OBSTETRICS

The influence of maternal body mass index on fetal weight estimation in twin pregnancy

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OBJECTIVE: Sonographic estimated fetal weight (EFW) is important in the management of high-risk pregnancies. The possibility that increased maternal body mass index (BMI) adversely affects EFW assessments in twin pregnancies is controversial. The aim of this study was to investigate the effect of maternal BMI on the accuracy of EFW assessments in twin gestations prospectively recruited for the ESPRiT (Evaluation of Sonographic Predictors of Restricted growth in Twins) study.

STUDY DESIGN: One thousand one twin pair pregnancies were recruited. After exclusion, BMI, birthweights, and ultrasound determination of EFW (within 2 weeks of delivery) were available for 943 twin pairs. The accuracy of EFW determination was defined as the difference between EFW and actual birthweight for either twin (absolute difference and percent difference). Cells with less than 5% of the population were combined for analysis resulting in the following 3 maternal categories: (1) normal/underweight, (2) overweight, and (3) obese/extremely obese.

RESULTS: Analysis of the 3 categories revealed mean absolute variation values of 184 g (8.0%) in the normal/underweight group (n = 531), 196 g (8.5%) in the overweight group (n = 278), and 206 g (8.6%) in the obese/extremely obese group (n = 134) ($P = .028$, which was nonsignificant after adjustment for multiple testing). Regression analysis showed no linear or log-linear relationship between BMI and the accuracy of EFW (P value for absolute difference = .11, P value for percentage difference = .27).

CONCLUSION: Contrary to a commonly held clinical impression, increasing maternal BMI has no significant impact on the accuracy of EFW in twin pregnancy.

Key words: body mass index, estimated fetal weight, sonographic fetal weight, twin pregnancy

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Obesity and multiple pregnancy are 2 factors that carry the potential to increase the complexity of obstetric care, both in isolation and in combination. Obesity is a major public health problem, affecting an estimated 300 million women worldwide.[1] More than 50% of women of childbearing age in the United States[2] and more than 40% of women in an Irish obstetric population are overweight or obese.[3]

As a separate but somewhat related matter, the prevalence of multiple pregnancies is also increasing, secondary to assisted reproductive techniques, advancing maternal age, and other factors.[4] Twin pregnancies now account for 3% of all live births in the United States.[5] Although many factors have contributed to this, it is now apparent that maternal body mass index (BMI) may also have an influence on the rising prevalence of twin pregnancies. Reddy et al[6] reported that a maternal BMI of 30 kg/m^2 or greater was associated with dizygotic twinning, and there is evidence that mothers of dizygotic twins had a higher prepregnancy BMI than mothers of monozygotic twins.[6,7]

Sonographic estimated fetal weights (EFWs) are commonly considered in the management of twin pregnancies,

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particularly when planning obstetric interventions. There are many different formulae utilized to estimate fetal weight, using 1 or a number of fetal biometric measurements.[8,9] Although the reliability of whatever method used is critical to decision making, it is clear that there are other clinical factors, such as gestation,[10] fetal presentation,[11] fetal growth centile,[12] and maternal body habitus,[13] which may influence the predictive accuracy of the measurements obtained.

In relation to maternal body habitus, the accuracy of ultrasound assessment of the fetus in women of high BMI is controversial. There are published reports outlining that both for detection of the anomalous fetus[13,14] and for sonographic EFW,[15] increased maternal BMI is associated with decreased accuracy. There are other studies that have concluded that maternal obesity does not alter or decrease the accuracy of sonographic EFWs.[16-18]

Most of these studies and the majority of data on the accuracy of sonographic EFW pertain to singleton pregnancies. However, for multiple pregnancies, the potential impact of increased BMI on sonographic EFW is important because of the recent increased prevalence of both twin gestations[19] and obesity[1] in the developed world. One study by Gandhi et al[20] has previously addressed the issue of maternal BMI and EFW in twin pregnancy. Using a chart review, Gandhi et al[20] analyzed the EFWs made within 6 days of delivery for 194 patients with twin pregnancies and concluded that increasing maternal obesity reduced the accuracy of sonographically determined weights in twin gestations, particularly so for the second twin.

