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Effect of gestational weight gain on perinatal outcomes in women with type 2 diabetes mellitus using the 2009 Institute of Medicine guidelines

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Abstract

OBJECTIVE—We sought to examine associations between gestational weight gain according to the 2009 Institute of Medicine (IOM) guidelines and perinatal outcomes in overweight/obese women with type 2 diabetes mellitus (T2DM).

STUDY DESIGN—This is a retrospective cohort study of 2310 women with T2DM enrolled in the California Diabetes and Pregnancy Program. Gestational weight gain was categorized by 2009 IOM guidelines. Perinatal outcomes were assessed using the χ^2 test and multivariable logistic regression analysis.

RESULTS—With excessive gestational weight gain, the odds of having large-for-gestational age (adjusted odds ratio [aOR], 2.00; 95% confidence interval [CI], 1.33–3.00) or macrosomic (aOR, 2.59; 95% CI, 1.56 – 4.30) neonates and cesarean delivery (aOR, 1.47; 95% CI, 1.03–2.10) was higher. Women with excessive gestational weight gain per week had increased odds of preterm delivery (aOR, 1.57; 95% CI, 1.11–2.20).

CONCLUSION—In overweight or obese women with T2DM, gestational weight gain greater than the revised IOM guidelines was associated with higher odds of perinatal morbidity, suggesting these guidelines are applicable to a diabetic population.

Keywords

gestational weight gain; perinatal outcomes; type 2 diabetes mellitus

Obesity is a growing epidemic in the United States. In 2007 through 2008, nearly 60% of reproductive-age American women were reported to be overweight or obese, with the prevalence of obesity reported at approximately 30% across many demographic groups.[1] Prepregnancy obesity is a risk factor for adverse maternal and neonatal outcomes, including spontaneous abortion, gestational diabetes mellitus (GDM), cesarean delivery, preeclampsia, neonatal macrosomia, and operative and anesthetic complications.[2]

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The Institute of Medicine (IOM) first established guidelines for weight gain during pregnancy in 1990. These guidelines, with weight based on Metropolitan Life Insurance tables, were based primarily on neonatal outcomes.[3] In the 2 decades since these original guidelines were published, the American population has become considerably more obese. In 2009 the IOM published new guidelines for recommended gestational weight gain that take into consideration maternal morbidity (Table 1).[4] The revised guidelines categorize recommended weight gain based on the World Health Organization (WHO) body mass index (BMI) categories. They include more specific, narrower ranges of recommended weight gain for obese women, rather than an open-ended recommendation.[4] It has been demonstrated that extremely low or high gestational weight gain is associated with adverse perinatal outcomes across all weight groups. Low gestational weight gain has been associated with increased likelihood of small-for-gestational-age (SGA) neonates and of preterm birth, whereas excessive gestational weight gain has been associated with multiple types of neonatal morbidity and mortality, including neonatal macrosomia, and increased cesarean delivery and maternal morbidity.[5–7]

Currently, the IOM recommendations on gestational weight gain are based on prepregnancy BMI and do not take into consideration different race/ethnicity, age, or preexisting medical conditions.[4] Women with type 2 diabetes mellitus (T2DM) are already at increased risk of cesarean delivery, preeclampsia, congenital anomalies, neonatal macrosomia, intrauterine fetal demise (IUFD), multiple other neonatal morbidities, and exacerbation of diabetic end-organ damage.[8] As obesity and T2DM are frequently comorbid conditions,[9] obesity and excessive gestational weight gain may compound these risks in diabetic women. Because fat is an endocrine organ and interacts with diabetes, it is possible that the increased accumulation of fat has a differential effect on perinatal outcomes for women with T2DM. Ample diabetes literature, including data from the large-scale Nurses' Health Study, suggest that excess body weight aggravates insulin resistance (in nonpregnant patients), and that even modest changes in body weight can impact the development of diabetes as well as diabetes outcomes.[10,11] It is possible that this principle applies to gestational weight gain and perinatal outcomes as well. Previous data have established that excessive gestational weight gain among women with GDM is associated with increased neonatal morbidity.[12] However, the effect of gestational weight gain in a population of women with T2DM has not yet been studied, and it is unclear whether the latest 2009 IOM guidelines for pregnancy weight gain are applicable to a T2DM population, given the possible compound effect of obesity and diabetes.

