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# Establishing Reference Ranges for Fetal Biometry in Chattogram, Bangladesh

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## Abstract

**Background:** Fetal biometry is used in modern obstetrics to precisely estimate gestational age, assess growth and detect anomalies. Nonetheless, different populations may not benefit from international growth charts, such as Hadlock's, which are widely used in Bangladesh. This study aimed to establish local reference ranges for fetal biometric parameters in the Chattogram population of Bangladesh and compare them with the World Health Organization (WHO) international standards.

**Materials and methods:** A retrospective chart review of 2,017 ultrasound reports of singleton, non-anomalous pregnancies between 14 and 40 weeks of gestation. Percentile curves for Biparietal Diameter (BPD) Abdominal Circumference (AC) Femur Length (FL) and Estimated Fetal Weight (EFW) were generated and compared with the corresponding WHO International Fetal Growth Standards.

**Results:** While the median BPD and AC were largely comparable to WHO standards, the local 97.5th percentiles were consistently lower in the later stages of pregnancy. FL measurements, in contrast, were consistently slightly larger than WHO standards. The most significant finding was a distinctive "Crossover" pattern in the EFW charts, with the local 2.5th percentile showing accelerated growth and the 97.5th percentile flattening in the third trimester. Additionally, a 1.35% prevalence of congenital anomalies was detected, with Anencephaly and Multiple anomalies being the most common, each representing 9.30% of the total detected anomalies.

**Conclusion:** The findings suggest that a one-size-fits-all approach to fetal growth monitoring is inappropriate for this population. The development and adoption of local reference charts are crucial for improving prenatal care and ensuring better perinatal outcomes in Bangladesh, as international charts may lead to the misclassification of fetal growth abnormalities.

**Key words:** Congenital anomalies; Fetal biometry; Fetal growth standards; Hadlock; Prenatal care; Reference charts; Ultrasound.

## Introduction

Modern obstetrical practice is based on fetal biometry, which includes measurements of several fetal anatomical segments. Although many parts of the fetus can be scanned, routine assessment typically focuses on the fetal head, abdomen, and femur, as well as crown-rump length in the early stages of gestation. These measurements are crucial for accurately estimating gestational age and fetal weight, monitoring fetal growth, and identifying cases of growth restriction or macrosomia. Biometric data are therefore important indicators of peripartum outcomes and have a substantial impact on antepartum and intrapartum management interventions.[1] Over the past four decades, more than 100 fetal growth charts have been developed, nonetheless, significant variability exists in study design, statistical modelling techniques, and cutoff lines.[2] A significant number of practitioners depend on the default chart that the ultrasound manufacturer loads when choosing a reference chart.[3] Hadlock published the most widely used chart equipped with ultrasound machines in the 1980s, which was based on several hundred white women, mostly from the middle class, from a single centre in the United States.[4-6] However, due to the differences from the standard nomograms, many researchers have since worked on different population groups and created reference charts relevant to their respective populations.[7-11] Differences in percentile curves and median values among studies have frequently been linked to variations

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in race, gender or other biological and demographic distributions.[12-14] Studies conducted in diverse geographical regions, including Peru, have shown that even changes in altitude can have a substantial effect on biometric measures, producing different reference values for various people within the same nation.[14] Chattogram, with its unique demographic profile and environmental specificities, may exhibit different fetal growth trajectories compared to other regions of Bangladesh, thus necessitating localised data. While a prospective study published in 2003 provided valuable insights into fetal biometry within the broader Bangladeshi population, the need for region-specific reference ranges remains critical.[15]

Furthermore, Ultrasound has emerged as a crucial tool for identifying fetal structural defects since its initial application in obstetrics was reported.[16] Approximately 6% of babies worldwide are born with a congenital defect, contributing significantly to the global burden of disease, and about 94% of severe cases occur in low- and middle-income countries.[17,18] Studies from various parts of the world have reported diverse prevalence rates, such as the antenatal prevalence of congenital anomalies was 52.1 per 1000 pregnancies in a study from Saudi Arabia, 1.73% in a tertiary care hospital in India and 7.0% in a study from Ghana.[19-21] Modern prenatal care must identify these abnormalities through routine biometry and thorough anomaly scans in order to provide timely counselling, effective management planning, and improved postnatal outcomes. Hence, the present study was designed to establish population-specific reference ranges for fetal biometry in Chattogram and to compare these measurements with the World Health Organization (WHO) growth charts. Furthermore, the study evaluates the performance of different biometric parameters in estimating gestational age and concludes by reporting the incidence of congenital anomalies observed within the study population.