The aim of this study was to investigate the effect of maternal BMI on the accuracy of EFW assessments in twin gestations prospectively recruited for the ESPRiT (Evaluation of Sonographic Predictors of Restricted growth in Twins) study, carried out by the Perinatal Ireland consortium.[21]

Materials and Methods

Perinatal Ireland is a multicenter research network involving leading maternal fetal medicine specialists at 8 academic perinatal centers in Ireland, which encompasses a total delivery population of 50,000 per annum. The prospective ESPRiT study was conducted at these centers between May 2007 and October 2009. Institutional review board approval was obtained at each participating site, and the study participants gave written informed consent.

Participants were enrolled between 11 and 22 weeks' gestation, and their BMI was recorded at the first antenatal visit. Chorionicity was assigned at the first ultrasound examination and subsequently confirmed postnatally with pathological examination. EFW assessments were performed at 2-week intervals from 16 weeks on the monochrorionic diamniotic twins, and from 24 weeks on the dichorionic twin pairs, using the composite of 4 parameters (Hadlock formula): abdominal circumference, biparietal diameter, head circumference, and femur length. Umbilical artery Doppler ultrasound measurements were also taken by dedicated research ultrasonographers, and standardized ultrasound equipment (GE Voluson Expert 730; GE Healthcare, Cleveland, OH) was used in all centers. All prenatal and ultrasound data were contemporaneously transferred to an ultrasound software system (Viewpoint; MDI Viewpoint, Jacksonville, FL) and uploaded onto a live Web-based central consolidated database. Ultrasonographers' images and Doppler traces underwent regular quality review by a central ultrasonography quality assurance committee.

Comparisons were made between the EFWs observed at the last available ultrasound examination (within 2 weeks of delivery) and the actual birthweights (BWs) recorded. The accuracy of EFW determination was defined as the difference between EFW and actual BW for both twins (absolute difference and percentage difference). Regression analysis was used to model the data and the data were log transformed to meet normality assumptions. The χ^2 test was used for categorizations of BMI. The Wilcoxon rank-sum test was used to determine statistical significance of nonnormally distributed data.

A linear regression analysis was performed to evaluate the accuracy of prediction across the following 5 BMI categories: underweight (BMI of <18.50 kg/m^2); normal weight (BMI of 18.50-24.99 kg/m^2); overweight (BMI of ≥ 25.00 kg/m^2); obese (class I; BMI of 30.00-34.99 kg/m^2 and class II; BMI of 35.00-39.99 kg/m^2); and extremely obese (class III; BMI of ≥ 40.00 kg/m^2).[22]

The mean absolute difference was defined as the absolute value of BW minus the EFW. The mean percentage difference was defined as the absolute difference divided by the BW. The difference between the actual BW and the EFW was calculated as a percentage of the actual BW.

A separate analysis of mean absolute variations in BW was compared between 3 different BMI groups as follows: group 1 included women who were underweight combined with women of normal BMI; group 2 included women in the overweight BMI category; and group 3 included women in the obese and extremely obese BMI categories. This arrangement of groups was determined so that individual BMI categories that contained less than 5% of the population (namely the underweight and extremely obese categories) were combined with other categories to enhance the accuracy of observed associations. A significance level of 2.5% was used to account for multiple testing (Bonferroni adjustment).

Results

One thousand one twin pregnancies recruited, of which 58 were excluded from analysis because of miscarriage, stillbirth, or unavailable data. The data from the remaining 943 twin pairs were analyzed. Seven hundred sixty four (81%) were dichorionic and 179 (19%) were monochorionic. There was no relationship between maternal BMI and chorionicity; the median BMI for the monochorionic twins was 24.4 (n= 1 79), and the median BMI for the dichorionic twins was 24.4 (n = 764) ($P = .869$).

The mean maternal age was 33 years (SD, 5.3 years; range, 14−47 years). The mean gestation at delivery was 36 weeks

(SD, 2.7 weeks; range, 23−39 weeks) (Figure 1). Gestational age (GA) at delivery was different for the monochorionic and dichorionic pregnancies: the median GA for the monochorionic twins was 34.8 weeks compared with 36.3 weeks for the dichorionic twins ($P < .0001$). There were 14 cases of twin-to-twin transfusion syndrome that continued as a twin gestation past 24 weeks.