Given this background, we designed a retrospective cohort study to examine whether these narrower pregnancy weight gain recommendations are predictive of adverse perinatal outcomes in a population of women with known T2DM. Our objective was to examine if the revised 2009 IOM guidelines for pregnancy weight gain apply to and are predictive of adverse perinatal outcomes in women with T2DM. We hypothesized that the new guidelines would be applicable to this population of overweight and obese women with T2DM. Furthermore, we hypothesized that, as in a population of women with GDM, weight gain beyond the IOM recommendations would be predictive of adverse perinatal outcomes.

Materials and Methods

We conducted a retrospective cohort study of all women with T2DM who were cared for in the Sweet Success California Diabetes and Pregnancy Program (CDAPP) from 2001 through 2004. In California, Sweet Success is the clinical component of CDAPP, which provides technical support and education to providers involved in the care of high-risk pregnant women with preexisting diabetes and women who develop GDM. As a part of the Maternal, Child, and Adolescent Health Branch of the California Department of Health Services,

CDAPP collects data on all women enrolled in Sweet Success, including hemoglobin A1c, weight at enrollment and last visit, maternal outcomes, neonatal outcomes, treatments instituted, and demographic information. CDAPP oversees collection by trained clinicians into standardized data collection forms. Institutional review board approval was obtained from the University of California, San Francisco, Committee on Human Research for this study.

The study population includes all overweight and obese women with T2DM who were enrolled in the CDAPP during the years under investigation. Exclusion criteria included: GDM, type 1 diabetes mellitus, multifetal gestations, and pregnancies with fetal anomalies. Overweight and obese women were specifically chosen because the changes to the IOM recommendations in 2009 focused on these groups and they are at highest risk for morbidity. All data were collected from the CDAPP/Sweet Success data collection forms. Prepregnancy weight was classified using the WHO guidelines for calculation of BMI.[13] Women classified as having pre-GDM were those with known preexisting T2DM prior to conception, with a hemoglobin A1c >6.5% in the first trimester, or with a diagnosis of GDM made <14 weeks' gestational age. Once identified, these women were classified by gestational weight change. Change in pregnancy weight was calculated as the difference between prepregnancy weight and weight at the last reported clinic visit. Using the 2009 IOM guidelines, weight change was then categorized as weight loss (<0 lb), weight gain less than IOM guidelines according to maternal prepregnancy BMI, weight gain within IOM guidelines, and weight gain beyond IOM guidelines. For this study, we focus on gestational weight gain.

Further, since women who delivered preterm or experienced IUFD preterm might have a shorter gestational length to gain weight, we additionally examined the association of gestational weight gain and these outcomes by calculating expected gestational weight gain per week based on the IOM guidelines: between 15–25 lb divided by 38 weeks for overweight and 11–20 lb divided by 38 weeks for obese women. We used 38 weeks' gestational length as we assume normal pregnancy to be 40 weeks in length, but not accounting for the 2 weeks between last menstrual period to ovulation when the woman is actually not pregnant. After determining expected gestational weight gain per week based on IOM guidelines, we then determined the actual gestational weight gain per week (again, using 38 weeks as the denominator) and categorized women to having gestational weight gain per week below, within, or above IOM recommendations.

Deliveries were performed at a variety of academic and community institutions throughout California, with all data reported by CDAPP clinic providers to the centralized CDAPP database. Neonatal outcomes of interest in this study included: preterm delivery <37 weeks, elevated birthweight (>4000 g), large-for-gestational-age status (>90th centile by gestational age), SGA status (<10th centile by gestational age), neonatal intensive care unit (NICU) admission, and IUFD. Neonatal outcomes were controlled for gestational age at delivery. CDAPP does not collect data on neonatal hypoglycemia or jaundice. Maternal outcomes include all and primary cesarean deliveries; CDAPP does not collect data on preeclampsia. Categorical perinatal outcomes were examined by category of gestational weight change using Pearson χ^2 statistic for analysis of trend. A P value of < .05 indicated statistical significance. Multivariable logistic regression analysis was utilized to control for potential confounders, including age, race/ethnicity, parity, and maternal education.

Results

Our study cohort consisted of 2310 women with T2DM who were either overweight or obese and met study inclusion/exclusion criteria. There were 241 (10.4%) women who lost

weight, 537 (23.3%) who gained less weight than IOM guidelines, 594 (25.7%) who gained weight within IOM guidelines, and 938 (40.6%) who gained more weight than recommended. Nulliparous women were more likely to have excessive weight gain than multiparas (48.9% vs 39.1%, P =.008). Approximately 50% of African American and 43.7% of Latina women gained weight beyond IOM guidelines. Women age <35 years were also more likely to gain excessive weight compared to older women (43.1% vs 36.5%, P = .001). Table 2 demonstrates maternal characteristics associated with degree of weight gain; of note, there are some missing data, where not reported by CDAPP providers.

