Role of Fetal Length in the Prediction of Fetal Weight

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Objectives—The purpose of this study was to compare the accuracy of routine fetal biometric indices in the prediction of fetal length and to determine whether more accurate sonographic measures of fetal length can improve the accuracy of fetal weight estimation.

Methods—The accuracy of the common sonographic fetal biometric indices for predicting fetal length was determined using 3689 sonographic weight estimations performed within 3 days before delivery. The fetal length at the time of the sonographic examination was assumed to be equal to the neonatal length, which is routinely measured within 24 hours of delivery. Two new regression models for fetal weight estimation, one with and one without fetal length as an independent variable, were generated to determine the potential contribution of more accurate predictors of fetal length to the accuracy of fetal weight estimation.

Results—Abdominal circumference was a significantly more accurate predictor of fetal length ($r = 0.732$) compared with femur length ($r = 0.712$), biparietal diameter ($r = 0.644$), and head circumference ($r = 0.661$; $P < .05$), although each of these biometric indices explained only about 50% of the variance in fetal length ($R^2 = 0.423–0.548$). The addition of fetal length as an independent variable to a birth weight prediction model significantly improved the model’s correlation with birth weight ($r = 0.917$ versus $0.903$; $P = .006$), systematic error (0.2% versus 0.6%; $P < .001$), random error (6.7% versus 7.5%; $P < .001$), mean absolute percent error, and the proportion of estimations within 5% and 10% of birth weight.

Conclusions—The correlation between routine biometric indices and fetal length is limited. Identification of new fetal sonographic biometric indices with greater predictive accuracy for fetal length may improve the accuracy of fetal weight estimation.

Key Words—estimation; fetal; height; length; weight

Accurate estimation of fetal weight has an important role in routine antenatal care and in the detection of fetal growth abnormalities.\textsuperscript{1,2} Sonographic estimation of fetal weight is based on regression models that incorporate various combinations of sonographically measured fetal biometric indices, the most common of which are abdominal circumference, femur length, biparietal diameter, and head circumference.

It has been previously suggested that accurate estimation of fetal length (also known as fetal height or fetal stature) may improve the accuracy of fetal weight estimation\textsuperscript{3–5} as well as assist in the detection of placenta-related fetal growth restriction.\textsuperscript{6–8} Moreover, it has been reported that the sonographically measured femur length is strongly correlated with the fetal length.\textsuperscript{9–11}
for the incorporation of the femur length into sonographic models for fetal weight estimation.

However, some questions remain regarding the role of fetal length in the prediction of fetal weight: (1) there is a substantial variation between different studies with respect to the type and degree of correlation between femur length and fetal length, which might be attributed to limited sample sizes, racial differences in study populations, and large intervals between sonographic estimation and delivery; (2) the predictive accuracy of femur length for fetal length is still limited, and it is unclear whether other sonographic fetal biometric indices can provide more accurate estimations of fetal length; and (3) there are only limited data regarding the potential contribution of more accurate sonographic predictors of fetal length to the accuracy of sonographic models for fetal weight estimation.

The aim of this study was to compare the accuracy of the various fetal biometric indices in the prediction fetal length and to determine whether the incorporation of more accurate sonographic predictors of fetal length can improve the accuracy of sonographic models for fetal weight estimation. In this study, the fetal length at the time of the sonographic examination (performed within 3 days before delivery) was assumed to be equal to the neonatal length, which was routinely measured within 24 hours of delivery.

Materials and Methods

Data Collection
A retrospective cohort study design was used. Data were collected from a comprehensive database of sonographic examinations in a single tertiary university-affiliated medical center. Routine sonographic evaluations include the standard fetal biometric measurements (abdominal circumference, femur length, biparietal diameter, and head circumference), and the findings are saved directly to the computerized database. Antenatal data, gestational age at delivery, fetal sex, actual birth weight, and neonatal length were obtained from the hospital’s perinatal database. The study was approved by the local Institutional Review Board.

Study Population
The database was searched for all sonographic fetal weight estimations performed from 2002 to 2008 in an unselected population. Inclusion criteria for the study were live-birth singleton pregnancy, birth gestational age of greater than 34 weeks, fetal weight estimation performed within 3 days before delivery, and absence of fetal malformations or hydrops. Only women who gave birth in our center and for whom neonatal length measurement was available were included. Pregnancies complicated by gestational or pregestational diabetes or fetal growth restriction (birth weight <10th percentile), cases in which not all 4 biometric indices were recorded, cases for which neonatal length was not available, and women who did not give birth in our center were excluded from the study.