In relationship to the general features of fetal growth and BW of the cohort, 84% of all twin pairs were appropriately grown for gestational age. We noted differences in BW according to chorionicity alone; the mean BW for the monochorionic twins was 2213 g compared with 2518 g for the dichorionic twins ($P < .0001$). However, after adjusting for gestational age at delivery (analysis of covariance), there was no evidence of difference in BW according to chorionicity (mean BW for monochorionic twins was 2455 g; mean BW for dichorionic twins was 2482 g [$P = .199$]).

The median BW discordance was 9.3%. The BW discordance was predictive of EFW accuracy (accuracy deteriorating by 0.14% per 1% additional discordance, $P < .0001$). Alternatively, those with less than 18% BW discordance had an EFW accuracy of within 10.3%, whereas those with greater than 18% BW discordance had an accuracy within 12.4%. There was a tentative increasing trend in both BW discordance and the risk of small for gestational age (SGA; BW less than the fifth centile) with increasing BMI, but these trends were not statistically significant ($P = .06$ and $P = .09$, respectively).

The sensitivity/specificity for detecting SGA (BW less than the fifth centile) was 51%/90% in the normal-weight group, 52%/91% for the overweight group, and 71%/89% in the obese group (BMI >30 kg/m^2). Cochrane-Armitage trend tests were nonsignificant (P values were .2244 and .7868 for sensitivities and specificities, respectfully) (ie, there was insufficient evidence to suggest percentages changed across the BMI categories.

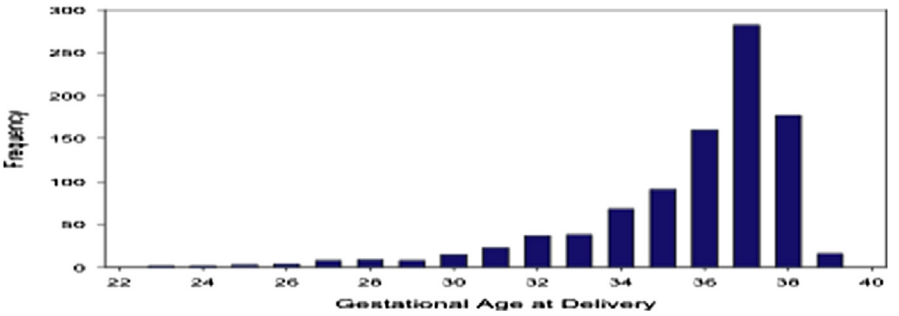
In a similar analysis of EFW for BW discordance of 18%, the sensitivities/specificities were 37%/95%, 34%/97%, and 31%/92% for normal, overweight, and obese BMI categories, respectively. The Cochrane-Armitage trend tests were nonsignificant (P values were .4841 and .5252 for sensitivities and specificities, respectfully). On a continuous scale of measurement, the EFW discordance and BMI category interaction was nonsignificant ($P = .2003$). Taking all of these findings together, there was no clear difference across the BMI categories in terms of predicting the risk of an SGA infant or of BW discordance.

The numbers for each BMI group and the corresponding percentage values are shown in Table 1. The median BMI in our cohort was 24.4 (interquartile range, 5.9). In addition, 43.5% of all women were either overweight or obese. There were 1886 infants. The average absolute variation in EFW was 190 g (n = 943). Analysis revealed no linear or log-linear relationship between BMI and the accuracy of EFW assessment (P value for absolute difference = .110, P value for percentage difference = .270). These findings are depicted in Figures 2-4. This was true in presenting and nonpresenting twins separately.

Analysis of the results for mean absolute variation and mean percentage difference for the 3 combined BMI groups revealed the following absolute and percentage variation values: normal/underweight group, 184 g (SD, 230 g) (8%); overweight group, 196 g (SD, 264 g) (8.5%); and obese/extreme obesity group, 206 g (SD, 227 g) (8.6%). There was therefore a significant association between EFW accuracy and BMI ($P = .028$, nonsignificant after adjustment for multiple testing) as determined by absolute differences across the 3 groups. A summary is provided in Table 2. There was no statistically significant greater discordance in EFW associated with higher BMI groups ($P = .110$).

