

Establishment of Growth Curves to Full Term Newborns: A Moroccan Study

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Abstract

Neonatal anthropometric data is an important reflection of the growth and fetal development. **Objective:** Knowing the anthropometric standards of Moroccan newborns according to sex, gestational age, parity, age and corpulence of women. **Materials and Methods:** Prospective and cross-sectional study. The information forward newborns alive, healthy, Moroccan parents, from normal pregnancies, born in Rabat Souissi's maternity between January 2008 and December 2013, was gathered. **Results:** 5000 births were recruited. The ratio was balanced. Anthropometric standards identified according to gestational age and gender were lower than the Frenchs (AUDIPOG) and Tunisians. With our curves, we determined new thresholds for SGA and macrosomia. **Factors influencing fetal growth,** it was verified, in addition to sex and gestational age of the newborn, age, parity and maternal body mass index (BMI), that have proven determinants of fetal growth in our context. **Conclusion:** The curves of birth weight, height and head circumference of Moroccan newborns recruited have determined a new thresholds for hypotrophy and macrosomia.

Keywords

Anthropometric Data, Gestational, Age, Parity, Corpulence, Hypotrophy, Macrosomia

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1. Introduction

The assessment of intrauterine growth based on simple measures of weight, height and head circumference of the newborn, is an important instrument that helps a lot to support adequate and proper care management for newborns. Those measures must be reported on reference curves.

In Morocco, national reference curves don't exist and those French or North's America used, but that are not necessarily suitable to the standards of our people. However, several factors influence fetal growth [1], like the size and maternal weight [2] [3], ethnicity [4]-[7], socioeconomic's conditions [8] and altitude of the place of residence [9]. The geographical position and socio-economic conditions in Morocco are not like those of European or North America's countries. It is the same for ethnicity and anthropometric measures. So one might ask whether the evaluations carried from these "international" curves are less accurate and less adapted to our context.

This work is a first initiative whose main objective is the evaluation of anthropometric standards of a group of newborns Moroccans aged 37 to 42 completed weeks of gestation. Our results will be compared to:

- AUDIPOG those of the study (Association of Computerized Records Users Perinatology, Obstetrics and Gynecology) recently conducted in France by Mama *et al.* [10]
- For weight curves of the Tunisian experience, conducted by El Mhamdi *et al.* [11] due to the ethnic and geographic similarity we have with Tunisia, but this study is limited to the data weight newborns.

The secondary objectives are:

- Analysis of the impact of certain factors (especially those related to the mother in addition to the sex of the fetus [12] [13] on fetal growth.

2. Materials and Methods

2.1. Methodology

It was a prospective and cross-sectional study conducted in Maternity Souissi University Hospital of Rabat-Morocco between January 2008 and December 2013. This hospital drains the northern half of Moroccans. Parturients who are admitted Moroccan represent different ethnicities.

- ✓ Inclusion criteria: Newborns whose gestational age was between 37 and 42 weeks from Moroccan women, healthy, with no obstetrical pathology, with at least three antenatal consultations, informed and after obtaining their consent. Gestational age, it is calculated by the last menstrual period and/or by the data of early obstetrical ultrasound (before the 12^o week of amenorrhea), then checked birth by the score of Dubowitz. They are included newborns whose don't have any clinically detectable malformation.
- ✓ Exclusion criteria: They are excluded twin pregnancies, those with enamelled complications have disturbed intrauterine growth (hypertension, diabetes, severe anemia, severe malnutrition), those with a dubious term dating and/or discordance with the data clinical examination (a difference of more than a week), parturients having a long-term treatment (anti-bacillary, anti-HIV), newborns parent(s) not Moroccan(s), all malformed and died newborns.

Each newborn was measured in the first hour after birth, weight, height and head circumference.

The weighing was done with a balance accurate to 10 g, the size was taken with six feet and head circumference was measured using a flexible tape measure.

For every woman in labor was established a standardized assessment sheet with the collection of: age, weight, height, Body Mass Index (BMI), the number of pregnancies and the number of parities, if multipare, age at first pregnancy and birth space.

Anthropometric measurements (weight and height) of the women were held during the first consultation and admission to the room of childbirth; we used a Scale-type mechanical balance "Seca viva 750" for weight gain and a fathom of wood to adult for measuring the size.

2.2. Definition of Terms

- Is considered as a newborn "SGA" small for gestational age or "with intrauterine growth restriction" when its weight, based on gestational age, is strictly less than the 10^o percentile of the weight curve reference.
- Harmonious hypotrophy: weight, size and head circumference are reduced.
- Dysharmonious hypotrophy: only the weight that is reduced.