Accuracy of the Biometric Indices in Predicting Fetal Length
In this study, the fetal length at the time of the sonographic examination (performed within 3 days before delivery) was assumed to be equal to the neonatal length, which is routinely measured within 24 hours of delivery. The correlation of each of the biometric indices (abdominal circumference, biparietal diameter, head circumference, and femur length) with fetal length was determined using Pearson correlation coefficient analysis on the entire study group.

In addition, after determining the optimal type of association between each of the individual biometric indices and fetal length using the curve estimation algorithm, a regression model for the prediction of fetal length was generated for each of the individual biometric indices. For the purpose of generation and evaluation of these models, the study population was randomly divided into two distinct groups of similar size. The first group was used to generate the models (model generation group), and the second group was used to evaluate the accuracy of these models (model evaluation group). The predictive accuracy of each of the models was compared using the following measures of accuracy: (1) systematic error (mean of [estimated fetal weight – birth weight] / birth weight × 100), which reflects the systematic deviation of a model from actual fetal length, expressed as a percentage of the actual fetal length; (2) random error (standard deviation of the systematic error × 100), which is a measure of precision (rather than accuracy) that reflects the random (or nonsystematic) component of the prediction error; and (3) mean absolute percent error (mean of absolute [estimated fetal weight – birth weight] / birth weight × 100), which reflects the unsigned deviation of a model from the actual fetal length, expressed as a percentage of the actual fetal length.
two newly developed sonographic models for fetal weight estimation, one with and one without fetal length (which was assumed to be equal to neonatal length, as described above) as an independent variable. For the purpose of generation and evaluation of these new sonographic models, we used the same two subgroups defined above: the model generation group was used to generate the new sonographic models, and the model evaluation group was used to evaluate the accuracy of these models.

Stepwise multivariate linear regression analysis was used to develop the new sonographic models. Actual birth weight was defined as the dependent variable, whereas the independent variables included the routine biometric indices (abdominal circumference, femur length, biparietal diameter, and head circumference), the products of these indices (abdominal circumference × femur length, abdominal circumference × biparietal diameter, abdominal circumference × head circumference, femur length × biparietal diameter, and femur length × head circumference), as well as additional transformations of these indices, including $X^2$, $X^3$, $X^{1/2}$, $X^{1/3}$, log$_{10}$X, lnX, $e^X$, and $10^X$ (X representing each of the biometric indices). One of the two models also included fetal length and transformation of fetal length (the same transformation used for the biometric indices) as the independent variables. A forward selection procedure was used to obtain the best fit model. The cutoff value for selection or removal of covariates was $P = .05$.

The two new models were compared to each other using the following measures of accuracy: (1) correlation with the actual birth weight (using the Pearson correlation coefficient); (2) systematic error, as described above; (3) random error, as described above; (4) mean absolute percent error, as described above; and (5) fraction of estimates within 5% and 10% of the actual birth weight.

** Definitions **

Gestational age at the time of examination is recorded in the database along with the details of the sonographic examination and is calculated on the basis of the last menstrual period. When first-trimester sonography was available, the last menstrual period was corrected on the basis of the discrepancy between the calculated last menstrual period (based on the crown-rump length reference tables of Hadlock et al$^{10}$) and the reported last menstrual period exceeded 7 days, according to the recommendations of the American College of Obstetricians and Gynecologists.$^{11}$ The gestational age at the time of examination was further verified by comparing the interval (in days) between the sonographic examination date and the delivery date with the interval between the gestational age at the time of the examination and the gestational age at delivery (the latter was available from the perinatal database). Because these intervals are expected to be identical (considering that the gestational age in both cases should have been calculated using the same last menstrual period), cases in which the difference between these intervals was greater than 1 day were excluded.

All sonographic fetal weight estimations were performed in our ultrasound unit. Weight estimations were performed by senior physicians who specialized in sonography or by experienced sonographers. In the latter case, the examination was reviewed and confirmed by a senior physician.

The biparietal diameter was measured from the proximal echo of the fetal skull to the proximal edge of the deep border (outer-inner) at the level of the cavum septum pellucidum. The head circumference was measured as an ellipse around the perimeter of fetal skull.$^{12}$ The abdominal circumference was measured in the transverse plane of the fetal abdomen at the level of the umbilical vein in the anterior third and the stomach bubble in the same plane; measurements were taken around the perimeter.$^{13}$ The femur length was measured in a view where the full femoral diaphysis was seen and was taken from one end of the diaphysis to the other, not including the distal femoral epiphysis.$^{14}$

Neonatal length (crown-heel length) is routinely measured by a trained pediatrician in the nursery within 24 hours after delivery. The neonate is placed supine on a firm flat surface to which a fixed ruler is attached; the lower extremities are extended; and the length from the crown of the head to the planter surface of the feet is recorded.

