Construction of intrauterine growth curves in a high altitude area of Saudi Arabia

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ABSTRACT

Objective: The aim of the present study was to construct intrauterine percentile growth curves for body weight, length and head circumference for local use in a high altitude area of Saudi Arabia.

Methods: This is a cross-sectional study of all Saudi births from Abha General Hospital over a 6-year period from 1999 to 2004. We included a total of 6,035 Saudi births in the present study after eliminating babies that were stillbirths, twins or those with major congenital anomalies. The gestational age of the infants ranged from 26-42 weeks. The anthropometric measurements included birth weight, crown-heel length and head circumference. We calculated the 10th, 25th, 50th, 75th, and 90th percentiles for weight, length and head circumference against the periods of gestation. We also calculated the mean weight and mean ± 2SD. We determined the curves of best fit for weight, length and head circumference measurements at different weeks of gestation by polynomial regression of the following general form to construct the clinical curves: $Y = a + bX + cX^2$.

Results: We derived intrauterine growth curves for weight, length and head circumference from measurements made on infants born at each week of gestation in the latter half of pregnancy. By calculating mean values and deviations around these (expressed either as centiles or standard deviations), we constructed distance (size attained) growth curves. The mean values for weight and length of births of the present study are lower than those of published charts in all gestational periods. However, for head circumference, evident appeared only before 32 weeks of gestation. The mean values of head circumference were nearly comparable.

Conclusion: Constructed smoothed gestational curves are a useful tool for assessing the intrauterine growth of births in high altitude areas of Saudi Arabia.

Saudi Med J 2005; Vol. 26 (11): 1723-1727

A variety of factors influenced fetal growth racial, social and economic among others, as well as specific medical conditions that may present or develop during pregnancy.[1] Hence, it is not surprising that mean birth weight shows a degree of variation from country to country and from area to area within the same country.[2] Intrauterine growth retardation (IUGR) implies inhibited intrauterine growth (IUG) and unattained fetal growth potential. Intrauterine growth retardation is a clinical term with the diagnosis usually based on small size for gestational age at birth (SGA). However, IUGR is not equal to SGA. Women seem programmed for having births of a certain size; some SGA babies are not IUGR, and some larger babies are still IUGR. A large number of growth charts, based on populations with different inclusion criteria, and constructed

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Received 31st May 2005. Accepted for publication in final form 11th September 2005.

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according to different methods, have been developed and used; this complicates or invalidates comparisons between studies and populations. Growth charts (in percentiles) must be standardized and population-specific. In addition, the charts, when we use as diagnostic tools, should allow controlling for factors such as gender and parity and, if possible, include previous reproduction experience.[3,4] The region of Aseer, with a population of 1,200,000, covers more than 80,000 km^2 in Southwestern Saudi Arabia. Sharing its southern border with Yemen, the area extends from the high Aseer mountains almost 3200 m above sea level down to the Red Sea. Abha, the capital city of the region (population 122,000), is in the Aseer mountains which is 3133 m above sea level; it has the lowest mean annual temperature of any of the southern urban areas and has a high annual rainfall with rain falling mainly in winter and spring. Neonates of Southwestern Saudi Arabia were significantly lighter and shorter than those of the reference population, as well as neonates in other areas of the Kingdom, with prevalent low birth weight (LBW) especially in high altitude area, possibly due to IUGR of secondary type.[5] The aim of the present study was to construct intrauterine percentile growth curves for body weight, length and head circumference for assessing the intrauterine growth of births born in high altitude areas of Saudi Arabia.

Methods. This is a cross-sectional study of all births from Abha General Hospital Southwestern of Saudi Arabia over a 6-year period from 1999 to 2004. A total of 6035 Saudi births (2979 males and 3056 females) were included in the present study after eliminating babies that were stillbirths, twins or those with major congenital anomalies. The gestational age of the infants ranged from 26-40 weeks. This was estimated using Naegele's rule based on the first bleeding day of the last menstrual period. When the date was uncertain, estimations were made by an ultrasound scan during pregnancy and later followed by Dubowitz scoring[6] of the baby. The anthropometric measurements included birthweight, crown-heel length and head circumference. The birthweight of the baby was measured without clothes to the nearest 10 gms on an infant's beam balance, which was calibrated daily for accuracy. Measurements were taken within a few hours of birth. An infant's board was used to determine the crown-heel length with the neonate lying flat and legs extended. The head circumference (occipitofrontal) was measured to the nearest 5 mm with an inelastic tape. Babies of LBW were identified. Low birth weight was defined as <2,500 grams at birth.[7] A group of nurses was allocated and trained to conduct the anthropometric measurements. Batches of nurses participated in the field data collection during the study period. Accuracy of measurements was assured by practical training sessions for nurses by repeated spot checks of normal and abnormal anthropometric values. Factors affecting apparatus reliability were reduced by obtaining the infant's beam balance, and the infant board was checked and calibrated regularly. Field data collection were supervised to ensure that the procedures were followed adequately. Daily meetings were held between the nurses and field supervisors and discussed the field activities to solve problems, to check the accuracy and to emphasize the standardization of procedures.