Maternal and neonatal outcomes were examined by gestational weight change categorized according to maternal prepregnancy BMI and IOM recommendations (Table 3). On univariate analysis, weight gain beyond recommendations was associated with increased rate of cesarean delivery. Women with excessive weight gain had more primary cesarean deliveries (28.1%) compared to women with weight gain within guidelines (20.9%) or less than guidelines (21.2%). Gestational weight gain above IOM guidelines was further associated with increased incidence of birthweight >4000 g, large-for-gestational-age status, and NICU admission. Our population demonstrated a decrease in IUFD and a trend toward decreased incidence of SGA status among those with excessive gestational weight gain. Because Tables 3 and 4 report outcomes as assessed by total weight gain, and total gestational weight gain does not apply to preterm deliveries, we do not report the outcome of preterm delivery in these tables.

Multivariable logistic regression analysis was used to control for possible confounders (Table 4). Women whose weight gain was less than or greater than the 2009 IOM guidelines were compared to the referent group of women whose weight gain was within IOM guidelines. Although some overweight and obese women with T2DM lost weight during pregnancy, there were too few women in this category to perform multivariable analysis on those who lost weight. No perinatal outcomes were statistically significantly associated with low gestational weight gain. In contrast, women with weight gain beyond IOM guidelines were more likely to have cesarean delivery and neonatal macrosomia. On adjusted analysis, there was no significant association between weight gain outside of guidelines and likelihood of IUFD, SGA status, or NICU admission. We also performed stratified analysis by parity and observed similar association as entire cohort, but due to diminished statistical power secondary to stratification for many of the outcomes of interest, these results were not presented.

Lastly, to further investigate the association between gestational weight gain and the risk of IUFD or preterm birth, we examined these outcomes by amount of gestational weight gain per week, since women who delivered preterm or have IUFD preterm would have less gestational time to gain weight and thus appeared to gain less weight due to shorter pregnancy duration. Compared to women who had weight gain per week within the IOM guidelines, women who had weight gain per week above IOM guidelines had higher risk of preterm delivery <37 weeks (12.9% vs 17.8%, P = .02, respectively). This association was examined using the same multivariable regression model, and we persistently observed higher odds of preterm delivery in women who gained (per week) above the IOM guidelines (adjusted odds ratio, 1.57; 95% confidence interval, 1.11–2.20). Using the same comparison scheme, there was no incidence of IUFD in women who gained (per week) within the IOM guidelines but 1.9% incidence of IUFD in women who gained (per week) above the IOM guidelines.

Comment

This study investigates the relationship between perinatal outcomes and gestational weight gain, as classified by category of compliance with the 2009 IOM guidelines for gestational weight gain, in women with T2DM who were either overweight or obese. This is the first study to investigate the interaction between high maternal prepregnancy BMI, gestational weight gain, and perinatal outcomes in women with T2DM.

Our findings suggest that the 2009 IOM guidelines are indeed applicable to women with T2DM who are either overweight or obese.

We observed that women with gestational weight gain beyond the recommended amount were significantly more likely to experience adverse maternal outcomes, namely cesarean delivery, as well as increased likelihood of neonatal macrosomia. Of note, on univariate analysis, we initially noted a decreased incidence of SGA and IUFD and increased rate of NICU admission in women with excessive gestational weight gain; these findings did not persist in multivariable analysis. For the outcome of IUFD, we analyzed data by gestational weight gain per week, and found no incidence of IUFD among those with weight gain (per week) within guidelines.

Our findings are consistent with prior studies indicating that excessive gestational weight gain in populations of nondiabetic women or women with GDM is associated with increased likelihood of cesarean delivery and neonatal macrosomia. We also found that overweight or obese women with T2DM who have weight gain per week greater than the IOM guidelines were at risk for preterm birth. In contrast, we did not observe an association between maternal or neonatal morbidity and less-than-recommended weight gain in overweight/obese women with T2DM. Based on these findings, we speculate that overweight/obese diabetic women with low gestational weight gain are somewhat protected against preterm birth, perhaps because adequate nutritional stores are already present and less than IOM-recommended weight gain may be adequate. One limitation of this specific finding, however, is that in this study, we were unable to calculate per-trimester weight gain in this population, because we only had available data on total weight gain, from prepregnancy to last clinic visit. As a result, we cannot precisely estimate the rate of gestational weight gain along a specific per-trimester sigmoid curve, which would more accurately describe the pattern of weight gain in most pregnancies. It is possible that this finding that women with excess weight gain per week are at increased risk of preterm birth is due to our calculation of gestational weight gain as a linear pattern; future work should assess this outcome with more accurate per-trimester rates of weekly weight gain to clarify risk of preterm birth.