**Statistical Analysis**

Data analysis was performed with SPSS version 15.0 software (SPSS Inc, Chicago, IL). The correlations of the biometric indices with fetal length were compared to each other using the Fisher $z$ transformation. The accuracy of the regression models for the prediction of fetal length was compared using the following statistical tests: paired samples Student $t$ test for the systematic error, Pitman test for the random error, and Wilcoxon rank sum test for the mean absolute percent error. The accuracy of the regression models for the prediction of fetal weight (with or without fetal length as an independent predictor) was compared using the following statistical tests: Fisher $z$ transformation for the correlation with birth weight, paired samples Student $t$ test for the systematic error, Pitman test for the random error, Wilcoxon rank sum test for the mean
absolute percent error, and McNemar test for the fraction of estimation within 5% or 10% of birth weight. Differences were considered significant at \( P < .05 \). Bonferroni corrections were used as necessary to maintain an overall type I error rate of .05 when multiple comparisons were done.

**Results**

**Characteristics of the Study Group**

A total of 3689 fetal weight estimations met the inclusion criteria. The characteristics of the study groups are presented in Table 1. Most of the weight estimations (66%) were conducted within 24 hours from delivery. The mean neonatal length ± SD was 50.1 ± 2.3 cm. The study population was randomly divided into two distinct groups of similar size: model generation group (n = 1844), and model evaluation group (n = 1845). There were no significant differences in the characteristics of these two subgroups (Table 1).

**Accuracy of the Biometric Indices in Predicting Fetal Length**

A graphic representation of the relationship between the common biometric indices and fetal length is provided in Figure 1. The correlations of the various biometric indices with fetal length are presented in Table 2. The biometric index that was most strongly correlated with fetal length was abdominal circumference (\( r = 0.732 \)), followed by femur length (\( r = 0.712; P = .03 \) for the difference between these two correlation coefficients; Table 2). The correlations with fetal length for biparietal diameter and head circumference were similar and were much lower compared with abdominal circumference and femur length (\( r = 0.644 \) and 0.661, respectively; Table 2).

The association of the various biometric indices with fetal length was best described using cubic regression models (Table 3 and Figure 1), although these models explained only about 50% of the variance in fetal length (\( R^2 = 0.423–0.548 \); Table 3 and Figure 1). The regression model that was based on abdominal circumference was significantly more accurate in the prediction of fetal length than the models that were based on femur length, biparietal diameter, and head circumference (\( P < .001 \); Table 3).

To provide a better understanding of the reasons for which the correlation between abdominal circumference and fetal length was higher than that of femur length and fetal length, we recalculated the correlation between these biometric indices and fetal length, stratified by gestational age at the time of examination/delivery (Figure 2). The correlation between abdominal circumference and fetal length was significantly higher than that of femur length and fetal length throughout the range of gestational ages (34–42 weeks; Figure 2), suggesting that this observation is independent of gestational age.

**Contribution of Fetal Length to the Accuracy of Fetal Weight Estimation**

Considering the limited correlation between the common biometric indices and fetal length, it can be questioned whether the incorporation of more accurate predictors of fetal length to sonographic models for weight estimation would improve the accuracy of fetal weight estimation. To try to provide an answer to this question, we investigated whether the incorporation of fetal length (which was assumed to be equal to neonatal length, as described in "Materials and Methods") as an independent variable in a sonographic model for weight estimation would result in improved accuracy for fetal weight estimation. For that

