original article

Sonographic fetal weight estimation using femoral length: Honarvar equation

Raziah Dehghani Firoozabadi,* Nasrin Ghasemi,† Mehdi Dehghani Firoozabadi‡

From the *Obestetric and Gynecology Department, Infertility and Treatment Centre, Yazd Shahid Sadoughi Medical Sciences University, †Medical Genetics Department, Medical School, Yazd Shahid Sadoughi Medical Sciences University, ‡Iran Medical University, Yazd, Iran

Correspondence and reprint requests: Nasrin Ghasemi, Medical Genetics, Yazd Shahid Sadoughi Medical Sciences University, Infertility Research and Treatment Centre, Boali St, Safayeh Yazd 8916895473 Islamic Republic of Iran, T: +98 351 8252266 F: +98 351 8247087 n479g@yahoo.co.uk Accepted for publication December 2006

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BACKGROUND: Fetal growth is the result of interactions between various factors and can be estimated by ultrasonic measurements. Fetal femur length is a scale for estimating the fetal weight in individual races because fetal growth patterns differ among different races.

SUBJECTS AND METHODS: This was a prospective study involving 500 pregnant women at 36 weeks of gestational age. Real-time sonography was done to measure the femoral length and then the weight of the fetus was estimated by the Honarvar 2 equation. The correlation between estimated fetal weight (EFW) and real weight was tested by Pearson correlation coefficient and relationships with the age and BMI of the mother, the sex of the neonate and parity were tested by multiple regression.

RESULTS: EFW by the Honarvar 2 equation correlated significantly with the actual birthweight. Therefore, this equation is valid for fetal weight estimation. It also does not depend on the age and BMI of the mother, sex of neonate, or parity.

CONCLUSION: Ethnicity potentially plays an important role in the fetal weight estimation. The Honarvar formula produced the best estimate of the actual birthweight for Iranian fetuses, and its use is recommended.

The birthweight is an important factor in the outcome of a pregnancy. It is well known that prenatal morbidity and mortality increase in abnormal birthweight range fetuses. They also have poor developmental outcomes.[1] In addition, marked birth traumas have been increased in macrosomic infants.[2] The accurate antenatal measurement of fetal weight is very important. It gives useful information for fetal growth assessment, information that could help to decide the time of delivery, the need for specific obstetrical intervention and delivery at an equipped center.[3]

At present, two-dimensional ultrasonography is the most widely accepted method to estimate fetal weight. This method has been used for more than three decades, and is the most extensively studied modality of birthweight estimation.[4] It has good validity in clinical applications.[5]

Most of the fetal weight estimation models have been derived from data from Western populations.[6-9] Ethnicity and secular changes have been known to affect birth weight.[10-12] Thus, birthweight models derived from one ethnic population and applied in another locality, without the validation of clinical applicability, might result in wrong estimations.[13] It has been demonstrated that birthweight standards change over time, and therefore, it is necessary to regularly revalidate a model in a population. Honarvar published a model for ultrasonic fetal weight estimation in Iran. He believes that fetal femoral length illustrates fetal growth accurately.[14] Femoral length was used in a few other studies to determine fetal growth, which was a significant marker.[15-17] The aim of this study was to test the validity of the Honarvar equation using ultrasonic femoral length measurement of Iranian fetuses collected in a Yazd gynecology and obstetric clinic.

SUBJECTS AND METHODS

This was a prospective observational study, conducted in an obstetric clinic, Shahid Sadoughi Hospital, Yazd, Iran. Five hundred pregnant Iranian women were examined at 36 weeks of pregnancy by ultrasonography. The subjects were invited to participate in this study when they attended the antenatal ward. The inclusion criteria were Iranian ethnic origin, singleton pregnancy, 36-weeks pregnancy and regular menstrual cycles before pregnancy. Exclusion criteria were past history of

