Fetal biometric parameters: Reference charts for a non-selected risk population from Uberaba, Brazil

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Abstract

**Objective:** To establish reference charts for fetal biometric parameters in a non-selected risk population from Uberaba, Southeast of Brazil. **Methods:** A retrospective cross-sectional study was performed among 5656 non-selected risk singleton pregnant women between 14 and 41 weeks of gestation. The ultrasound exams were performed during routine visits of second and third trimesters. Biparietal diameter (BPD) was measured at the level of the thalami and cavum septi pellucidi. Head circumference (HC) was calculated by the following formula: \( HC = 1.62 \times (BPD + \text{occipital frontal diameter, OFD}) \). Abdominal circumference (AC) was measured using the following formula: \( AC = (\text{anteroposterior diameter + transverse abdominal diameter}) \times 1.57 \). Femur diaphysis length (FDL) was obtained in the longest axis of femur without including the distal femoral epiphysis. The estimated fetal weight (EFW) was obtained by the Hadlock formula. Polynomial regressions were performed to obtain the best-fit model for each fetal biometric parameter as the function of gestational age (GA). **Results:** The mean, standard deviations (SD), minimum and maximum of BPD (cm), HC (cm), AC (cm), FDL (cm) and EFW (g) were 6.9 ± 1.9 (2.3 – 10.5), 24.51 ± 6.61 (9.1 – 36.4), 22.8 ± 7.3 (7.5 – 41.1), 4.9 ± 1.6 (1.2 – 8.1) and 1365 ± 1019 (103 – 4777), respectively. Second-degree polynomial regressions between the evaluated parameters and GA resulted in the following formulas:

- BPD = \(-4.044 + 0.540 \times GA – 0.0049 \times GA^2\) \( (R^2 = 0.97) \);
- HC = \(-15.420 + 2.024 \times GA – 0.0199 \times GA^2\) \( (R^2 = 0.98) \);
- AC = \(-9.579 + 1.329 \times GA – 0.0055 \times GA^2\) \( (R^2 = 0.98) \);
- FDL = \(-3.778 + 0.416 \times GA – 0.0035 \times GA^2\) \( (R^2 = 0.98) \);
- EFW = \(916 – 123 \times GA + 4.70 \times GA^2\) \( (R^2 = 0.96) \);

**Conclusion:** Reference charts for the fetal biometric parameters in a non-selected risk population from Uberaba, Southeast of Brazil, were established.
Introduction

Fetal size and fetal growth trajectories are important indicators of fetal health and prenatal ultrasound is a gold-standard. Fetal growth disorders are usually identified based on discrepancies between the actual and expected biometric measurements for a given gestational age.

Routine third trimester ultrasound increases the detection rate of small for gestational age (SGA) embryos from 46 to 80% and large for gestational age (LGA) embryos from 36 to 91%, without Doppler ultrasound as proved in a randomized controlled trial. Furthermore, late third trimester ultrasound (34 – 37 weeks) significantly increased to 75.2% and 63.2% for the prediction of SGA and LGA, respectively. Short-term outcomes of SGA and LGA fetuses are associated with cerebral palsy, hypoglycemia, hyperbilirubine-
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There are a lot of reference charts for fetal biometric parameters established for different populations, i.e. European, African, Asian and Latin American(8–14). All these reference charts were unconditional (cross-sectional) studies, because they are more appropriate for the quantification of fetal size(10). There is a unique unconditional study with 31,476 singleton Brazilian pregnant women which established reference charts for fetal biometric parameters(16). However, because of a lot of miscegenation of Brazilian population with great ethnic differences among its regions, it is not possible to establish reference charts for fetal biometric parameters to the whole Brazilian population.

The objective of this study is to establish reference charts for fetal biometric parameters between 14 and 41 weeks of gestation in a non-selected risk population from Uberaba, Southeast of Brazil.