Women with T2DM are at risk of maternal and neonatal complications in pregnancy, and being overweight or obese with excessive gestational weight gain appears to compound this risk. Of particular concern is the relationship between excessive weight gain and neonatal macrosomia, as literature would suggest an association between elevated birth weight and long-term childhood health outcomes.[14] Furthermore, the rising cesarean delivery rate in the United States is worrisome, and it appears that excessive weight gain in obese and overweight diabetic women is a strong risk factor for cesarean delivery. However, gestational weight gain is a modifiable risk factor for adverse outcomes. These data suggest that at least the upper limits of the 2009 IOM recommendations should be applied to this population of overweight and obese T2DM women during prenatal visits, particularly integrating patient education, medical as well nutritional interventions, and exercise recommendations as an integral part of their health care. However, as we were not powered to examine further strata within the IOM guideline recommendations, larger studies should attempt to identify if even lower thresholds for weight gain may improve outcomes in

women with T2DM. Going forward, the specific actions recommended by the IOM in the new guidelines should also include recommendations for the populations of overweight and obese diabetic women.[4]

There are few data to suggest how to manage weight in this population of overweight and obese diabetic women during pregnancy. Based on these data, we would recommend that intensive patient education regarding weight gain goals take place preconceptionally when possible, and then early and regularly during pregnancy, consistent with a recent randomized trial.[15] However, further research is required to better understand how to perform successful interventions to improve adherence to the 2009 IOM guidelines in a diabetic population. Further, other studies have suggested that there may be room for even tighter weight gain guidelines in some categories of obese women, while still balancing the risks associated with inadequate nutrition.[16–19] This question remains controversial even in a nondiabetic obese population, and we would suggest more work is needed to identify whether narrower guidelines might be safe and beneficial in a diabetic obese population.

This study is limited by the retrospective nature of this cohort study, which is prone to confounding bias. While we attempt to control for potential confounding factors by implementing multivariable logistic regression analyses for effect estimates, there may be uncontrolled confounding from unmeasured or unobserved factors for which we did not have information or could not account for by statistical models. Additionally, there are a number of outcomes associated with diabetes in pregnancy which we could not examine due to lack of information collection. For example, ideally, we would like to examine the association between gestational weight gain and preeclampsia, and other maternal outcomes such as postpartum hemorrhage or severe lacerations, indications for cesarean and operative vaginal deliveries, and degree of glycemic control to further ascertain the role of gestational weight gain in women with diabetes in pregnancy. We additionally do not know the reasons for preterm delivery in this population, although we suspect that the rate of preterm delivery reflects the underlying risk of having T2DM, as literature suggests women with T2DM have an increased risk of both spontaneous and iatrogenic preterm birth.[20,21] Further, we could not examine neonatal outcomes often associated with pregnancies complicated by insulin resistance, such as neonatal hypoglycemia, jaundice, and other metabolic derangements. One additional limitation is that these data are from a specific population of overweight and obese women, largely Latina, receiving specialized care in a population program; as a result, these data may not be generalizable to a population of normal-weight diabetic women or to a population with a different racial and ethnic distribution. Finally, because of the observational nature of these data, we cannot claim a causal relationship between gestational weight gain and adverse outcomes. As there are no prior data that apply the 2009 IOM guidelines to this population of women and since it is not possible to perform randomized controlled studies that assign women to various amount of gestational weight gain, we believe that the large sample size and statistical models may provide valid information that may be useful in caring for this high-risk population.

Our study validates the revised IOM guidelines for narrower gestational weight gain in a population of overweight and obese women with T2DM. Our findings suggest that excessive weight gain beyond the IOM guidelines is associated with adverse maternal and neonatal outcomes in overweight and obese women with T2DM. Women with T2DM who experience less than the recommended weight gain do not appear to have significantly worsened perinatal outcomes. We would suggest that these new guidelines be aggressively utilized in the clinical setting for overweight and obese women with T2DM, and that further research investigate whether perhaps even narrower guidelines are warranted for this population.