diabetes mellitus, chronic hypertension and previous stillbirth or fetal anomaly, and use of oral contraceptive pills during the last 3 months before pregnancy. Pregnancies that were complicated by congenital abnormalities were excluded from the validation study. Written consent was obtained from the participants and the study protocol was approved by the research committee at Yazd Shahid Sadoughi Medical Sciences University. The ultrasound examinations were specifically arranged for this study and fetal biometric measurements were performed on all subjects according to the Honarvar formula. Fetal weight was estimated according to femoral length (FL) at 36 weeks of pregnancy and compared to the weight of neonates immediately after birth. The neonates were weighed using a digital baby scale with a standard deviation of ±10 g. FL was measured by the O'Brien method[18] (from the proximal to the distal metaphysic), three times and the mean of the measured length taken as the FL. All measurements were done by one gynecologist using real time linear-array and convex sonography with a transducer with 3.5 MHz power.

The Honarvar 2 equation was used to estimate fetal weight according to:

$$EFW\ (kg) = 0.042\ FL^2(cm) + 0.32\ FL - 1.36$$
$$SD \sim \pm 235g$$

The weights of all neonates were measured immediately after birth and compared with the EFW.

The correlation was tested between the EFW and actual weight according to the sex of the neonate, parity, mother's age and body mass index (BMI) by the Pearson correlation coefficient. The mean estimated and actual fetal weights were compared in boys and girls and they were tested by Student's t test. In addition, both mean weights were compared according to parity (0, 1, 2, 3, ≥ 4), mother's age (15-25, 26-35, ≥36 years) and mother's BMI (≤18.5, 18.51-24.9, 25-29.9, ≥30). Significant relationships were tested by Student's t test. The effect of the sex of the fetus, parity, mother's age and BMI on the predicted fetus weight was tested by multiple linear regression using stepwise technique.

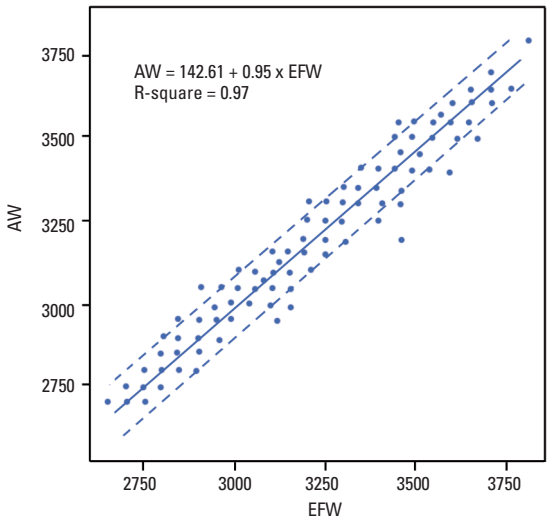

Figure 1. Correlation between estimated fetal weight (EFW) and actual birthweight (AW) (linear regression with 95% prediction interval).

RESULTS

The weight of the fetus was estimated by the Honarvar 2 formula according to FL and then compared with the weight immediately after birth. The mean (±SD) estimated weight was 3188.17 (±414.88) g and the mean weight measured immediately after birth was 3147.62 (±433) g. Estimated fetal weight by the Honarvar 2 equation significantly correlated with actual weight (P=0.001, r=0.983). Therefore this equation is valid for EFW (Figure 1).

The mean of the EFW and actual weight was compared by the gender of fetuses (Table 1) and there were no significant differences between EFW and the actual weight in male and female fetuses, indicating that sex of the fetus has no effect on EFW using the Honarvar equation. In addition, the mean of the EFW and actual weight of the neonate according to parity showed that differences were not significant, which means weight estimated using this formula are not affected by parity (Table 2). The mean of the EFW and actual weight was compared according to the age (Table 3) and BMI of mothers. The mean age was 24 years (15 to 45 years). There were no significant differences between the estimated and actual weights according to age and BMI of mothers, meaning that the age and BMI of the mother have no effect on the estimated weight.

To examine the effect of the sex of fetuses, parity, mother's age and BMI on the predicted fetus weight, a multiple linear regression using stepwise technique was applied. No significant colinearity was found between independent variables in the model so the predictive ability of the estimated fetus weight on the actual fetus weight is independent of other factors. A multiple regression coefficient of 0.95 was obtained in the model. This significant linear association was confirmed by the related scatterplot as seen Figure 1 (P=0.001).