A multivariate analysis was performed, with BMI, GA at delivery, and

FIGURE 1
Gestational age at delivery



Histogram shows the percentage distribution of gestational age at delivery of twin pairs.

Ryan. Ultrasound and maternal BMI in twin pregnancy. Am J Obstet Gynecol 2014.

TABLE 1
Frequency of BMI groups

BMI category, kg/m^2	Frequency	%
Underweight (<18.5)	22	2.33
Normal (18.5-24.9)	509	53.98
Overweight (25.0-29.9)	278	29.48
Obese (30.0-34.9)	96	10.18
Extreme obesity (>35)	38	4.03

BMI, body mass index.

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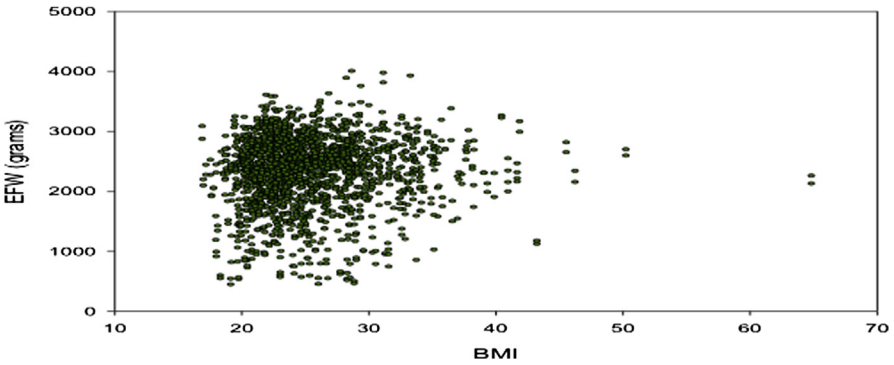
FIGURE 2
Body mass index vs estimated fetal weight



Scatterplot of the relationship of maternal BMI to EFW in grams is shown.

BMI, body mass index; *EFW*, estimated fetal weight.

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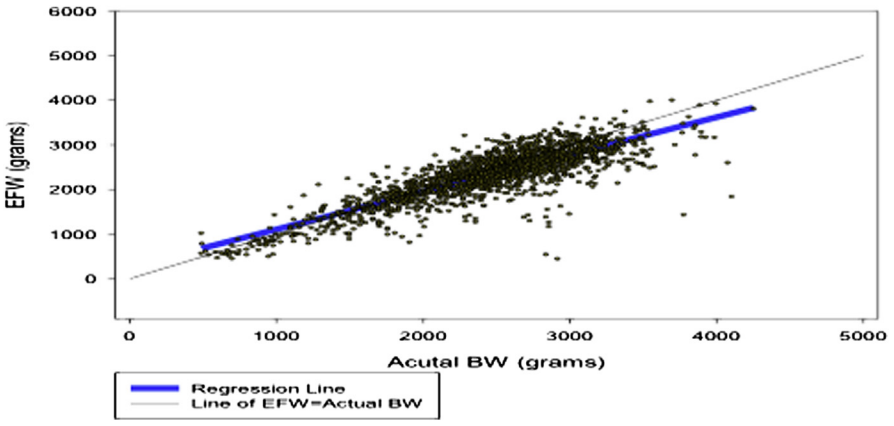
chorionicity all included as predictors. Chorionicity was a statistically significant predictor of EFW accuracy ($P = .025$, after adjusting for GA and BMI). There was greater accuracy in the dichorionic twins than in the monochorionic twins (the difference in the monochorionic twins was 10.1% vs 11.4% in the dichorionic twins). GA at delivery was also independently predictive of EFW accuracy (accuracy actually improved by 0.6% per gestational week from 24 weeks to delivery; $P < .0001$). However, maternal BMI was not a significant independent predictor of EFW accuracy ($P = .075$).

With regard to gender, 49% were female and 51% were male in the study. BW was higher in males than females (mean male BW, 2578 g; mean female BW, 2442 g [$P < .000$]). In a multivariate analysis looking at the accuracy of EFW determination with baby sex included as a predictor, there was no difference between males and females in terms of EFW accuracy ($P = .501$).