Materials and methods
We performed a retrospective cross-sectional study from February 2012 through March 2015 among pregnant women who underwent routine second and third ultrasound exams between 14 and 41 weeks of gestation. This study was approved by the Ethic Committee of Uberaba University (UNIUBE), the consent form which was not

| GA  | N  | 5th | 50th | 95th |
|-----|----|-----|------|------|
| 14  | 81 | 2.2 | 2.6  | 2.9  |
| 15  | 64 | 2.6 | 3.0  | 3.3  |
| 16  | 151| 3.0 | 3.3  | 3.7  |
| 17  | 191| 3.3 | 3.7  | 4.1  |
| 18  | 138| 3.7 | 4.1  | 4.5  |
| 19  | 101| 4.0 | 4.4  | 4.9  |
| 20  | 207| 4.4 | 4.8  | 5.2  |
| 21  | 441| 4.7 | 5.1  | 5.6  |
| 22  | 680| 5.0 | 5.5  | 5.9  |
| 23  | 306| 5.3 | 5.8  | 6.3  |
| 24  | 132| 5.6 | 6.1  | 6.6  |
| 25  | 81 | 5.9 | 6.4  | 6.9  |
| 26  | 63 | 6.2 | 6.7  | 7.2  |
| 27  | 109| 6.4 | 7.0  | 7.5  |
| 28  | 272| 6.7 | 7.2  | 7.8  |
| 29  | 173| 6.9 | 7.5  | 8.1  |
| 30  | 211| 7.2 | 7.7  | 8.3  |
| 31  | 197| 7.4 | 8.0  | 8.6  |
| 32  | 322| 7.6 | 8.2  | 8.8  |
| 33  | 286| 7.8 | 8.4  | 9.1  |
| 34  | 225| 8.0 | 8.7  | 9.3  |
| 35  | 271| 8.2 | 8.9  | 9.5  |
| 36  | 305| 8.4 | 9.0  | 9.7  |
| 37  | 297| 8.6 | 9.2  | 9.9  |
| 38  | 192| 8.7 | 9.4  | 10.1 |
| 39  | 75 | 8.9 | 9.6  | 10.3 |
| 40  | 64 | 9.0 | 9.7  | 10.4 |
| 41  | 21 | 9.2 | 9.9  | 10.6 |

| GA  | N  | 5th | 50th | 95th |
|-----|----|-----|------|------|
| 14  | 81 | 8.1 | 9.0  | 9.9  |
| 15  | 64 | 9.5 | 10.5 | 11.4 |
| 16  | 151| 10.9| 11.9 | 12.8 |
| 17  | 191| 12.2| 13.2 | 14.3 |
| 18  | 138| 13.5| 14.6 | 15.6 |
| 19  | 101| 14.7| 15.9 | 17.0 |
| 20  | 207| 15.9| 17.1 | 18.3 |
| 21  | 441| 17.1| 18.3 | 19.5 |
| 22  | 680| 18.2| 19.5 | 20.7 |
| 23  | 306| 19.3| 20.6 | 21.9 |
| 24  | 132| 20.4| 21.7 | 23.0 |
| 25  | 81 | 21.4| 22.7 | 24.1 |
| 26  | 63 | 22.3| 23.8 | 25.2 |
| 27  | 109| 23.2| 24.7 | 26.2 |
| 28  | 272| 24.1| 25.7 | 27.2 |
| 29  | 173| 25.0| 26.5 | 28.1 |
| 30  | 211| 25.8| 27.4 | 29.0 |
| 31  | 197| 26.6| 28.2 | 29.8 |
| 32  | 322| 27.3| 29.0 | 30.7 |
| 33  | 286| 28.0| 29.7 | 31.4 |
| 34  | 225| 28.6| 30.4 | 32.2 |
| 35  | 271| 29.2| 31.0 | 32.8 |
| 36  | 305| 29.8| 31.7 | 33.5 |
| 37  | 297| 30.3| 32.2 | 34.1 |
| 38  | 192| 30.8| 32.8 | 34.7 |
| 39  | 75 | 31.3| 33.2 | 35.2 |
| 40  | 64 | 31.7| 33.7 | 35.7 |
| 41  | 21 | 32.1| 34.1 | 36.2 |

GA – gestational age

Tab. 1. Estimated 5th, 50th and 95th percentiles for the biparietal diameter measurement (cm) according to gestational age (weeks)

Tab. 2. Estimated 5th, 50th and 95th percentiles for the head circumference measurement (cm) according to gestational age (weeks)

mia, polycythemia, or dystocia(4,5). Long-term outcomes of these fetuses are associated with high risk of systemic arterial pressure, diabetes mellitus and coronary heart disease(6).

