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Glycemic Characteristics and Neonatal Outcomes of Women Treated for Mild Gestational Diabetes

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Abstract

OBJECTIVE—To estimate the association between fasting and 2-hour postprandial blood glucose levels and neonatal outcomes in women treated for mild gestational diabetes.

METHODS—In this secondary analysis of a multicenter randomized treatment trial of mild gestational diabetes, the median fasting and 2-hour postprandial glucose levels were analyzed in 2-week intervals and change over time (slope) was calculated for women with gestational diabetes (abnormal oral glucose tolerance test) and a fasting glucose less than 95 mg/dL who received nutritional management with self blood glucose monitoring and insulin as needed. Regression analyses were performed to estimate the relationship between median fasting and postprandial glucose and neonatal fat mass, cord blood C-peptide, birth weight, large-for-gestational-age neonates, macrosomia (greater than 4,000 g), and neonatal hypoglycemia.

RESULTS—Among 460 women with gestational diabetes, median fasting ($P<.001$), postprandial breakfast ($P<.001$), and postprandial lunch ($P<.001$) glucose values declined over the treatment period, whereas postprandial dinner values remained stable ($P=.83$). Higher median fasting glucose during the first 2 weeks of treatment was significantly associated with increased odds ratios for neonatal fat mass (1.35; 95% CI 1.09–1.66; $P=.006$) and elevated C-peptide (1.29; CI 1.09–1.52; $P=.003$). Higher median fasting glucose during the last 2 weeks before delivery was associated with higher rates of large-for-gestational-age neonates (1.27; CI 1.05–1.53; $P=.01$), macrosomia (1.32; CI 1.04–1.65; $P=.02$), and elevated C-peptide (1.19; CI 1.03–1.38; $P=.02$).

CONCLUSION—In women treated for mild gestational diabetes, higher fasting glucose during initiation of diet therapy was associated with increased neonatal fat mass and elevated C-peptide

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and during the last 2 weeks before delivery with macrosomia, large-for-gestational age, and elevated C-peptide.

LEVEL OF EVIDENCE—II

The recent Hyperglycemia and Adverse Pregnancy Outcome study found a continuous association between maternal glucose concentrations and increasing birth weight, umbilical cord C-peptide levels, and neonatal adiposity.¹ Although the link between increasing maternal glucose and such neonatal outcomes has been established, whether it is the fasting or postprandial blood glucose levels that correlate better with such markers of adiposity is uncertain. Previous studies have suggested that postprandial blood glucose levels are more predictive than fasting glucose for neonatal outcomes such as macrosomia and hypoglycemia.^{2–4} However, these studies have included women with pregestational diabetes^{2,3} or those with insulin-requiring gestational diabetes.⁴ A recent study of 18 women with gestational diabetes, of which 50% were treated with insulin, revealed that fasting glucose correlated most with fetal fat mass.⁵

The relationship of fasting and postprandial glucoses as well as the length of nutrition intervention to neonatal outcomes in women diagnosed with mild gestational diabetes is unknown. Establishing such a relationship can aid in establishing blood glucose targets when treating women with glucose intolerance during pregnancy. We therefore performed the current analysis to estimate if fasting, 2-hour postprandial glucose levels, or both in such women correlate with select markers of neonatal hyperinsulinemia and adiposity.

MATERIALS AND METHODS

This is a secondary analysis of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network multicenter randomized trial of treatment for gestational diabetes. This study was conducted over 5 years at 16 academic medical centers designed to evaluate perinatal outcomes associated with glucose intolerance in pregnancy. Each center's institutional review board approved the study protocol. The study protocol has been previously described.⁶

This analysis includes women diagnosed with mild gestational diabetes (fasting glucose less than 95 mg/dL and at least two of three glucose values that met or exceeded the following: 1-hour of 180 mg/dL, 2-hour 155 mg/dL, 3-hour 140 mg/dL) who were randomly assigned to dietary treatment. All women were instructed to perform daily self blood glucose monitoring, including fasting and 2-hour postprandial measurements, using a portable memory-based reflectance meter. Target values for blood glucose control on dietary therapy were less than 95 mg/dL for fasting and less than 120 mg/dL for 2-hour postprandial values. Blood glucose data were downloaded from each woman's memory-based reflectance meter by study personnel at every physician visit on a weekly or biweekly basis throughout the study period. Women were treated with insulin as needed if the majority of their blood glucose levels were above the designated target values.