We analyzed the accuracy of EFW according to time interval between the last ultrasound and delivery: less than 1 week from the last ultrasound to delivery and between 1 and 2 weeks prior to delivery. Absolute and percentage differences were dependent on the time interval to delivery. The absolute difference within 1 week was 181 g, compared with 254 g between 1 and 2 weeks of delivery ($P < .0001$). This difference was due to growth over and across the time intervals. Similarly, the estimated percentage difference within 1 week was 7.8% compared with 10.1% between 1 and 2 weeks ($P < .0001$).

Using an analysis of covariance adjusting for time to delivery as a covariate (plus a time to delivery by BMI group interaction term), we found no differences between the BMI groups in terms of accuracy ($P = .413$ and $P = .8817$). On further analysis, we restricted the analysis to those cases in which the ultrasound was within 1 week of delivery only. There was no difference between the BMI groups in the accuracy of EFW ($P = .1961$ and $P = .1843$ for absolute or percentage difference, respectively).

FIGURE 3
Estimated fetal weight vs actual birthweight



Scatterplot of the relationship of the EFW in grams to the actual BW of all twins (n = 1886). *Black line* indicates EFW—actual BW. *Blue line* indicates regression line.

BW, birthweight; *EFW*, estimated fetal weight.

Ryan. Ultrasound and maternal BMI in twin pregnancy. Am J Obstet Gynecol 2014.

COMMENT

This study focused on the topic of accuracy of EFWs in twin pregnancies in relationship to maternal BMI. We studied a large cohort of twin pregnancies, and it represents the first large prospective study examining growth in such pregnancies. The analysis of the study population overall demonstrated that there was no linear or log-linear relationship between maternal BMI and the accuracy of EFW assessment.

In addition, on multivariate analysis, maternal BMI was not a significant predictor of accuracy of EFW. However, separate analysis of the absolute variations in BW observed between 3 groups categorized on the basis of BMI (1, underweight and normal BMI; 2, overweight BMI; 3, obese and extremely obese BMI) suggested that there was a difference in accuracy across the 3 groups, but when analyzed as a trend, this was not significant.

Taken together, the findings from this study indicate that maternal BMI has no important bearing on the accuracy of EFW assessments in twin pregnancies.

The strengths of this study include its prospective nature, the large number of women recruited, the broad spread of gestational age at which the assessments took place, the accuracy of the BMI data, and the multifaceted analysis performed.

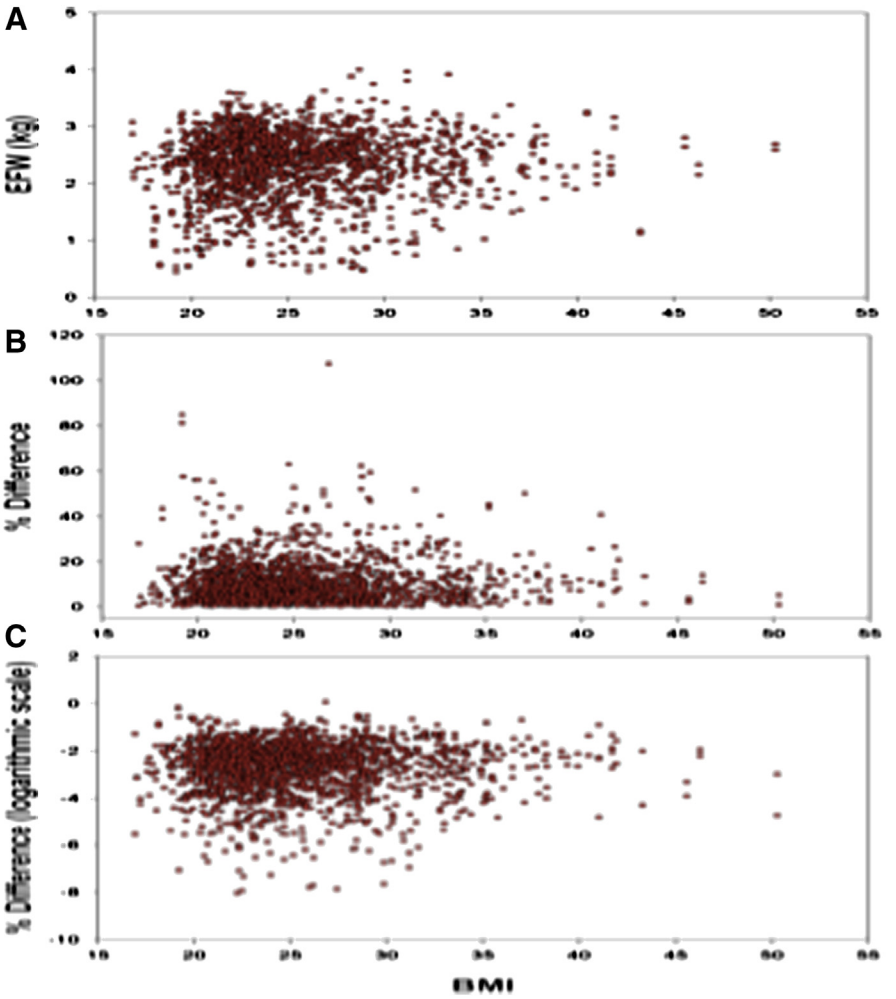
There are minimal published data available pertaining to the potential influence of maternal BMI on accuracy of EFW assessments in twin pregnancies. For singleton gestations, this is also a controversial topic.[15] Some reports in singleton pregnancies have suggested that the accuracy of the measurement was not influenced by maternal BMI,[16-18] whereas others have indicated that maternal obesity limits ultrasound evaluation of fetal anatomy and growth.[13,14,20] However, for many of these studies, a single assessment of EFW close to term constituted a major part of the analysis.