**Materials and methods**

This was a retrospective chart review conducted at a specialised diagnostic centre in Chattogram, Bangladesh, from 2016 to 2019. A single radiologist conducted all ultrasonography measurements using a 4D ultrasound machine, the Voluson E8 (Advanced Ultrasound System) from GE Healthcare,ensuring the minimal influence of inter-observer variability on data acquisition. This methodology aligns with the established clinical practice in Bangladesh, where radiologists perform both the imaging and the subsequent interpretation of the reports.

A total of 3,191 ultrasound reports were initially collected. For the purpose of establishing a local reference range for fetal biometry and comparing it with the WHO international standards, a rigorous data filtering process was employed. To ensure the accuracy and reliability of the reference curves, several exclusion criteria were applied. First, only reports with a gestational age between 14 and 40 weeks were selected. Reports of multiple pregnancies were excluded, and the analysis was limited to singleton pregnancies only. Furthermore, to eliminate confounding factors, only non-anomalous reports were included. Following the ACOG (American College of Obstetricians and Gynecologists) guideline, any reports where a significant discrepancy was found between the gestational age by last menstrual period (GA(LMP)) and gestational age by ultrasound biometry (GA(AUA) were also excluded.[22] Finally, reports with missing values for any of the key fetal biometric parameters, including Biparietal Diameter (BPD) Abdominal Circumference (AC) Femur Length (FL) and Estimated Fetal Weight (EFW) were removed from the dataset. This systematic data cleaning resulted in a final study sample of 2,017 reports, all within a gestational age range of 14 to 40 weeks.

The data analysis and visualisation were performed using Microsoft Excel for Microsoft 365 (Version 2508) copyright © 2021. The descriptive statistics for this final study population were calculated, and local percentile curves for BPD, AC, FL and EFW were generated and visually compared with the corresponding WHO International Fetal Growth Standards.[23]

The study was approved by the Ethical Review Committee of Chittagong Medical College (Memo No: CMC/PG/2021/163).

**Results**

A total of 3,191 ultrasound reports were initially collected from the local population. A rigorous

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data filtering process was employed, resulting in a final study sample of 2,017 reports for the establishment of the local reference range and comparison with WHO standards. A total of 43 fetal anomalies were detected within the initial 3,191 reports, yielding an overall prevalence of 1.35%. The frequency and percentage distribution of these detected anomalies are presented in Table I. The most prevalent anomalies were Anencephaly and Multiple anomalies, each representing 9.30% of the total detected anomalies.

**Table I** Frequency and Percentage Distribution of Fetal Anomalies

| System | Pattern of anomaly | Frequency | Percentage (%) |
|---|---|---|---|
| CNS | Anencephaly | 4 | 9.30% |
| | Ventriculomegaly | 1 | 2.33% |
| Genitourinary system | Dysplastic kidney | 1 | 2.33% |
| | Fetal hydronephrosis (Laterality unspecified) | 1 | 2.33% |
| | Fetal pelvicalyceal system dilated | 1 | 2.33% |
| | Left kidney hydronephrosis | 2 | 4.65% |
| | Left kidney pelvicalyceal system dilated | 1 | 2.33% |
| | Posterior Urethral Valves (PUV) | 1 | 2.33% |
| | Right kidney hydronephrosis | 2 | 4.65% |
| | Right kidney pelvicalyceal system dilated | 1 | 2.33% |
| | Polycystic Kidney Disease | 1 | 2.33% |
| GIT | Fetal ascites | 2 | 4.65% |
| Musculoskeletal | Short forearm | 1 | 2.33% |
| | Short limb dwarfism | 3 | 6.98% |
| | Short right upper limb | 2 | 4.65% |
| | Achondroplasia | 1 | 2.33% |
| Cardiovascular System | Arteriovenous malformation | 1 | 2.33% |
| | Congenital Heart Disease | 2 | 4.65% |
| Lymphatic System | Cystic hygroma | 1 | 2.33% |
| Respiratory System | Lung cyst | 1 | 2.33% |
| Other | Hydrops fetalis | 2 | 4.65% |
| | Hydrocephalus, Cleft Palate and Gastroschisis | 1 | 2.33% |
| | Hydrocephalus, Meningocele | 1 | 2.33% |
| | Omphalocele, Caudal Regression | 1 | 2.33% |
| | Hydrops fetalis, Cystic hygroma | 1 | 2.33% |
| | Posterior Urethral Valves (PUV) with Hydronephrosis of the kidney | 1 | 2.33% |
| | Short limb, Agyria of the brain | 1 | 2.33% |
| | Short limb dysplasia, Kidney abnormality, & Hydrocele | 1 | 2.33% |
| | Multiple anomaly | 4 | 9.30% |
| | Total | 43 | 100.00% |