- We define “hypertrophy” or “Macrosomia” when the weight exceeds the 90° percentile.
- An Appropriate for gestational age (AGA) if the weight is between the two limits (10° and 90° percentile).

2.3. Statistical Analysis

The data were analyzed by SPSS statistical software (Statistical Package for Social Sciences) version 13.0 for Windows. Quantitative variables were expressed as average and standard deviation, and/or median and quartiles. The qualitative variables were expressed as frequency and percentage. The t-Student test for paired sample was used for comparison of averages. ANOVA has been used for comparison of more than two averages. The test “post hoc” Bonferroni was used for comparison between the subgroups. A value of “p” of less than 0.05 was considered statistically significant.

3. Results

Neonatal Data

During the study period, 5000 births, 2500 boys and 2500 girls were included. The delivery was vaginally in 85% of cases and by caesarean in 15% of cases. Each age group of 37 to 41 WA was composed of 416 male newborns and 416 female newborns. When the group of 42 WA it featured 420 male newborns and 420 female newborns. The birth weight of all infants ranged from 2000 g to 4800 g with an average of 3358.90 g (± 493.5) in boys and 3228.82 g (± 460.4) in girls with a statistically significant difference ($p < 0.001$).

Table 1 shows the average weights of the newborns according to their genders and ages.

The sizes ranged from 36 cm to 58 cm with an average of 48.90 cm (± 3.01) in boys and 48.20 cm (± 2.71) in girls with a statistically significant difference ($p < 0.001$). The distribution of average sizes of newborns according to their gender and their AG is presented in **Table 2**.

The values of head circumference (HC) were measured between 28 cm and 40 cm with an average of 33.90 cm (± 1.72) in boys and 33.60 cm (± 1.65) in girls and the difference was statistically significant ($p < 0.001$). The averages by gender and GA are outlined in **Table 3**.

The 3°, 10°, 25°, 50°, and 75°, 90° and 97° percentile of the various anthropometric parameters of newborns (males) are presented in **Table 4**; and those female newborns in **Table 5**.

Constructed weight curves are shown in **Figure 1** for newborn male and **Figure 2** for newborn female.

The size and head circumference curves produced are shown in **Figure 3** for newborns of male sex and **Figure 4** for newborns of female sex.

4. Discussion

Growth curves are remarkably useful in neonatology units, serving the trophic status of newborns. This status can draw the support scheme and the list of potential risks.

Although the population is not representative of Morocco, these curves we obtained can be considered unique to our center and valid for maternity and neonatal units of the Rabat’s region, as they can give an idea about the anthropometric constants of Moroccan neonates. The limitation of this study to full-term newborns is due to the low number of premature births that met our inclusion criteria.

Table 1. Average of weight of term newborns by Sex and the GA.

| GA | Boys | | Girls | | p |
|-------|---------|--------|---------|--------|------------------|
| | Average | SD | Average | SD | |
| 37.00 | 3174.11 | 506.10 | 3045.03 | 436.07 | 0.167 |
| 38.00 | 3297.96 | 625.10 | 3101.98 | 386.40 | 0.095 |
| 39.00 | 3322.82 | 382.53 | 3161.10 | 440.25 | 0.007 |
| 40.00 | 3351.68 | 502.92 | 3246.10 | 468.96 | 0.016 |
| 41.00 | 3524.40 | 479.50 | 3355.73 | 446.61 | 0.013 |
| 42.00 | 3453.41 | 458.55 | 3394.29 | 472.49 | 0.558 |
| Total | 3358.89 | 493.50 | 3228.77 | 460.40 | <0.001 |

Table 2. Medium to term newborn by sex and GA.

| GA | Boys | | Girls | | P |
|-------|---------|-------|---------|-------|-------|
| | Average | SD | Average | SD | |
| 37.00 | 47.82 | 2.465 | 47.333 | 3.393 | 0.356 |
| 38.00 | 48.14 | 3.011 | 47.740 | 2.465 | 0.445 |
| 39.00 | 48.49 | 2.777 | 48.026 | 2.689 | 0.223 |
| 40.00 | 49.38 | 3.184 | 48.509 | 2.866 | 0.001 |
| 41.00 | 49.58 | 2.494 | 48.574 | 2.751 | 0.010 |
| 42.00 | 48.99 | 2.593 | 48.619 | 2.305 | 0.466 |
| Total | 48.90 | 3.052 | 48.312 | 2.715 | 0.001 |