Statistical method. We calculated the 10th, 25th, 50th, 75th, and 90th percentiles for weight, length and head circumference against the periods of gestation. Also, we calculated the mean weight and mean ± 2SD. The curves of best fit for weight, length and head circumference measurements at different weeks of gestation were determined by polynomial regression of the following general form to construct the clinical curves: $Y = a + bX + cX^2$

Such an expression uses increasing power of X, the independent variable, a different regression coefficient preceding each power of X. The independent variable (X) = weeks of gestation. The dependent variable (Y) = weight, length or head circumference measurements. Smoothed values of 10th, 25th, 50th, 75th and 90th percentiles for weight, length and head circumference were calculated accordingly against the periods of gestation. Also, smoothed values of mean, and mean ± 2SD for these anthropometric measures were calculated. Clinical intrauterine growth curves for weight, length and head circumference were constructed based on all these smoothed values.

All these statistical analyses were performed using the Statistical Package for Social Sciences software program (version 9.0).

Results. **Figure 1** represents the smoothed values of weight and length percentiles at each gestational period. That is, these figures represent the clinical curves of these cut-off points. Polynomial regression models from which those curves were constructed are shown in **Table 1.**

Figure 2 represents the smoothed values of the mean and 2 standard deviations below and above the mean weight and length at each gestational period. That is, these figures represent the clinical curves of these cut-off points. Polynomial regression models from which those curves were constructed are shown in **Table 1**.

Table 1 - Polynomial regression models from which intrauterine growth curves were constructed.

Percentiles and mean and mean ± 2SD	Smoothed weight percentiles and mean and mean ± 2SD by the period of gestation	Smoothed length percentiles and mean and mean ± 2SD by the period of gestation	Smoothed head circumference percentiles and mean and mean ± 2SD by the period of gestation
10th	Y= -10964.68 + 628.76X - 7.68X^2	Y= -41.66 + 3.97X - 0.0456X^2	Y= -33.97 + 2.94X - 0.0317X^2
25th	Y= -10161.62 + 570.73X - 6.57X^2	Y= -8.06 + 1.89X - 0.0127X^2	Y= -42.20 + 3.43X - 0.0381X^2
50th	Y= -6780.11+ 347.80X - 2.74X^2	Y= -0.005 + 1.47X - 0.0067X^2	Y= -32.52 + 2.95X - 0.03189X^2
75th	Y= -5340.85+241.25X - 0.69X^2	Y= 1.07 + 1.41X - 0.0046X^2	Y= -49.48 + 4.06X - 0.04876X^2
90th	Y= 4990.94 - 414.41X + 9.68X^2	Y= 1.30 + 1.41X - 0.0040X^2	Y= 37.95 + 3.44X - 0.04006X^2
Mean	Y= -6212.84 + 309.74X - 2.1327X^2	Y= -8.60 + 1.99X - 0.01435X^2	Y= -40.78 + 3.48X - 0.03995X^2
Mean - 2SD	Y= -13305 + 785.17X - 10.4130X^2	Y= -30.30 + 3.27 - 0.03600X^2	Y= -42.50 + 3.40X - 0.0384X^2
Mean + 2SD	Y= 881.56 - 165.78X + 6.1490X^2	Y= 13.12 + 0.70X + 0.00731X^2	Y= -39.18 + 3.56X - 0.0416X^2

Y - dependent variable = weight, length or head circumference measurements, X - independent variable = weeks of gestation