The key characteristics of the study population are described in Table II. The mean maternal age of the participants was 26.90 years (Standard Deviation [SD] 4.44), with a mean gestational age of 29.84 weeks (SD 6.81). The mean BPD was 72.36 millimetres (mm) AC was 248.79 mm, FL was 55.35 mm and EFW was 1692.99 grams.

**Table II** Descriptive Statistics (n=2017)

| Variable | Mean | Median | Standard Deviation (SD) | Min Value | Max Value |
|---|---|---|---|---|---|
| Age | 26.90 | 27.00 | 4.44 | 12.00 | 42.00 |
| Gestational Age (Weeks) | 29.84 | 31.86 | 6.81 | 14.14 | 40.86 |
| BPD (mm) | 72.36 | 79.00 | 17.55 | 23.80 | 97.60 |
| AC (mm) | 248.79 | 268.70 | 73.44 | 75.30 | 388.80 |
| FL (mm) | 55.35 | 60.50 | 15.75 | 13.40 | 80.70 |
| EFW (gram) | 1692.99 | 1760.00 | 1059.59 | 93.00 | 4307.00 |

n = Number of participants, mm = millimetres.

In the subsequent analysis, a set of local percentile growth charts for the Chattogram population was developed and compared with the WHO International Fetal Growth Standards.

**Biparietal Diameter (BPD)**

Reference charts for BPD from the Chattogram population were established and are presented in Supplementary Table III. These were directly compared with the WHO standards, as shown in Supplementary Table 4 and visually represented in Figure 1. The local 50th percentile curve (Cyan) for the Chattogram population largely aligns with or remains slightly above the WHO standard (Red) throughout most of the gestational period, with a minor downward deviation observed after week 37. At the lower end, the local 2.5th percentile (Purple) is generally positioned slightly above or in line with the WHO standard (Blue). Conversely, the local 97.5th percentile (Orange) begins on par with or slightly above the WHO standard (Green) but crosses below it around week 27 and remains consistently lower from week 36 onwards. These findings suggest that while the median fetal head size in Chattogram is comparable to the global standard, the growth trajectories at the extremes of the distribution show a different pattern, with a slight upward shift at the lower end and a notable flattening of the upper percentiles in the later stages of pregnancy.

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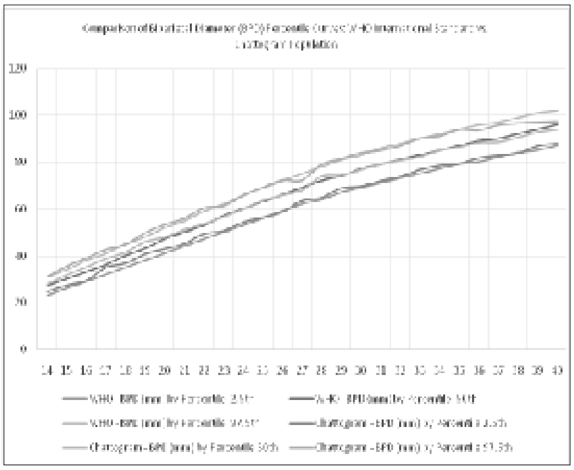

**Figure 1** Comparison of the 2.5th, 50th, and 97.5th percentile curves for Biparietal Diameter (BPD) based on a local population from Chattogram, Bangladesh, with the WHO international growth chart. The blue, red, and green lines represent the WHO standard, while the purple, cyan and orange lines represent the corresponding percentiles for the Chattogram data. The X-axis indicates Gestational Age in weeks, and the Y-axis indicates BPD in millimetres (mm)