Table 3. HC' averages of full-term infants by sex and GA.

| GA | Boys | | Girls | | P |
|-------|---------|------|---------|------|------------------|
| | Average | SD | Average | SD | |
| 37.00 | 33.39 | 1.82 | 33.25 | 1.52 | 0.157 |
| 38.00 | 33.70 | 1.91 | 33.50 | 1.67 | 0.620 |
| 39.00 | 34.01 | 1.70 | 33.38 | 1.69 | 0.042 |
| 40.00 | 34.11 | 1.71 | 33.65 | 1.70 | 0.012 |
| 41.00 | 34.06 | 1.34 | 33.72 | 1.50 | 0.087 |
| 42.00 | 33.90 | 1.72 | 33.70 | 1.70 | 0.613 |
| Total | 33.90 | 1.72 | 33.60 | 1.65 | <0.001 |

Table 4. Weight distribution, sizes and HC FOR newborn males by gestational age.

| Weight (g) | | | | | | | |
|-------------------------|---------|---------|---------|---------|-----------|---------|---------|
| 37 | 2175.00 | 2480.00 | 2777.50 | 3140.00 | 3420.00 | 3810.00 | 4020.00 |
| 38 | 2378.50 | 2564.00 | 2872.00 | 3210.00 | 3573.00 | 4010.00 | 4179.00 |
| 39 | 2433.00 | 2700.00 | 3010.00 | 3310.00 | 3620.00 | 4020.00 | 4195.00 |
| 40 | 2500.00 | 2830.00 | 3100.00 | 3355.00 | 3730.00 | 4240.00 | 4578.00 |
| 41 | 2610.00 | 2960.00 | 3255.00 | 3520.00 | 38,550.00 | 4275.00 | 4760.00 |
| 42 | 2470.50 | 2810.00 | 3247.50 | 3440.00 | 3840.00 | 4000.00 | 4398.00 |
| Size (cm) | | | | | | | |
| 37 | 40.35 | 42.00 | 45.00 | 48.00 | 50.00 | 52.00 | 52.80 |
| 38 | 40.40 | 42.90 | 47.00 | 48.50 | 50.00 | 52.00 | 53.00 |
| 39 | 40.70 | 45.00 | 47.00 | 49.00 | 50.00 | 52.00 | 53.00 |
| 40 | 41.55 | 46.20 | 48.00 | 50.00 | 51.00 | 53.00 | 54.00 |
| 41 | 43.90 | 47.00 | 48.00 | 50.00 | 51.00 | 52.00 | 55.00 |
| 42 | 42.00 | 45.00 | 48.00 | 49.00 | 50.00 | 52.00 | 54.80 |
| Head circumference (cm) | | | | | | | |
| 37 | 29.10 | 31.000 | 32.000 | 34.00 | 35.00 | 35.50 | 36.255 |
| 38 | 30.00 | 31.00 | 32.00 | 34.00 | 35.00 | 36.00 | 36.20 |
| 39 | 30.00 | 32.00 | 33.00 | 34.00 | 35.00 | 36.00 | 36.70 |
| 40 | 30.00 | 32.00 | 33.00 | 34.00 | 35.00 | 36.00 | 37.00 |
| 41 | 31.00 | 32.00 | 33.00 | 34.00 | 35.00 | 36.05 | 37.45 |
| 42 | 30.50 | 31.20 | 32.50 | 34.00 | 35.00 | 36.00 | 37.00 |

Table 5. Distribution of weights, sizes and HC for newborn females according to GA.