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TABLE 1

2009 Institute of Medicine guidelines[4]

Prepregnancy BMI	BMI, kg/m^2	Total weight gain range, lb	Rates of weight gain, second and third trimesters, lb/wk(mean range)
Underweight	<18.5	28–40	1 (1–1.3)
Normal weight	18.5–24.9	25–35	1 (0.8–1)
Overweight	25.0–29.9	15–25	0.6 (0.5–0.7)
Obese	≥30.0	11–20	0.5 (0.4–0.6)

BMI, body mass index.

TABLE 2

Maternal characteristics associated with gestational weight gain

Characteristic	Weight loss, n (%)	Weight gain < IOM guidelines, n (%)	Weight gain within IOM guidelines, n (%)	Weight gain > IOM guidelines, n (%)
Parity				
Multiparous (n = 1958)	209 (10.7)	465 (23.8)	518 (26.5)	766 (39.1)
Nulliparous (n = 352)	32 (9.1)	72 (20.5)	76 (21.6)	172 (48.9)
Ethnicity				
White (n = 292)	32 (11.0)	63 (21.6)	81 (27.4)	116 (39.7)
Black (n = 136)	11 (8.1)	30 (22.1)	26 (19.1)	69 (50.7)
Latina (n = 1620)	179 (11.1)	381 (23.5)	418 (25.8)	642 (39.6)
Asian (n = 231)	15 (6.5)	58 (25.1)	57 (24.7)	101 (43.7)
Maternal age, y				
<35 (n = 1418)	153 (10.8)	297 (20.9)	357 (25.2)	611 (43.1)
≥35 (n = 767)	71 (9.3)	210 (27.4)	206 (26.9)	280 (36.5)
Education				
≤12th grade (n = 1541)	164 (10.6)	356 (23.1)	379 (24.6)	642 (41.7)
≥Some college (n = 557)	59 (10.6)	142 (25.5)	148 (26.6)	208 (37.3)

IOM, Institute of Medicine.

TABLE 3

Adverse perinatal outcomes associated with gestational weight gain

Outcome	Weight gain < IOM guidelines, n (%)	Weight gain within IOM guidelines, n (%)	Weight gain > IOM guidelines, n (%)	*P* value
All cesarean (n = 1060)	211 (40.3)	263 (45.5)	499 (54.8)	< .001
Primary cesarean (n = 512)	100 (21.2)	117 (20.9)	253 (28.1)	.002
Birthweight >4000 g (n = 398)	57 (12.3)	90 (16.3)	224 (25.5)	< .001
LGA >90th percentile (n = 562)	83 (18.0)	129 (23.4)	313 (35.6)	< .001
SGA <10th percentile (n = 113)	33 (7.1)	25 (4.5)	39 (4.4)	.051
NICU admission (n = 237)	67 (18.8)	47 (12.1)	106 (18.5)	.008
IUFD (n = 50)	23 (4.2)	10 (1.7)	10 (1.1)	< .001

IOM, Institute of Medicine; *IUFD*, intrauterine fetal demise; *LGA*, large-for-gestational-age; *NICU*, neonatal intensive care unit; *SGA*, small-for-gestational-age.

TABLE 4

Multivariable analysis of adverse perinatal outcomes associated with gestational weight gain according to 2009 IOM guidelines

aOR (95% CI)	Weight gain < IOM guidelines	Weight gain > IOM guidelines
All cesarean	1.10 (0.69–1.74)	1.47 (1.03–2.10)
Primary cesarean	1.49 (0.83–2.68)	1.62 (1.03–2.57)
Birthweight >4000 g	1.28 (0.66–2.48)	2.59 (1.56–4.30)
LGA >90th percentile	0.85 (0.49–1.48)	2.00 (1.33–3.00)
SGA <10th percentile	1.95 (0.80–4.74)	0.94 (0.43–2.07)
NICU admission	1.89 (0.67–5.38)	1.14 (0.53–2.47)
IUFD	9.18 (0.60–141.39)	1.10 (0.07–16.66)

Referent is women with weight gain within IOM guidelines.

aOR, adjusted odds ratio; *CI*, confidence interval; *IOM*, Institute of Medicine; *IUFD*, intrauterine fetal demise; *LGA*, large-for-gestational-age; *NICU*, neonatal intensive care unit; *SGA*, small-for-gestational-age.