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**Table 1. Demographic and Obstetric Characteristics of the Study Population**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study Group (N = 3689)</th>
<th>Model Generation Subgroup (n = 1844)</th>
<th>Model Evaluation Subgroup (n = 1845)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age, y</td>
<td>30.3 ± 5.0 (20.6–48.7)</td>
<td>30.4 ± 4.8</td>
<td>30.2 ± 5.2</td>
<td>.5</td>
</tr>
<tr>
<td>Nulliparity</td>
<td>1542 (41.8)</td>
<td>763 (41.4)</td>
<td>779 (42.2)</td>
<td>.6</td>
</tr>
<tr>
<td>Gestational age at delivery, wk</td>
<td>39.5 ± 1.7 (34–42)</td>
<td>39.3 ± 1.7</td>
<td>39.3 ± 1.7</td>
<td>.5</td>
</tr>
<tr>
<td>Time from fetal weight estimation to delivery, d</td>
<td>1.3 ± 0.9 (0–3)</td>
<td>1.3 ± 0.9</td>
<td>1.3 ± 0.9</td>
<td>.8</td>
</tr>
<tr>
<td>Male fetus</td>
<td>1934 (52.4)</td>
<td>955 (51.8)</td>
<td>979 (53.1)</td>
<td>.4</td>
</tr>
<tr>
<td>Fetal length, cm</td>
<td>50.1 ± 2.3 (41–56)</td>
<td>50.0 ± 2.4</td>
<td>50.1 ± 2.3</td>
<td>.3</td>
</tr>
<tr>
<td>Birth weight, g</td>
<td>3303 ± 573 (1638–5004)</td>
<td>3295 ± 585</td>
<td>3311 ± 561</td>
<td>.4</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD (range) and number (percent).
purpose, two new sonographic models for fetal weight estimation, one with and one without fetal length as an independent variable (in addition to the commonly used biometric indices), were generated and compared (see “Materials and Methods”; Table 4).

The sonographic model that included fetal length as an independent variable (in addition to the routine biometric indices) explained a larger proportion of the variance in birth weight compared with the regression model that did not include fetal length ($R^2 = 0.872$ versus 0.830; Table 4) and was associated with a significantly higher correlation with birth weight ($r = 0.917$ versus 0.903; $P = .006$), a significantly lower systematic error (0.2% versus 0.6%; $P < .001$), a significantly lower random error (6.7% versus 7.5%; $P < .001$), a significantly lower mean absolute percent error (5.1% versus 6.7%; $P < .001$), and significantly higher fractions of weight estimations within 5% (57.6% versus 52.8%; $P < .001$) and 10% (89.0% versus 84.5%; $P < .001$) of actual birth weight (Table 4). In addition, during the generation phase of the model that included fetal length, the product of fetal length and abdominal circumference (abdominal circumference $\times$ length) was the independent variable that was most strongly correlated with birth weight and was thus the first variable to be selected for the model by the stepwise linear regression algorithm.

**Discussion**

In this study, we sought to compare the accuracy of the various fetal biometric indices in the prediction fetal length and to determine whether more accurate sonographic predictors of fetal length can improve the accuracy of fetal weight estimation. Our study has 3 key findings: (1) the strongest predictor of fetal length is not femur length (as previously believed and as intuitively expected) but rather abdominal circumference, a finding that is independent of
gestational age; (2) the common fetal biometric indices are relatively limited in their ability to predict fetal length, explaining only approximately 50% of the variation in fetal length; and (3) more accurate predictors of fetal length are expected to significantly improve the accuracy of sonographic models for fetal weight estimation.

Considering the fact that the fetal femur is the longest bone in the fetus and that femur length has been reported to increase with fetal length,\(^5\) it is intuitively expected that femur length will be more strongly correlated with fetal length than any of the other routine biometric indices (ie, head circumference, biparietal diameter, and axial measures such as abdominal circumference). Indeed, several studies have investigated the correlation between femur length and fetal length. Hadlock et al\(^6\) compared sonographically measured femur lengths in 102 fetuses at gestational ages of 30 to 40 weeks with neonatal length measurements. The relationship between femur length and neonatal length was best described using a linear model (\(R^2 = 0.66\)). Similarly, in another study of 200 fetuses at gestational ages of 23 to 42 weeks,\(^7\) the optimal model describing the relationship between femur length and neonatal length was linear (\(R^2 = 0.81\)). In contrast, Ott\(^\text{5}\) reported that the relationship between femur length and neonatal length at gestational ages of 20 to 42 weeks was best described using a power function (\(R^2 = 0.75\)), suggesting that the fetal femur grows at a greater rate than the overall body length during the last trimester. In this study, the correlation between femur length and fetal length was weaker, and the predictive accuracy of fetal length by femur length was lower (\(R^2 = 0.51\)) than previously reported. Possible explanations for these differences include the relatively small sample sizes in previous studies,\(^5\) \(^7\) racial differences in study populations, which have been shown to affect the correlation between femur length and neonatal length,\(^9\) and differences in gestational age groups between the different studies. Importantly, in this study, the interval between the sonographic examination and the measurement of neonatal length was short (up to 4 days) compared with previous studies.

