices in Determining Gestational Age in Third Trimester in South Indian Population. Journal of South Asian Federation of Obstetrics and Gynaecology. 2022;14(5):587-91.

13. 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. Journal of Tropical Pediatrics. 2021;67(4):fmab010.

14. Stevenson A, Joolay Y, Levetan C, Price C, Tooke L. A comparison of the accuracy of various methods of postnatal gestational age estimation; including Ballard score, foot length, vascularity of the anterior lens, last menstrual period and also a clinician's non-structured assessment. Journal of Tropical Pediatrics. 2021;67(1):fmaa113.

15. Siddique R, Hamid F, Mairaj M, Riffat H, Shams RMAA, Babar A, et al. Predicting Gestational Age of Fetus with the Reference of Humerus and Foot Length by Ultrasonography. J Health Med Nurs. 2021;91:91-05.

16. Prabhu M, Kuller JA, Biggio JR, Medicine SfM-F. Society for Maternal-Fetal Medicine Consult Series# 57: Evaluation and management of isolated soft ultrasound markers for aneuploidy in the second trimester:(Replaces Consults# 10, Single umbilical artery, October 2010;# 16, Isolated echogenic bowel diagnosed on second-trimester ultrasound, August 2011;# 17, Evaluation and management of isolated renal pelviectasis on second-trimester ultrasound, December 2011;# 25, Isolated fetal choroid plexus cysts, April 2013;# 27, Isolated echogenic intracardiac focus, August 2013). American journal of obstetrics and gynecology. 2021;225(4):B2-B15.

17. Dey D, Ghosh S, Raja S, Dolui K, Bairagi A. Evaluation of fetal clavicular length as a sonological parameter for the estimation of gestational age. Sch J App Med Sci. 2021;3:322-8.

18. Borgohain L, George C. Ultrasonographic correlation of fetal foot length and gestational age (GA) in Indian population. International Journal Dental and Medical Sciences Research. 2021;3:1622-31.

19. Walad R. A Study to Assess the Suitability of Fetal Kidney Length Measurement for Determining the Gestational Age in Third Trimester: Rajiv Gandhi University of Health Sciences (India); 2020.

20. Scott K, Gupta S, Williams E, Arthur M, Somayajulu U, Noguchi L. "I can guess the month… but beyond that, I can't tell" an exploratory qualitative study of health care provider perspectives on gestational age estimation in Rajasthan, India. BMC pregnancy and childbirth. 2020;20:1-13.

21. Ramachandran K, Gnaneshwar A, Kumar RD, Parvathavarthine C. Estimation of gestational age using foetal kidney length during second and third trimester in south Indian population. Biomedicine. 2020;40(4):436-41.