| Weight (g) | | | | | | | |
|-------------------------|---------|---------|---------|---------|---------|---------|---------|
| 37 | 2051.00 | 2515.00 | 2757.00 | 3028.00 | 3301.00 | 3610.00 | 3878.00 |
| 38 | 2155.00 | 2530.00 | 2750.00 | 3110.00 | 3410.00 | 3635.00 | 4124.00 |
| 39 | 2303.00 | 2604.00 | 2851.00 | 3152.00 | 3455.00 | 3755.00 | 4140.00 |
| 40 | 2427.00 | 2695.00 | 2953.00 | 3204.00 | 3555.00 | 3823.00 | 4240.00 |
| 41 | 2618.00 | 2809.00 | 3054.00 | 3355.00 | 3707.00 | 4163.00 | 4375.00 |
| 42 | 2604.00 | 2730.00 | 3053.00 | 3305.00 | 3655.00 | 3933.00 | 4369.00 |
| Size (cm) | | | | | | | |
| 37 | 40.87 | 44.10 | 46.00 | 48.00 | 49.70 | 50.90 | 51.50 |
| 38 | 41.05 | 45.00 | 47.00 | 48.00 | 50.00 | 51.00 | 52.00 |
| 39 | 41.50 | 45.00 | 47.00 | 48.00 | 50.00 | 51.00 | 52.00 |
| 40 | 41.70 | 45.00 | 47.00 | 49.00 | 50.00 | 51.00 | 53.00 |
| 41 | 43.30 | 46.30 | 48.00 | 49.00 | 50.00 | 52.00 | 54.80 |
| 42 | 42.00 | 45.20 | 47.50 | 48.00 | 50.00 | 51.80 | 54.00 |
| Head circumference (cm) | | | | | | | |
| 37 | 29.60 | 31.00 | 32.00 | 33.00 | 34.000 | 35.00 | 35.75 |
| 38 | 30.00 | 31.00 | 32.00 | 33.00 | 34.85 | 35.00 | 36.00 |
| 39 | 30.00 | 31.00 | 32.50 | 34.00 | 35.00 | 35.30 | 36.50 |
| 40 | 30.00 | 31.00 | 33.00 | 34.00 | 35.00 | 36.00 | 37.00 |
| 41 | 31.00 | 32.00 | 33.00 | 34.00 | 35.00 | 36.00 | 37.00 |
| 42 | 30.00 | 32.00 | 33.00 | 34.00 | 35.00 | 35.90 | 36.90 |

We have analyzed for the first time in Morocco three anthropometric parameters of birth: weight, height and head circumference. The data collected from our sample confirmed elevated anthropometric values (weight, height and head circumference) in newborn boys than girls, according to gestational age, which corroborates the findings of other studies [14]-[18].

By convention, to compare the results of neonatal growth curves, we take as reference point the values obtained at 40 weeks gestation and essentially the average or median age (50 th percentile). Was chosen for the comparison of our curves, those of Mama (France: AUDIPOG study) [10] Dawodu (UAE) [15] and El Mhamdi (Tunisia) [11].

The average weight at birth of our male newborns to 40 weeks gestational age is less than 65 g of UAE [15] and 170 g to that of Tunisian [11]; Similarly, the average weight of our newborn female is less than 52 g of UAE [15] and 148 g that of the Tunisian [11].

The average size and head circumference of boys in our study are lower than those found in the United Arab Emirates [15], 1.70 cm and 0.65 cm in succession; and in our average girls are inferior to those of UAE [14], of 1.80 cm and 0.55 cm successively.

The median (50° percentile) weight in our newborn males 40 weeks gestational age is less than AUDIPOG in the study [10] of 112 g and 148 g compared to Tunisian [11]; and among our newborn females, it is less than 128 g than in France [10] and 195 g than in Tunisian [11]. The median size and head circumference of boys in our study are lower than those of Mama [10], 0.3 cm and 1.1 cm in succession; and with our girls are below the median of 0.6 cm and 0.5 cm in succession. The values of 50° percentile of our weight newborns 38 SA 42 SA are below their corresponding among Tunisians [11] and in AUDIPOG study [10] with the exception of females who are 38 WA weight slightly higher than the French [10], while our values 37 weeks are almost similar to those of Tunisia [11] and slightly larger than that of the French study [10]. Similarly, are the values of 10° percentile except 37 weeks where our results exceed those of Tunisia [11] and French [10]. For values of 90° percentile, they stand between the corresponding values in the Tunisian experience [11] and the study of Udder.

About the values of 10° and 50° percentile of the size and values of 10°, 50° and 90° head circumference