In the relationship to multiple pregnancies, a previous study by Gandhi et al,[20] which included 194 patients, concluded that increasing maternal obesity reduced the accuracy of sonographically determined weights in twin gestations, particularly so for the second twin. Using the data presented in this study, when comparisons were made between the overweight and the obese/extremely obese groups, in relationship to the normal/underweight group, there was no statistical significance observed ($P = .044$ and $P = .085$, respectively). In essence, these individual pairwise comparisons exhibited lower power than the overall comparison presented ($P = .028$ for any difference between groups).

Our findings suggest that maternal BMI exerts little or no influence on the accuracy of EFW assessments in twin pregnancies and also reveal that there was also no relationship between BMI and the accuracy of EFW assessment in presenting and nonpresenting twins.

There are some limitations to the findings presented here. Assignment of the women recruited to a BMI category was done on the basis of a BMI calculation done at first presentation in pregnancy, rather than before pregnancy. All of the sonographers were highly trained and worked in tertiary referral centers, and hence, these results may not be applicable to all settings. There is also the

FIGURE 4
Accuracy of EFW in relation to maternal BMI



A, BMI and accuracy of EFW. **B,** BMI and percentage difference in weight. **C,** BMI and accuracy of EFW (logarithmic scale). Shown are scatterplots of the relationship of **A,** maternal BMI to the accuracy of EFW in kilograms, **B,** to the percentage difference in EFW and **C,** to the logarithmic scale of the percentage difference of EFW.

BMI, body mass index; *EFW*, estimated fetal weight.

Ryan. Ultrasound and maternal BMI in twin pregnancy. Am J Obstet Gynecol 2014.

TABLE 2
Mean absolute variation in EFW for each BMI category

BMI category	Median absolute difference (g) with SD	Median percentage difference
Normal/underweight	184 (±230)	8.0%
Overweight	196 (±264)	8.5%
Obese/extreme obesity	206 (±227)	8.6%

BMI, body mass index; *EFW*, estimated fetal weight.