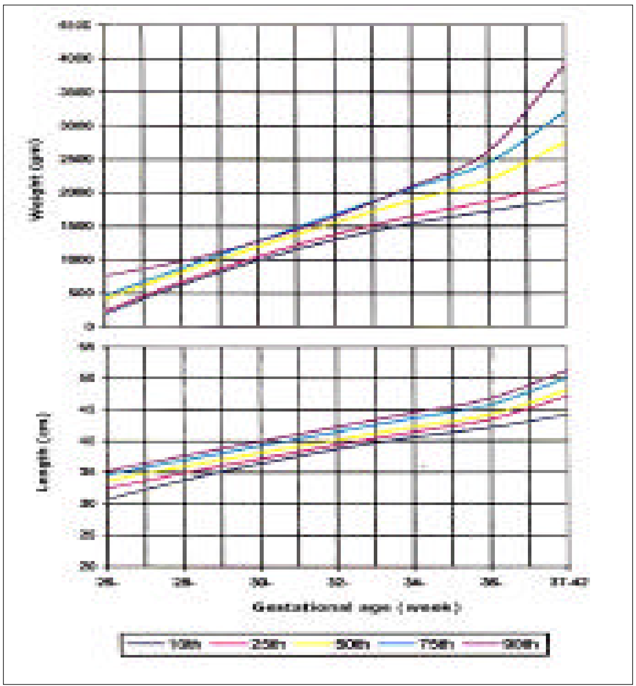

Figure 1 - Smoothed weight and length percentiles by the period of gestation.

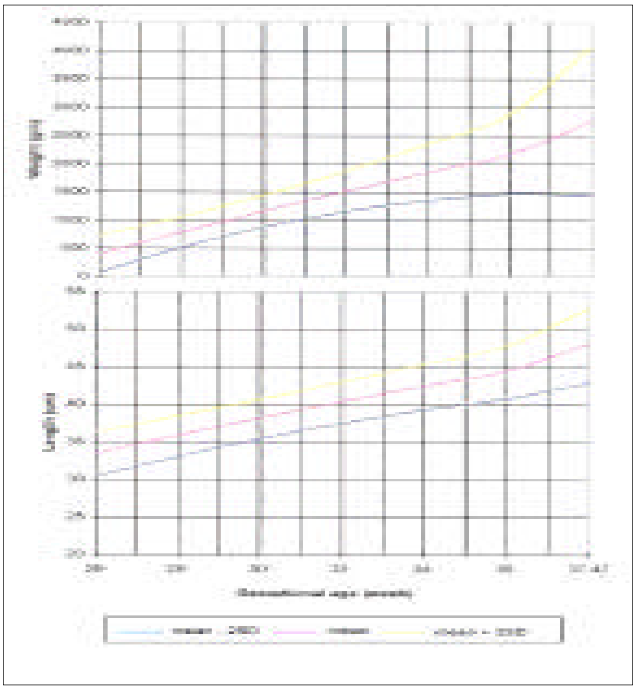

Figure 2 - Smoothed mean weight and length and there mean ± 2SD by the period of gestation.

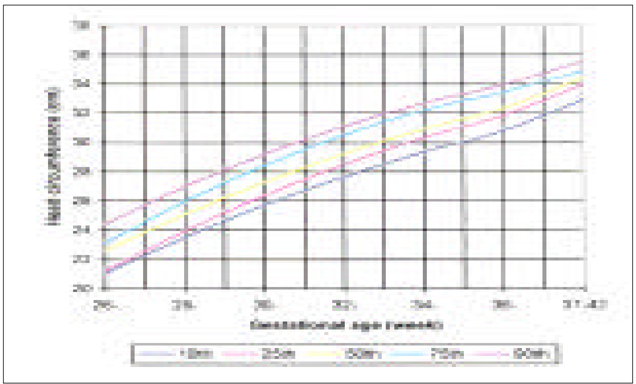

Figure 3 - Smoothed head circumference percentiles by the period of gestation.

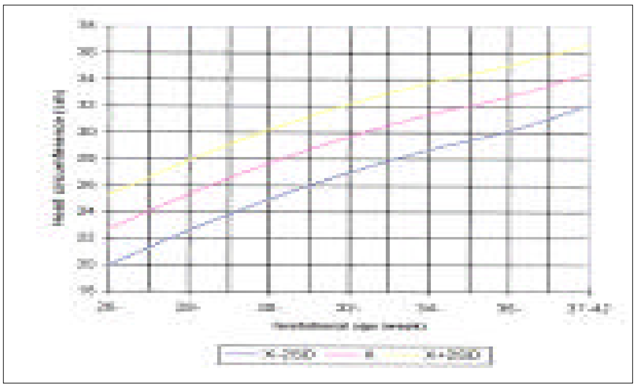

Figure 4 - Smoothed mean head circumference and mean ± 2SD by the period of gestation.