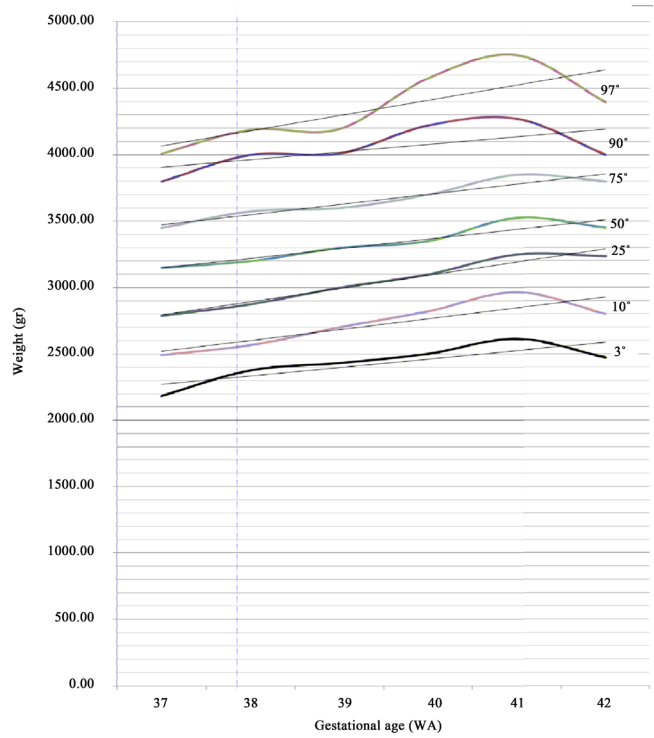


Figure 1. Curves of weight percentiles at birth (boys).

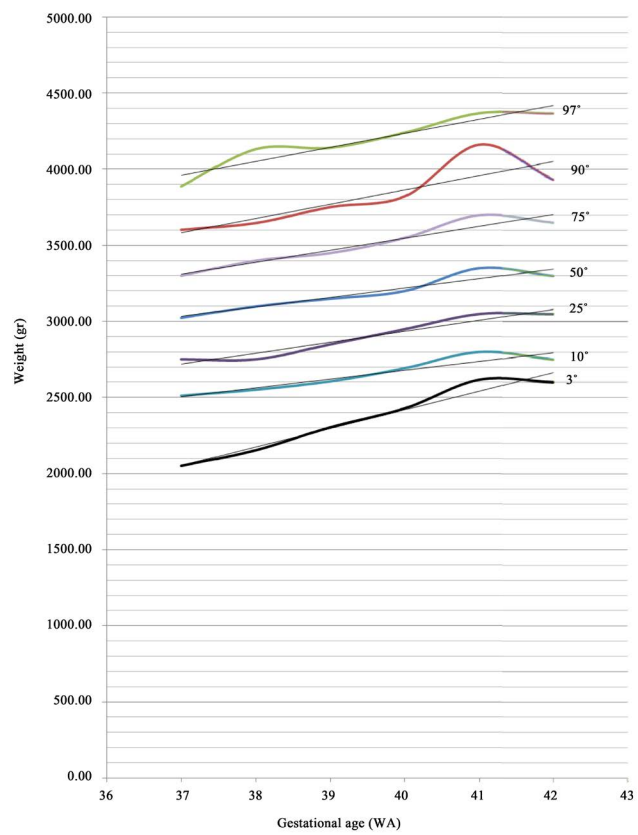


Figure 2. Curves weight percentiles at birth (girls).

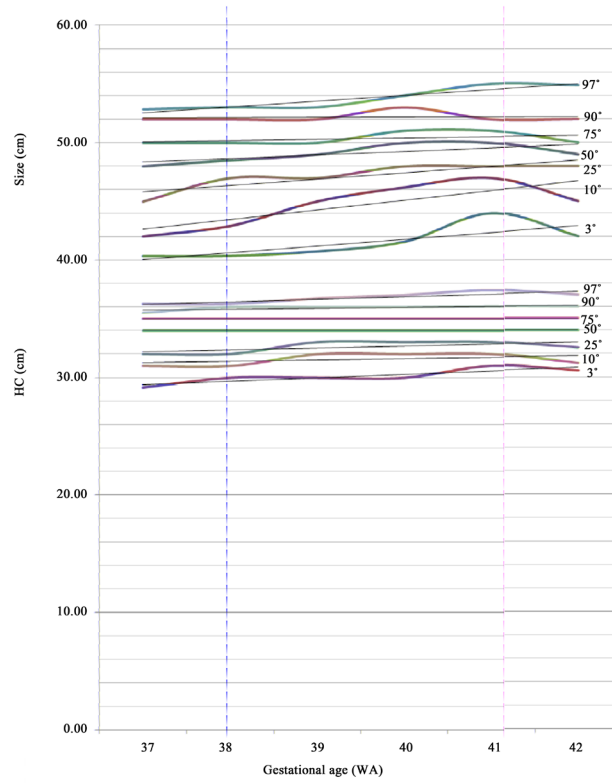


Figure 3. Size and head circumference curves (HC) for boys.