Ryan. Ultrasound and maternal BMI in twin pregnancy. Am J Obstet Gynecol 2014.

possibility of a so-called Hawthorne effect, whereby an improvement in performance may occur simply because one (ie, the sonographer) knows that the results are being studied.[23] However, previous reports relating to this matter in clinical EFW have indicated that knowledge that a clinician is being studied is unlikely to improve clinical EFW accuracy.[24]

In summary, the accuracy of EFWs in twin pregnancies was within 8-9% overall for this large cohort. Contrary to a commonly held clinical impression, increasing maternal BMI has no significant impact on the accuracy of EFWs in twin pregnancies. ■

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REFERENCES

1. Overweight and obesity. World Health Organization fact sheet number 311. Geneva (Switzerland): World Health Organization; May 2012.
2. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA 2006;295:1549-55.
3. Lynch CM, Sexton DJ, Hession M, Morrison JJ. Obesity and mode of delivery in primigravid and multigravid women. Am J Perinatol 2008;25:163-7.
4. Martin JA, Hamilton B, Osterman MJ. Three decades of twin births in the United States, 1980-2009. NCHS Data Brief 2012:1-8.
5. Martin JA, Hamilton BE, Ventura SJ, et al. Births: final data for 2009. Natl Vital Stat Rep 2011;60:1-70.
6. Reddy UM, Branum AM, Klebanoff MA. Relationship of maternal body mass index and height to twinning. Obstet Gynecol 2005;105:593-7.
7. Hoekstra C, Willemsen G, van Beijsterveldt CEMT, Lambalk CB, Montgomery GW, Boomsma DI. Body composition, smoking, and spontaneous dizygotic twinning. Fertil Steril 2010;93:885-93.
8. March MI, Warsof SL, Chauhan SP. Fetal biometry: relevance in obstetrical practice. Clin Obstet Gynecol 2012;55:281-7.
9. Edwards A, Goff J, Baker L. Accuracy and modifying factors of the sonographic estimation of fetal weight in a high-risk population. Aust N Z J Obstet Gynaecol 2001;41:187-90.
10. Chauhan SP, Hendrix NW, Magann EF, Morrison JC, Scardo JA, Berghella V. A review of sonographic estimate of fetal weight: vagaries of accuracy. J Matern Fetal Neonatal Med 2005;18:211-20.
11. McNamara J, Odibo A, Macones G, Cahill A. The effect of breech presentation on the accuracy of estimated fetal weight. Am J Perinatol 2011;29:353-60.
12. Unterscheider J, Geary MP, Daly S, et al. The customized fetal growth potential: a standard for Ireland. Eur J Obstet Gynecol Reprod Biol 2013;166:14-7.
13. Dashe JS, McIntire DD, Twickler DM. Maternal obesity limits the ultrasound evaluation of fetal anatomy. J Ultrasound Med 2009;28:1025-30.
14. Dashe JS, McIntire DD, Twickler DM. Effect of maternal obesity on the ultrasound detection of anomalous fetuses. Obstet Gynecol 2009;113:1001-7.
15. Houze de l'Aulnoit A, Closset E, Deruelle P. Accuracy of ultrasound estimated fetal weight performed by OB-Gyn residents at due date. Gynecol Obstet Fertil 2009;37:367-71.
16. Field NT, Piper JM, Langer O. The effect of maternal obesity on the accuracy of fetal weight estimation. Obstet Gynecol 1995;86:102-7.
17. Farrell T, Holmes R, Stone P. The effect of body mass index on three methods of fetal weight estimation. BJOG 2002;109:651-7.
18. Heer IM, Kumper C, Vogtle N, Muller-Egloff S, Dugas M, Strauss A. Analysis of factors influencing the ultrasonic fetal weight estimation. Fetal Diagn Ther 2008;23:204-10.
19. Ananth CV, Chauhan SP. Epidemiology of twinning in developed countries. Semin Perinatol 2012;36:156-61.
20. Gandhi M, Ferrara L, Belogolovkin V, Moshier E, Rebaber A. Effect of increased body mass index on the accuracy of estimated fetal weight by sonography in twins. J Ultrasound Med 2009;28:301-8.
21. Breathnach FM, McAuliffe FM, Geary M, et al. Prediction of safe and successful vaginal twin birth. Am J Obstet Gynecol 2011;205:237.e1-7.
22. World Health Organisation Global Database on Body Mass Index. Geneva (Switzerland): World Health Organisation; 2006.
23. Hsueh Y. The Hawthorne experiments and the introduction of Jean Piaget in American industrial psychology, 1929-1932. Hist Psychol 2002;5:163-89.
24. Fox NS, Brennan JS, Chasen ST. Clinical estimation of fetal weight and the Hawthorne effect. Eur J Obstet Gynecol Reprod Biol 2008;141:111-4.