Demographic characteristics, including maternal age, race, parity, body mass index at enrollment (calculated as weight (kg)/[height (m)]²), and gestational age at enrollment and at delivery, were evaluated. Neonatal birth weight as well as rates of large for gestational age (birth weight above the 90th percentile of a U.S. reference population) and macrosomia (birth weight more than 4,000 g) were recorded.⁷ Hyperinsulinemia was defined as an umbilical cord C-peptide level greater than the 95th percentile (above 1.77 ng/mL) as determined from an unselected obstetric population of women in the Maternal-Fetal Medicine Units Network.⁶ Neonatal fat mass was calculated using neonatal length, head and upper mid arm circumferences, and flank skinfold as previously described by Catalano.⁸

Increased fat mass was defined as fat mass greater than the 90th percentile based on this cohort of neonates. Neonatal hypoglycemia was defined as a value less than 35 mg/dL.

Median glucose levels were analyzed in 2-week intervals and change over time (slope) for each woman was calculated. The signed rank test was used to test for significant changes over time. Multiple linear and logistic regression analyses were performed to estimate the relationship between median fasting and 2-hour postprandial glucose for the first 2-week period and the 2 weeks before delivery and birth weight, large-for-gestational-age and macrosomic neonates, elevated cord C-peptide level, and high neonatal fat mass. Regression analyses were performed for both the entire population and those who were diet-controlled only. The relationship between the change in glucose values over the entire treatment period and these neonatal outcomes was also evaluated. Analyses were adjusted for possible confounding factors, including maternal age, parity, race and ethnicity, body mass index at enrollment, and gestational age at enrollment and at delivery. Statistical analysis was conducted with SAS software. A nominal two-sided *P* value less than .05 was considered to indicate statistical significance and no adjustments were made for multiple comparisons.

RESULTS

Of the 460 women who received nutrition intervention with glucose meter data, 424 (92.2%) achieved adequate glucose control with diet therapy alone. Thirty-six women required insulin therapy in addition to dietary management. The average time to insulin initiation was 34 days after beginning dietary management. Four of the 36 women who required insulin were initiated at the end of the first 2-week period. Clinical characteristics of the study population, stratified according to treatment, are shown in Table 1. Mean values ($\pm$ standard deviation) for the 3-hour oral glucose tolerance test were: fasting 86.5 ± 5.8 mg/dL, 1-hour 192.0 ± 22.0 mg/dL, 2-hour 173.6 ± 21.9 mg/dL, and 3-hour 137.0 ± 29.1 mg/dL.

During the study period, 25,822 fasting, 24,239 postprandial breakfast, 24,472 postprandial lunch, and 23,726 postprandial dinner glucoses were recorded. Median glucose values with ranges based on the reflectance based glucose monitoring obtained from women during the first 2 weeks after initiation of dietary management, for the entire study period, and during the last two weeks before delivery are listed in Tables 2, 3, and 4, respectively. Median fasting glucoses decreased over the entire treatment period ($P < .0001$). Two-hour postprandial breakfast and lunch levels also declined ($P < .0001$ and $P < .0004$, respectively); however, 2-hour postprandial dinner glucoses were unchanged ($P = .83$). Quantitatively, the decrease in median blood glucose values for fasting, 2-hour postprandial breakfast, and lunch was only a 1–2-mg/dL difference compared with the median blood glucose during the first 2 weeks of dietary management.

The relationship among median glucose values during the first 2 weeks, the duration of dietary treatment, and during the last 2 weeks before delivery and neonatal outcomes is shown in Tables 5, 6, 7, and 8 for the entire population and Tables 9, 10, 11, and 12 for those women who were diet-controlled only.