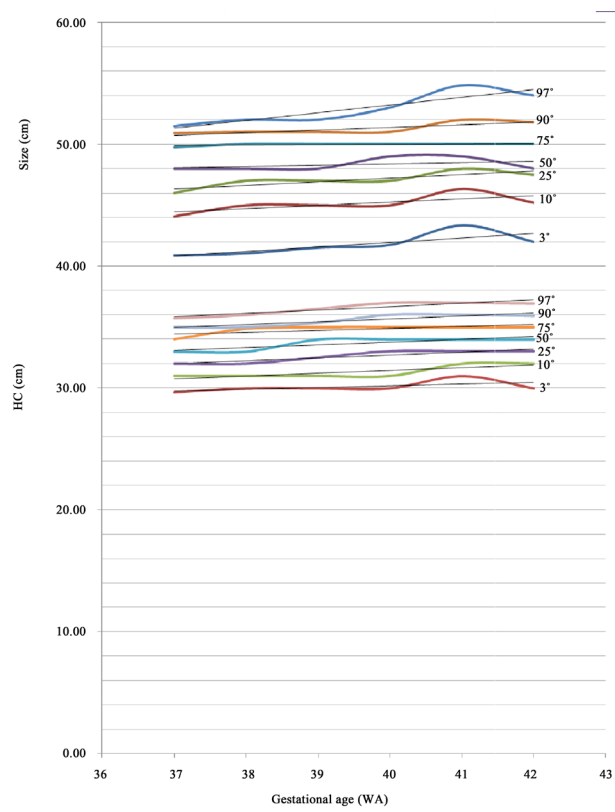


Figure 4. Size and head circumference curves (HC) for girls.

percentiles among our newborns are lower than their corresponding in France [10], while the percentile values of 90° size in our study are higher than Mama [10]. By comparing curves (10° and 90° percentile) with those of the AUDUPOG study [10] and those of the Tunisian study (weight curves) [11]; we find for weight newborn males that our curve 10° percentile (SGA threshold) is below except for 37 weeks, that is to say that the French and Tunisian curves could underestimate fetal growth in our population and 90° percentile curve (macrosomia threshold) is above except 42 SA which means that the comparison curves might consider some of our newborns as macrosomic while have a weight within normal limits according to our new curves (Figures 5-8).

On the curves of weight female newborns, our curves are close to those of the AUDIPOG except at 37 and 41 WA (Figure 5).

For the size and head circumference, our curves of 90° percentile (threshold macrosomia) are almost superimposed on those of our AUDIPOG and curves 10° percentile (IUGR threshold) are below the French curves (Figure 6) for male newborns (Figure 7) for females.

In total, we see that there is a difference between our results and those of curves selected for comparison, because of the ethnic and/or geographic factors. Thus one sees that the curves obtained we define new thresholds IUGR and macrosomia. These interesting data must be reinforced by a broader national multicenter study.