### Table 2. Correlation Between Common Sonographic Fetal Biometric Indices and Fetal Length

<table>
<thead>
<tr>
<th>Biometric Index</th>
<th>(r)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal circumference</td>
<td>0.732(^a)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Femur length</td>
<td>0.712(^a)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Head circumference</td>
<td>0.661</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Biparietal diameter</td>
<td>0.644</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

The analysis was conducted using the entire study group (\(N = 3689\)). Neonatal length (which was measured within 24 hours after delivery and thus within 4 days after the sonographic examination) was used as an accurate measure of fetal length at the time of the sonographic examination.\(^5\)

The correlation for abdominal circumference was significantly higher compared with femur length, biparietal diameter, and head circumference (\(P = .03\), \(P < .001\), \(P < .001\), respectively, Fisher z transformation).\(^5\)

The correlation for femur length was significantly higher compared with biparietal diameter and head circumference (\(P < .001\), \(P < .001\), Fisher z transformation).\(^5\)

### Table 3. Regression Models for the Prediction of Fetal Length Based on Each of the Individual Biometric Indices

<table>
<thead>
<tr>
<th>Biometric Index</th>
<th>Type of Model Associated With Best Fit</th>
<th>Model Equation</th>
<th>(R^2)</th>
<th>Systematic Error, %</th>
<th>Random Error, %</th>
<th>MAPE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal circumference</td>
<td>Cubic</td>
<td>(-2.83E-6 \times AC^3 + 0.16 \times AC + 6.61)</td>
<td>0.548</td>
<td>0.10(^a)</td>
<td>3.2(^a)</td>
<td>2.5 ± 2.0(^a)</td>
</tr>
<tr>
<td>Femur length</td>
<td>Cubic</td>
<td>(-0.000004 \times FL^3 + 1.04 \times FL - 10.58)</td>
<td>0.513</td>
<td>0.28(^a)</td>
<td>3.4(^a)</td>
<td>2.6 ± 2.0(^a)</td>
</tr>
<tr>
<td>Head circumference</td>
<td>Cubic</td>
<td>(-0.00000009 \times HC^3 + 0.41 \times HC - 51.78)</td>
<td>0.481</td>
<td>0.68</td>
<td>3.7</td>
<td>2.8 ± 2.2(^a)</td>
</tr>
<tr>
<td>Biparietal diameter</td>
<td>Cubic</td>
<td>(-0.000003 \times BPD^3 + 1.01 \times BPD - 21.69)</td>
<td>0.423</td>
<td>0.54</td>
<td>3.6</td>
<td>2.9 ± 2.2(^a)</td>
</tr>
</tbody>
</table>

Neonatal length (which was measured within 24 hours after delivery and thus within 4 days after the sonographic examination) was used as an accurate measure of fetal length at the time of the sonographic examination. For the purpose of generation and evaluation of these models, the study population was randomly divided into two distinct groups of similar size. The first group was used to generate the models (model generation group; \(n = 1844\), and the second group was used to evaluate the accuracy of these models (model evaluation group; \(n = 1845\)). AC indicates abdominal circumference; BPD, biparietal diameter; FL, femur length; HC, head circumference; and MAPE, mean absolute percent error.\(^5\)

The systematic error was significantly lower compared with models based on femur length, head circumference, and biparietal diameter (\(P = .009\), \(P < .001\), \(P < .001\), respectively, paired samples Student \(t\) test).\(^5\)

The random error was significantly lower compared with models based on femur length, head circumference, and biparietal diameter (\(P = .006\), \(P < .001\), \(P = .001\), Pitman test for correlated variance).\(^5\)

The mean absolute percent error was significantly different between the different biometric indices (\(P < .001\), Wilcoxon rank sum test).\(^5\)

The systematic error was significantly lower compared with models based on head circumference and biparietal diameter (\(P < .001\), \(P = .001\), paired samples Student \(t\) test).\(^5\)

The random error was significantly lower compared with models based on head circumference and biparietal diameter (\(P = .001\), \(P = .008\), Pitman test for correlated variance).\(^5\)
Although femur length might intuitively be expected to provide the best estimate of fetal length, other fetal biometric indices may also be associated with fetal length. Surprisingly, we were not able to identify studies that investigated the relationship between neonatal length and biometric indices other than femur length. In this study, we found that abdominal circumference, an axial fetal measurement, was the biometric index that was most strongly correlated with fetal length and was a significantly more accurate predictor of fetal length than was femur length. The reason for this apparently counterintuitive observation is unclear. One theoretical explanation for this finding is that the relative growth of the femur length and fetal length changes with gestational age to a greater degree than does the relative growth of the abdominal circumference and fetal length, thus leading to an overall weaker correlation between femur length and fetal length. However, the fact that the stronger correlation of abdominal circumference and fetal length (compared with femur length and fetal length) was independent of gestational age and persisted throughout the range of gestational age disputes this hypothesis.