The ethnic factor shows to interfere in the fetal growth pattern, impossible that reference ranges of fetal biometric parameters from homogeneous population could be applied in other populations, mainly heterogeneous populations. In an American study with singleton pregnancies between 17 and 22.9 weeks, Afro-American fetuses have smaller abdominal circumference (AC) than Caucasian fetuses. As AC contributes heavily to the estimated fetal weight, the Afro-American fetuses could be mistakenly underestimated(7).

There are a lot of reference charts for fetal biometric parameters established for different populations, i.e. European, African, Asian and Latin American(8–14). All these reference charts were unconditional (cross-sectional) studies, because they are more appropriate for the quantification of fetal size(10). There is a unique unconditional study with...
necessary because it was a retrospective study. Low-risk pregnant women were selected randomly from public and private health services of the metropolitan region of Uberaba, Minas Gerais state, Southeast of Brazil.

The inclusion criteria were the following: singleton pregnancies, lack of bleeding in the first trimester, gestational age determined by the last menstrual period (LMP) and confirmed by first trimester ultrasound using crown-rump length (CRL) until 13th week, lack of fetal structural malformations or chromosomal abnormalities in the ultrasound exam. The exclusion criteria were maternal chronic diseases, such as arterial systemic hypertension, diabetes mellitus, systemic lupus erythematosus and renal diseases. Postnatal outcomes were not available. Each pregnant woman was examined only once.

The ultrasound exams were performed at the Mario Palmério University Hospital and Radiologic Clinic of Uberaba as routine visits in the second and third trimesters of pregnancy. These ultrasound exams were performed by only two examiners (ABP and TMRCC) with Fetal Medicine Foundation (FMF) accreditation. The ultrasound exams were performed transabdominally using only two apparatuses (Accuvix V20 – Samsung, Seoul, Korea) equipped with a convex head (3D4-6ET) and Voluson E6 – General Electric, Zipf, Austria) equipped with a convex head (RAB4-6L).

The following fetal biometric parameters were assessed: biparietal diameter (BPD), head circumference (HC), AC and femur diaphysis length (FDL), according to the guidelines proposed by the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG)\(^{(17)}\). The estimated fetal weight (EFW) was automatically calculated by the apparatus using the Hadlock formula \[\text{Log 10 birth weight} = 1.4787 + 0.001837 \times (\text{BPD})^2 + 0.0458 \times (\text{AC}) + 0.158 \times (\text{FDL}) - 0.003343 \times (\text{AC} \times \text{FDL})\]\(^{(18)}\).

For the BPD measurement, a cross-sectional view of the fetal head was obtained at the level of thalamus, with symmetrical appearance of the hemispheres, continuous midline echo broken in the middle by the cavum septi pellucidi.
### Results

We assessed 5656 non-selected risk singleton pregnancies. The mean $\pm SD$ of age (years), weight (kg), height (cm), BMI (kg/m²), number of pregnancies, parity and gestational age at ultrasound exam (weeks) amounted to 29.4 ± 6.1, 71.6 ± 15.1, 162.5 ± 11.1, 27.0 ± 5.8, 1.8 ± 1.1, 0.6 ± 0.8 and 27.8 ± 7.0, respectively. According to ethnicity, 84.5% were white. Cigarette smokers and alcohol consumers represented 3.1% and 2.7%, respectively.

The mean, SD, minimum and maximum of BPD (cm), HC (cm), AC (cm), FDL (cm) and EFW (g) were 6.9 ± 1.9 (2.3 – 10.5), 24.51 ± 6.61 (9.1 – 36.4), 22.8 ± 7.3 (7.5 – 41.1), 4.9 ± 1.6 (1.2 – 8.1) and 1365 ± 1019 (103 – 4777), respectively. The second-degree polynomial regressions between the evaluated parameters and GA resulted in the following formulas: $BPD = -4.044 + 0.540 \times GA - 0.0049 \times GA^2$ ($R^2 = 0.97$); $HC = -15.420 + 2.024 \times GA - 0.0199 \times GA^2$ ($R^2 = 0.98$); $AC = -9.579 + 1.329 \times GA - 0.0055 \times GA^2$ ($R^2 = 0.97$); $FDL = -3.778 + 0.416 \times GA - 0.0035 \times GA^2$ ($R^2 = 0.98$) and $EFW = 916 - 123 \times GA + 4.70 \times GA^2$ ($R^2 = 0.96$); respectively.