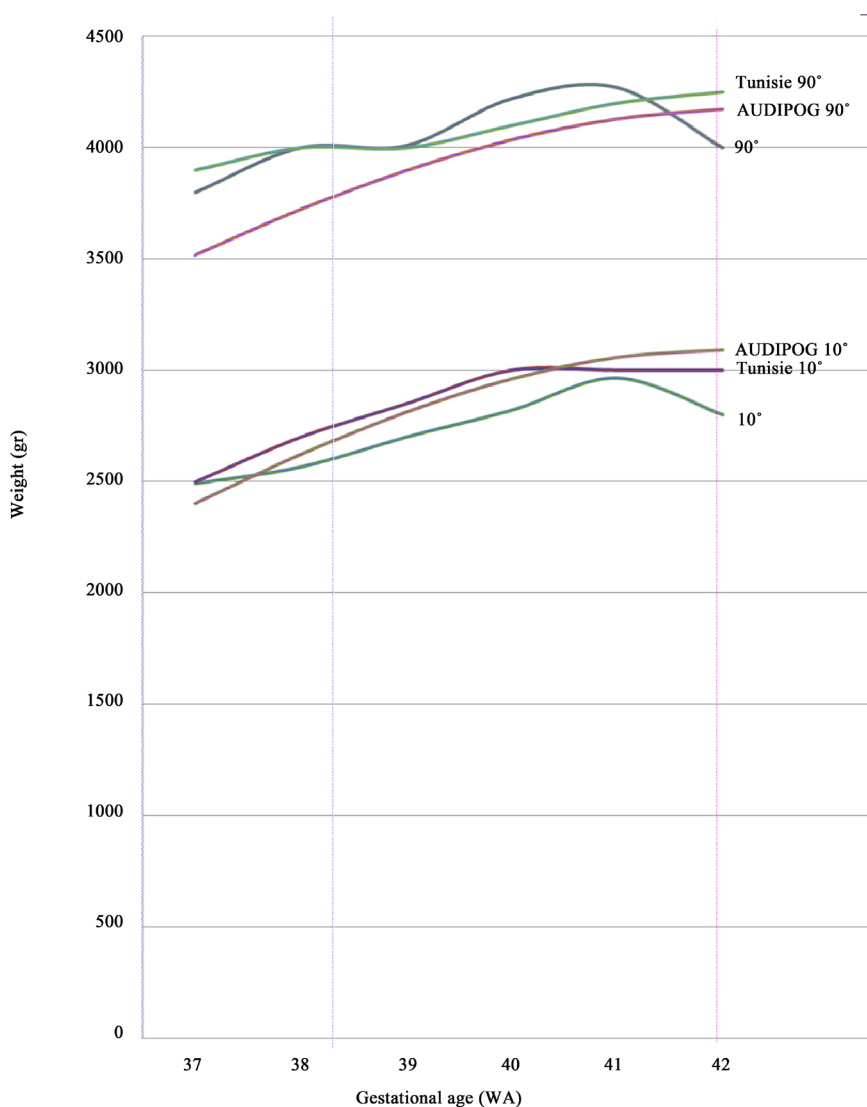


Figure 5. Comparison of 10 and 90th percentiles of weight in newborns of our curves with that of Tunisia and those AUDIPOG (boys).

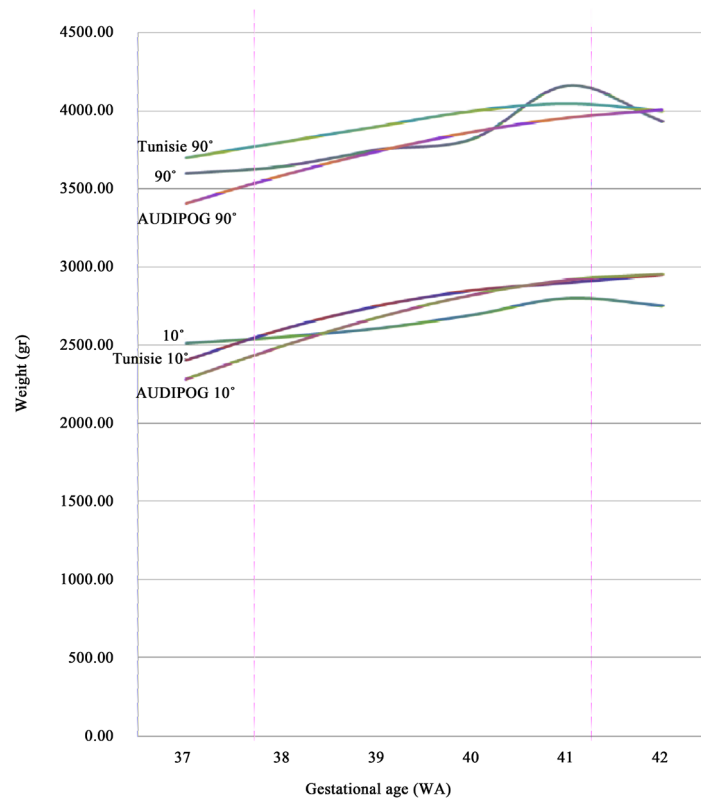


Figure 6. Comparison of 10 and 90th percentiles of weight newborns in our curves with that of AUDIPOG and those Tunisian (girls).

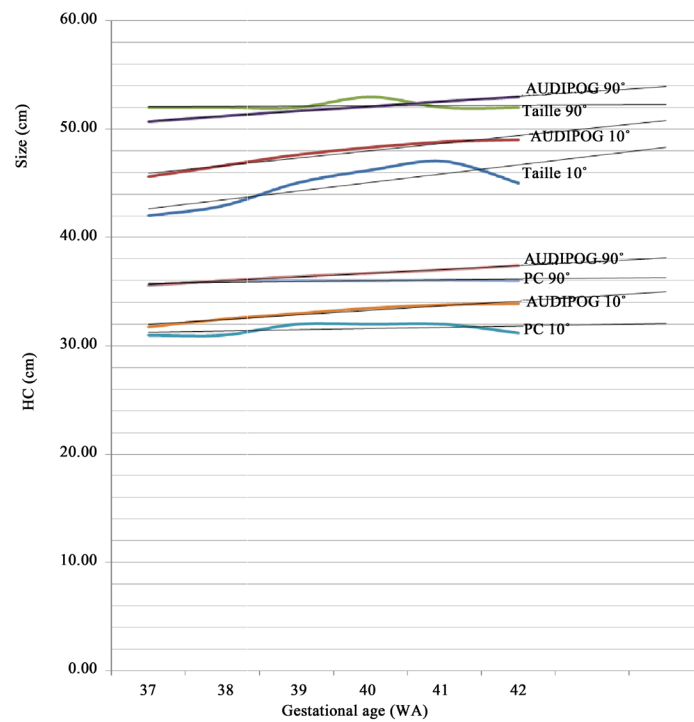


Figure 7. Comparison of 10 and 90th percentiles of sizes and HC newborn male AUDIPOG with our curves.