Another question of interest, considering the limited predictive accuracy of fetal length by the common biometric indices, is whether more accurate predictors of fetal length can improve the accuracy of sonographic models for fetal weight estimation. The volumetric approach to fetal weight estimation and the fact that the abdominal circumference × length variable was the independent variable that was most strongly correlated with birth weight and was the first variable to be selected for the model by the stepwise linear regression algorithm provide some support to this hypothesis.

Although it has been previously shown that incorporation of femur length (as a measure correlated with fetal length) into a regression model improves the accuracy of fetal weight estimation, we were not able to identify pre-

Table 4. Regression Models for the Prediction of Birth Weight: Effect of Adding Fetal Length to the Models

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Model Equation</th>
<th>R²</th>
<th>Systematic Error, %</th>
<th>Random Error, %</th>
<th>MAPE, %</th>
<th>EFW within ±5% of BW, %</th>
<th>EFW within ±10% of BW, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without fetal length</td>
<td>5.49 × HC + 1.56 × AC + 23.80 × FL + 0.05 × AC² + 0.004 × BPD – 0.30</td>
<td>0.830</td>
<td>0.903</td>
<td>0.6</td>
<td>75</td>
<td>6.7 ± 4.8</td>
<td>52.8</td>
</tr>
<tr>
<td>With fetal length</td>
<td>3.49 × HC – 3.56 × AC + 72.64 × FL – 197.49 × length + 0.06 × AC² + 1.44 × BPD × length – 0.18 × AC × BPD + 0.019 × length³ – 0.18 × AC × length + 144706</td>
<td>0.872</td>
<td>0.917</td>
<td>0.2</td>
<td>6.7</td>
<td>5.1 ± 4.4</td>
<td>57.6</td>
</tr>
</tbody>
</table>

Neonatal length (which was measured within 24 hours after delivery and thus within 4 days after the sonographic examination) was used as an accurate measure of fetal length at the time of the sonographic examination. For the purpose of generation and evaluation of these models, the study population was randomly divided into two distinct groups of similar size. The first group was used to generate the models (model generation group; n = 1844), and the second group was used to evaluate the accuracy of these models (model evaluation group; n = 1845). AC indicates abdominal circumference; BPD, biparietal diameter; BW, birth weight; EFW, estimated fetal weight; FL, femur length; HC, head circumference; and MAPE, mean absolute percent error.

²The correlation was significantly higher compared with the model not including neonatal length (P = .006, Fisher z transformation).
³The systematic error was significantly lower compared with the model not including neonatal length (P < .001, paired samples Student t test).
⁴The random error was significantly lower compared with the model not including neonatal length (P < .001, Pitman test for correlated variance).
⁵The mean absolute percent error was significantly lower compared with the model not including neonatal length (P < .001, Wilcoxon rank sum test).
⁶Proportions were significantly higher compared with the model not including neonatal length (P < .001, McNemar test).
vious studies that investigated the potential contribution of neonatal length (which provides the best estimation of fetal length when the sonographic examination is performed in close proximity to delivery, as was the case in this study) to the accuracy of a given sonographic model in the prediction of fetal weight. In this study, we have clearly shown that such an optimal estimation of fetal length can substantially improve the accuracy of fetal weight estimation. This finding provides a rationale for the prospective identification and development of new fetal biometric indices that will provide a more accurate estimation of fetal height than do the common biometric indices (ie, abdominal circumference, femur length, biparietal diameter, and head circumference).

Although our study was limited by its retrospective design, it represents the largest study published to date concerning the association of fetal biometric indices with fetal length using a cohort of weight estimation performed within 3 days before delivery in a single center. In addition, to our knowledge, no previously reported study used neonatal length as the optimal estimate of fetal length at the time of sonographic examination and investigated the potential contribution of more accurate predictors of fetal length to the accuracy of fetal weight estimation.

In conclusion, in contrast to the common opinion, femur length does not appear to be the optimal predictor of fetal length. In addition, the accuracy of the common biometric indices in the prediction of fetal length is relatively limited. The identification of new sonographic fetal biometric indices that predict fetal length with greater accuracy may contribute to the development of more accurate sonographic models for fetal weight estimation.

References