Table 1. Estimated fetal weight and actual birthweight by fetus gender.

Sex	N	Percentage	Mean (±SD) estimated weight	Mean (±SD) actual birth weight
Boy	253	50.6	3190.6±463	3160.8±421.4
Girl	247	49.4	3181.6±400.5	3134.1±408.9

No signficant differences in estimated fetal weight or actual birthweight.

Table 2. Estimated fetal weight and actual birthweight by parity.

Parity	N	Percentage	Mean (±SD) estimated weight	Mean (±SD) actual birth weight
0	158	31.6	3201.4±381.4	3192.8±408.2
1	134	26.8	3141.1±444.9	3066.8±486.6
2	104	20.8	3184.5±438.4	3158.1±41.2
3 ≤	104	20.8	3022.8±399.2	3172.7±398.7
Total	**500**	**100**	**3188.2±414.9**	**3147.6±433.1**

No signficant differences in estimated fetal weight or actual birthweight.

Table 3. Estimated fetal weight and actual birthweight by mother's age.

Mother's age	N	Percentage	Mean (±SD) estimated weight	Mean (±SD) actual birth weight
15 – 24	229	45.8	3185.6±418.8	3148.5±464.3
25 – 29	129	25.8	3196.7±433.4	3166.2±438.2
30 – 45	142	28.4	3177.4±393.5	3122.3±374.2
Sum	**500**	**100**	**3188.2±414.9**	**3147.6±433**

No signficant differences in estimated fetal weight or actual birthweight.

DISCUSSION

Estimation of fetal birthweight gives useful information about fetal growth, which helps determine the viability of the fetus or its chances of survival as well as the time and type of delivery. The few models used for the estimation of the fetal weight depend on ethnicity and regional differences in growth patterns.[10-12] However, Raman et al believed that ethnicity did not affect growth pattern.[19] Honarvar established a model for Iranian ethnicity, which we validated in the present study. The weight estimated by this equation was significantly near to the actual weight. This model is simple and only requires the FL of the fetus, while others need more than one measure. In addition, FL has been shown to be as accurate as biparietal diameter in estimating gestational age.[21-22] The normal ultrasonic fetal femur length curve of one population is unsuitable and inappropriate for another population.[14] Racial differences are due to genetic factors differences in the environment or social conditions are not relevant.[23]

The results of this study showed that there is no significant relationship between the sex of the neonate and estimated fetal weight. No effect of gender was noted on the growth of FL, therefore, this formula is not affected by the gender of the neonate and determination of the sex of the neonate is not important in assessing uteral growth.[19-20]

No differences in EFW were noted by parity of the mother, which is confirmed by other studies.[19,24,25] However, parity affected the limb length of Indian fetuses. The fetuses of multiparas have limb lengths significantly smaller than the fetuses of primiparas, but the rate of growth was not affected.[26] Neonates of Malaysian, Chinese and Indian multiparas mothers were heavier than those of primiparas mothers.[27]

The age or BMI of mothers showed no effects on EFW, which were tested by others and were not associated with the accuracy of the EFW.[24,25,28] Maternal factors do not alter the accuracy of sonographic fetal weight, so fetal weight prediction provides equally ac-

curate and valid guidelines for determining management decisions in women regardless of maternal factors.[29,30] However, other studies showed that younger and older mothers have lighter babies than mothers in the middle, with an optimal age of 28 years.[23]

In conclusion, this study shows that Honarvar models produced the best estimate of the actual birthweight in Iranian fetuses, which is accurate and simple and only based on femoral length. Knowledge of other variables is unnecessary to estimate fetal weight because there were no significant relationships between EFW and mother's age and BMI, parity and sex of the fetuses. Honarvar et al believes that the EFW according to this model is not accurate for other ethnic populations. Hadlock's equation estimates Iranian neonate weight lower than actual weight while estimated weight according to Ott's protocol is higher than actual weight.[31] So any given ethnic community needs a specific protocol for themselves and ethnicity potentially plays an important role in the fetal body weight estimation, which provides a valid guide for determining management despite maternal factors.

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