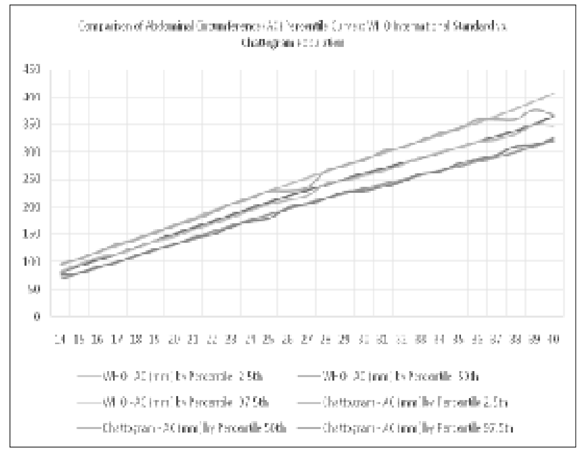

**Figure 2** Comparison of the 2.5th, 50th, and 97.5th percentile curves for Abdominal Circumference (AC) based on a local population from Chattogram, Bangladesh, with the WHO international growth chart. The blue, red and green lines represent the WHO standard, while the purple, cyan and orange lines represent the corresponding percentiles for the Chattogram data. The X-axis indicates Gestational Age in weeks, and the Y-axis indicates BPD in millimetres (mm)

**Abdominal Circumference (AC)**

The percentile curves for Abdominal Circumference (AC) in the Chattogram population were established and compared with the WHO standards, as presented in Supplementary Table V and Supplementary Table VI, respectively and visualised in Figure 2. For the most part, the local 2.5th percentile curve (Purple) closely mirrors the WHO standard (Blue) with only minor fluctuations. Similarly, the 50th percentile curve (Cyan) tracks very closely with the WHO median (Red) throughout the majority of the pregnancy, showing only slight downward deviations around weeks 26-27 and again at weeks 39-40. At the upper extreme, the local 97.5th percentile curve (Orange) follows the WHO standard (Green) but consistently falls below it around weeks 26-27 and from week 37 onwards, with the widest distance between the two curves observed at week 40. These findings suggest that while the growth trajectory for fetal abdominal size in the Chattogram population is generally similar to the WHO standard, the upper growth limit of the local population is notably lower in the final weeks of pregnancy.

**Femur Length (FL)**

The FL growth charts for the Chattogram population (Supplementary Table VII) were established and compared with the WHO standards (Supplementary Table VIII) as shown in Figure 3. The local 2.5th percentile curve (Purple) is generally positioned slightly above the WHO standard (Blue) a trend particularly noticeable in the early weeks (14-20) and again after week 36. Similarly, the local 50th percentile curve (cyan) consistently tracks slightly above the WHO standard (Red) across all gestational ages. The local 97.5th percentile curve (Orange) largely aligns with the WHO standard (Green) but shows a minor downward deviation after week 34, before crossing back over and staying slightly above the WHO line near the end of the gestational period at week 40. These findings suggest that the femur length in the Chattogram population is consistently slightly larger than the WHO standard, particularly in the lower and middle percentiles, indicating a minor upward shift in the overall growth trajectory.

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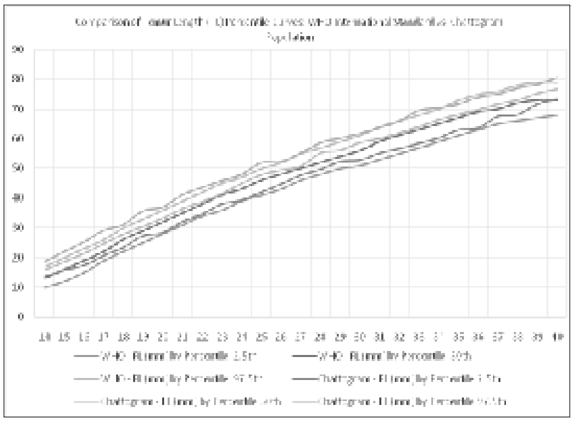

**Figure 3** Comparison of the 2.5th, 50th, and 97.5th percentile curves for Femur Length (FL) based on a local population from Chattogram, Bangladesh, with the WHO international growth chart. The blue, red and green lines represent the WHO standard, while the purple, cyan, and orange lines represent the corresponding percentiles for the Chattogram data. The X-axis indicates Gestational Age in weeks and the Y-axis indicates BPD in millimetres (mm)