Figures 3 and 4 represent the smoothed values of both the percentiles and the mean and 2 standard deviations below and above the mean head circumference at each gestational period. That is, these figures represent the clinical curves of these cut-off points. Polynomial regression models from which those curves were constructed are shown in **Table 1**.

Discussion. We still usually assessed intrauterine growth when the fetus is born or expelled. The size of the newborn relates to the duration of the pregnancy, and we considered relatively small size for gestational age as a reflection of intrauterine growth inhibition. Daily et al[3] and Manzar et al[4] considered growth curves as an usual tool for assessing the growth of the fetus in utero. Growth charts (in percentiles) need to be standardized and population-specific.[3,4] There is no standard definition of IUGR and we clinically diagnosed the condition. Modern technology, however, has made it possible to monitor intra-uterine growth, and ultrasonography could provide a basis for operational definitions of variations in intrauterine growth; however, such definitions, have not yet been agreed upon. In the present study, Bernstein et al[8] carried out ultrasonography for all cases where the exact date of LMP is not known. They labeled LBW for gestation either 'small-for-date' or 'small-for-gestational-age' (SGA). We most commonly used the 10th weight centile cut-off for defining SGA births. This implies that the 10% of babies with the lowest birth weight for gestation are considered as SGA. Or, where 2SD below the mean weight for gestation is used as the lower cut-off, the 2.5% of births with the lowest weight, are considered SGA. In the present study, Daily et al[3] and Manzar et al[4] constructed both percentile as well as standard deviation growth charts. Ideally, an international population standard is considered to exist for each geographic region, and these standards should be well defined and documented allowing for comparisons. Comparison of the values obtained in this study shows that the median (50th percentile) values for weight and length of infants of the present study are lower than those of published charts[9,10] in all gestational periods. However, for head circumference, the evident appeared only before 32 weeks of gestation. Following that, the median values of head circumference are nearly comparable. This difference may indicate ethnic variations. However, the results of a previous study reported significantly lower birth parameters in the high altitude area than in the low altitude area of the same country, Saudi Arabia. Al-Shehri et al[5] attributed such findings to the growth-retarding effects of high altitude hypoxia. Previous studies also attributed such effects to the negative energy balance and the interference with protein metabolism, leading to a significant weight loss.[11-15] However, further studies need to compare fetal growth charts of low and high altitude areas. It was interesting to see that although weight and length of neonates at the high-altitude area of the present study, both were significantly lower than those of published charts, yet this was not the case for head circumference, especially before the 32nd week of gestation. Fetal malnutrition should not affect the neonatal occipitofrontal circumference, since there is relative sparing of the fetal head.[16] This is in agreement with the previous study known as secondary or asymmetrical IUGR.[5] It is a form of growth slowing or cessation occurring in a fetus with normal growth potential. This is the most common type seen in clinical practice and usually occurs in the later part of pregnancy (32 weeks), when the fetus is at the stage of maximal fat accumulation. The baby appears long and scrawling**.** Weight will be affected more than length and ponderal index is abnormal. This type of IUGR is due to impaired utero placental function or nutritional deficiency. The infants show sparing of head growth whereas weight and organ growth are more severely affected. However, these cases have a better potential for future catch up growth.

In conclusion, this method of determining intrauterine growth profiles is not without criticism. The data are cross-sectional, and assuming the result growth curves are the same as those which the fetus would describe where intrauterine development to have continued normally until term. In fact, delivery before term is an unphysiological occurrence so that these infants could be considered unsuitable material for the construction of growth standards. Keeping in mind the limitations of interpreting intrauterine growth curves, nonetheless, in view of the inaccessibility of the fetus for study, there is no better method at the present time of drawing intra-uterine curves of weight, length and head circum-ference. For this reason, future studies will continuously use the described method to obtained growth curves.

Acknowledgment. The authors would like to acknowledge, with gratitude, the assistance of the Doctors and Nursing staff of the Neonatal Intensive Care Unit of Abha General Hospital, Abha, Kingdom of Saudi Arabia for their invaluable cooperation. Our special gratitude goes to Dr. Hind A. Musa for her help.

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