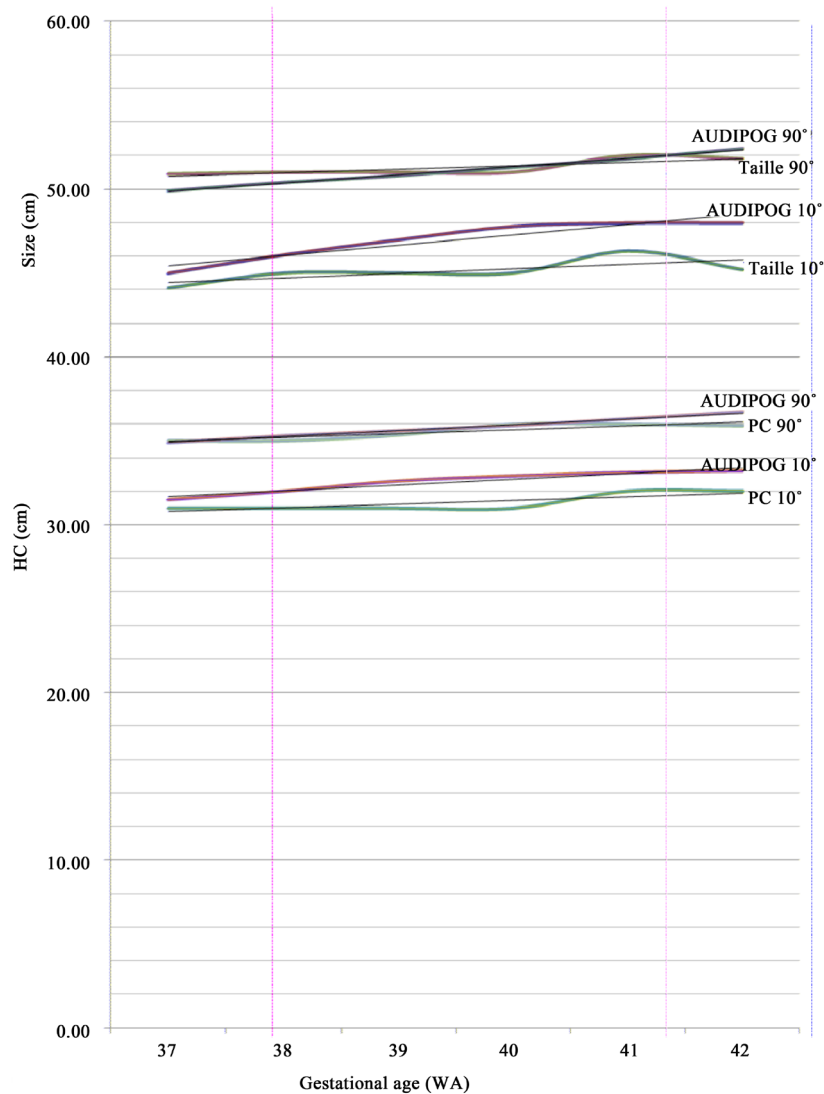


Figure 8. Comparison of 10 and 90th percentile sizes and HC for newborns in our curves with that AUDIPOG (girls).

5. Conclusion

This study, the first of its kind nationwide, is a real contribution to the study of fetal growth in Morocco. On the one hand, it provides us curves for weight, height and head circumference normal births ultimately occurred at the Souissi Maternity Hospital in Rabat. This is a true action research. This model is potentially extrapolated to the Moroccan population and such suitability can be verified by other subsequent studies. Moreover, it became clear through this work that the sex of newborn and gestational age is key factors in its growth. But, maternal body size and parity are major predictors of fetal growth in our population.

Competing Interests

Authors have declared that no competing interests exist.

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Abbreviations

UAE: United Arab Emirates;
 IUGR: Intrauterine Growth Restriction;
 GA: Gestational Age;
 WA: Weeks of Amenorrhea;
 HC: Head Circumference;
 BMI: Body Maternal Index;
 SGA: Small for Gestational Age;
 AGA: Appropriate for Gestational Age.