**Estimated Fetal Weight (EFW)**

The EFW percentile curves for the Chattogram population were compared with the WHO standards (Supplementary Table IX and Supplementary Table X) and visualised in Figure 4. The local 2.5th percentile curve (Purple) largely mirrors the WHO standard (Blue) for the initial weeks, but shows an upward deviation around weeks 27-29. Notably, a consistent upward trajectory begins after week 34, with the widest distance between the two curves observed at week 40. The local 50th percentile curve (Cyan) also generally aligns with the WHO standard (Red) with slight downward deviations at various points and a subsequent upward trend observed after week 38. Conversely, the local 97.5th percentile curve (Orange) closely tracks the WHO standard (Green) initially, but consistently falls below it after week 36, with this downward trend being most pronounced at week 40. These findings suggest that while the median fetal weight in Chattogram is comparable to the global standard, the growth trajectories at the extremes of the distribution show a distinctive crossover pattern in the later stages of pregnancy. The lower percentile shows a relatively more accelerated growth compared to the WHO standard, while the upper percentile shows a notable flattening.

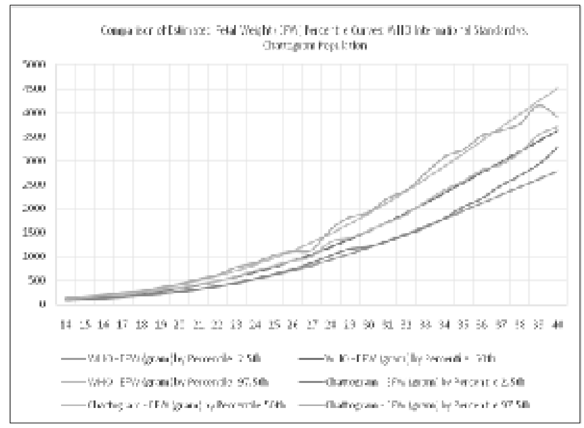

**Figure 4** Comparison of the 2.5th, 50th, and 97.5th percentile curves for Estimated Fetal Weight (EFW) based on a local population from Chattogram, Bangladesh, with the WHO international growth chart. The blue, red and green lines represent the WHO standard, while the purple, cyan, and orange lines represent the corresponding percentiles for the Chattogram data. The X-axis indicates Gestational Age in weeks, and the Y-axis indicates BPD in millimetres(mm)

**Supplementary Material**

The data that support the findings of this study, including detailed distribution tables of all fetal biometry parameters (Supplementary Tables III to X) are provided as supplementary files to support the main manuscript's findings. "Supplementary Materials - Fetal Biometry Study - JCMCTA". Google Drive link-https://drive.google.com/drive/folders/1c42uTpIw49tWQEfQMNI8Sy45JXQtF71W

**Discussion**

The findings reveal notable differences, particularly in the later stages of pregnancy, which highlight the need for population-specific growth charts. In Bangladesh, Hadlock's formula remains the most widely used standard for fetal biometry measurements, despite its limitations when applied to diverse populations. As many practitioners rely on the default charts integrated into ultrasound machine software, the use of such generic charts can lead to inaccurate diagnoses of Fetal Growth Restriction (FGR) or macrosomia. This study addresses this clinical gap by providing locally derived data. The necessity for population-specific charts is well-documented, as ethnic and regional variations in fetal growth are significant.[3,24]

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The comparative analysis of fetal biometry charts for the Chattogram population and the WHO international standards reveals a combination of alignments and clinically relevant deviations. While the median fetal head size (BPD) and Abdominal Circumference (AC) are largely comparable to the global standards, the growth trajectories at the extremes of the distributions show distinct differences. Specifically, the local BPD and AC 97.5th percentiles are notably lower than the WHO standards in the later stages of pregnancy, indicating a limited upper growth range in the Chattogram population. This contrasts with findings from other Asian studies, such as one in Taiwan, which found that their population's BPD, AC and FL values were slightly larger than the INTERGROWTH-21st project in the early second trimester and smaller in the third trimester.[10] In contrast, the Femur Length (FL) charts in our study consistently show that the local population's measurements are slightly larger than the WHO standards almost across all percentiles. The most pronounced and clinically significant difference is observed in the Estimated Fetal Weight (EFW) charts, which display a distinctive crossover pattern in the later stages of pregnancy. In this phase, the local 2.5th percentile shows an accelerated growth compared to the WHO standard, while the local 97.5th percentile demonstrates a notable flattening. These findings collectively suggest that a one-size-fits-all approach to fetal growth monitoring may be inappropriate for this population. A study comparing eight fetal growth standards for the prediction of adverse perinatal outcomes noted that the Hadlock chart, for instance, identified a higher percentage of fetuses as Small for Gestational Age (SGA) but a lower percentage as Large for Gestational Age (LGA) underscoring the potential for misclassification when using non-local standards.[25]