Figure 1 shows the scatterplots for the BPD (A), HC (B), AC (C), FDL (D) and EFW (E) measurements (cm) as the function of gestational age (weeks). Tables 1, 2, 3, 4, 5 present the 5th, 50th and 95th percentiles for the BPD, HC, AC, FDL and EFW measurements between 14 and 41 weeks of gestation, respectively.

### Discussion

In this study, we established reference charts for the fetal biometric parameters in a non-selected risk population from Uberaba, Southeast of Brazil. The effect of ethnic
origin influences the fetal biometric parameters. Kwon et al.\(^{(12)}\) comparing their fetal biometric parameters measurements with the North American and UK populations, Korean fetuses had greater BPD, head circumference (HC), and AC in the first half of pregnancy but tended to measure progressively smaller with advancing gestational age. In a conditional study which established reference charts between 15 and 40 weeks of gestation in a Congolese population, comparing with reference charts derived from developed populations consistently overestimated the 50th centile EFW value for Congolese fetuses by roughly 5–12\%\(^{(20)}\).

In this study, we proposed to assess reference charts for fetal biometric parameters in a specific population of a region of Brazil. According to the census of 2010, 43.1\% of the Brazilian population is classified as mixed ethnic \(^{21}\), constituting the largest miscegenation population in the world – as a result – the Brazilian population is classified due to skin color and not race. Furthermore, the rate of miscegenation changes in its different regions. Specifically in Uberaba city, Southeast of Brazil, in the same census of 2010, the rate of mixed amounted to 28.0\%\(^{(21)}\), in other words a difference of 35.1\% regarding the whole Brazilian population. Because of regional ethnic differences among populations in the same country, some authors have established reference charts for fetal biometrical parameters to specific regions\(^{(14,22)}\).

Araujo Júnior et al.\(^{(16)}\) determined reference charts for fetal biometric parameters in 31,476 singleton Brazilian pregnant women. This study was carried out in the metropolitan region of Sao Paulo city, which also presents different rates of mixed population regarding the whole Brazilian population. Despite a large sample, the ultrasound exams were performed by several sonographers with different expertise in this method, and 12 different ultrasound apparatuses were used to perform the ultrasound exams and the gestational age interval included only 18 to 38 weeks of gestation. It is known that changing ultrasound settings or apparatus may affect the calculation and repeatability of measurement of fetal myocardial performance index \(^{23}\), in the same way the professional experience in the fetal heart volume by a three-dimensional ultrasound\(^{(24)}\). In our study, all ultrasound exams were performed by only two experienced examiners with FMF accreditation, and the ultrasound exams were performed using only two apparatuses. Comparing our results with those of Araujo Júnior et al.\(^{(16)}\) between 18 and 38 weeks of gestation, the means of BPD, AC, FDL and EFW were similar, showing that the ethical factor did not have a significant importance in this local sample of Brazilian population. However, new studies with larger samples including other Brazilian regions are necessary to probe the real influence of ethical effect on the fetal biometry.

Kwon et al.\(^{(12)}\) established unconditional reference charts for fetal biometric parameters in 986 fetuses between 15 and 40 weeks of gestation. Comparing our results, we observed that the means of all biometric parameters were similar. Dubiel et al.\(^{(9)}\) established reference charts for fetal biometric parameters of a Caucasian Polish population with 959 normal pregnant women between 20 and 40 weeks of gestation. Comparing the median of BPD, AC, FDL and EFW of our results with those of Dubiel et al.\(^{(9)}\), we observed that they were similar. Table 6 shows the comparison of mean BPD, AC, FDL and EFW of our study with other ones from different ethnic populations.

As a summary, we established reference charts for the fetal biometric parameters in a non-selected risk population from Uberaba, Southeast of Brazil. As we did not observe significant differences between the fetal biometric parameter measurement obtained in our study and the ones from Araujo Júnior et al.\(^{(16)}\), who assessed a larger Brazilian population sample, we believe that our sample can represent a great miscegenation of the Brazilian population. These reference charts may be used in Brazilian pregnant women with high-risk of intrauterine growth disorders.

### Conflict of interest

Authors do not report any financial or personal links with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.
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