The patterns observed in this study align with global discussions on ethnic variations in fetal biometry. A Lithuanian study, for example, found that while their Head Circumference (HC) and AC were not significantly different from the INTERGROWTH-21st study, their Femur Length (FL) measurements were notably larger. The authors of that study proposed that FL is more genetically determined, whereas fetal nutrition is more likely to be reflected in the size of the abdomen.[8] This aligns with a UK study, which found that infants from ethnic minority groups, including Bangladeshi, recorded lower weights than white neonates.[26]

This research also included an analysis of congenital anomalies, which were detected in 1.35% of the study's ultrasound reports. The most common anomalies were Anencephaly and Multiple anomalies, each representing 9.30% of all detected anomalies.The next most frequent anomaly was Short limb dwarfism (6.98%). These findings provide valuable epidemiological data on the prevalence and types of congenital malformations in the Chattogram population. The documentation of these anomalies underscores the critical role of accurate ultrasound-based screening and highlights the need for dedicated prenatal diagnostic and counselling services in this region. This initial data serves as a crucial baseline for future public health initiatives aimed at reducing the incidence of birth defects.

**Limitations**

The interpretation of the established fetal reference ranges should be considered in light of several methodological limitations. First of all, this study provides a snapshot of fetal size rather than a longitudinal assessment of growth, which is a known limitation of such designs. The methodology, however, was comprehensive and followed established guidelines for chart construction. Secondly, the data used in our research were collected from daily clinical practice and were not originally structured for research purposes, which could introduce a degree of sampling bias. Additionally, another limitation was the reliance on a single institutional centre for data collection and the fact that all measurements were conducted by a single experienced radiologist. While the use of a single, skilled operator minimises inter-observer variability and measurement error, this approach limits the external validity and generalisability of the reference charts to the broader population. Furthermore, the dataset was limited to patient age and lacked crucial maternal information such as height, weight, socioeconomic status, educational background, comprehensive obstetric or gynaecological history, and pre-existing medical conditions, which are known to influence fetal growth patterns. These factors were not controlled for in our study, which is a limitation.

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**Conclusion**

This study reveals that whereas several fetal biometric measurements in the Chattogram population are in line with global standards, there are also notable and clinically significant variations from these norms. Using international charts for this group is inadequate due to the EFW crossover effect and the differing BPD and AC curves, which may cause growth abnormalities to be misclassified. To ensure better perinatal outcomes and enhance prenatal care in Bangladesh, local reference charts must be designed and established.

**Recommendations**

The findings, while specific to the Chattogram population, provide a strong argument for developing national or regional reference charts. Accurate individual fetal biometry necessitates a reference chart that consolidates several national fetal biometry measurements and may require adjustments based on maternal age, weight, height, and ethnicity.[10] This would allow clinicians to more accurately identify at-risk pregnancies, as using charts from different populations can lead to an over- or underdiagnosis of growth abnormalities. Future research should aim to conduct longitudinal studies with larger cohorts to validate these findings and create customised models for fetal biometry. They should also aim to substantially enhance the external validity and generalisability of the reference ranges by moving beyond the limitations of single-centre data collection and the exclusive reliance on a single experienced radiologist and systematically incorporate essential maternal data, including Body Mass Index (BMI) the presence of pre-existing medical conditions, detailed Obstetric and Gynaecological history and relevant socio-demographic factors.

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**Contribution of authors**

ZTA-Literature review, protocol preparation, data collection, data analysis, prepare first draft.

MQA-Concept, critical analysis, approving final manuscript.

AB, MNT, RAR, TM, BB, BKD, SY, MI, SA-Data collection, Literature review, protocol preparation.

TKC-Design, Literature review, data analysis, editing first draft, approving final manuscript.

TB-Supervision, critical analysis, approving final manuscript.

**Disclosure**

All the authors declared no conflict of interest.

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