For the entire population, after controlling for maternal race and ethnicity, age, parity, body mass index at enrollment, and both gestational age at enrollment and delivery, higher median fasting glucose values during the first 2 weeks after initiation of dietary management were associated with both increased neonatal fat mass and elevated umbilical cord C-peptide levels. The odds ratios and 95% confidence intervals for high fat mass and elevated C-peptide level associated with a 5-mg/dL increase in median fasting blood glucose for the first 2 weeks of dietary management were 1.35 (1.09–1.66) and 1.29 (1.09–1.52), respectively. Median fasting glucose levels during this time period were not associated with

the frequency of large-for-gestational-age neonates, macrosomia, higher birth weight, or neonatal hypoglycemia. Change over time in median fasting glucose was not associated with neonatal outcome. Similarly, median fasting glucose values for the last 2 weeks before delivery were also associated with elevated C-peptide levels (1.19; 1.03–1.38), frequency of large-for-gestational-age neonates (1.27; 1.05–1.53), and macrosomia (1.32; 1.04–1.65) but not increased fat mass, birth weight, or neonatal hypoglycemia.

Of postmeal glucoses, median 2-hour postprandial dinner glucoses both during initiation of dietary management and the last 2 weeks before delivery as well as the entire study period were associated with increased neonatal fat mass and frequency of large-for-gestational-age newborns. Median 2-hour postprandial dinner glucose during the last 2 weeks was also associated with macrosomia, birth weight, and neonatal hypoglycemia. Median 2-hour postprandial lunch glucose during the first 2 weeks was associated with increased neonatal fat mass. Median 2-hour postprandial breakfast glucoses during the last 2 weeks before delivery were associated with increased fat mass. The remainder of the 2-hour postprandial glucoses were not associated with neonatal outcome.

When analyzing the diet-controlled only group, after controlling for maternal race and ethnicity, age, parity, body mass index at enrollment, and both gestational age at enrollment and delivery, higher median fasting glucose during the first 2 weeks of dietary management was associated with elevated C-peptide levels, increased fat mass, and macrosomia. Median fasting glucose during the 2 weeks before delivery was associated with both rates of large for gestational age and macrosomia. Two-hour postprandial dinner glucose during the first 2 weeks was associated with increased fat mass and during the last 2 weeks before delivery was associated with fat mass, large for gestational age, macrosomia, and neonatal hypoglycemia.

DISCUSSION

We found that median fasting glucoses during initiation of dietary treatment for mild gestational diabetes are associated with elevated umbilical cord C-peptide levels and increased neonatal fat mass. Furthermore, median fasting glucose in the 2 weeks before delivery were also associated with increased C-peptide as well as large for gestational age and macrosomia. Our findings are consistent with those of Uvena-Celebrezze et al⁵ who described fasting glucose levels to be associated with neonatal adiposity including percent body fat and increased skinfold thickness in neonates born to women with both diet-controlled and insulin-treated gestational diabetes.

In contrast to previous studies,^{2–4} we did not find a consistent association between postmeal glucose values and birth weight, frequency of large for gestational age, macrosomia, or elevated C-peptide level. However, we were able to demonstrate an association between increased neonatal fat mass and both 2-hour postprandial lunch glucose during the first 2 weeks and postprandial dinner glucose both during the first 2 weeks, the last 2 weeks before delivery, and over the entire study period. Although no consistent association was identified, we found a link between 2-hour postprandial dinner glucose immediately before delivery and rates of large for gestational age, macrosomia, increased birth weight, fat mass, and neonatal hypoglycemia. Our study population of mild gestational diabetes differed from previous studies detailing maternal glycemia, which included either gestational diabetics requiring insulin therapy or women with preexisting diabetes. The study population derived from the randomized controlled trial included women with fasting glucose less than 95 mg/dL, the majority of whom were treated with diet intervention alone. It is plausible that postprandial glucoses may correlate better with neonatal measures of fetal overgrowth and hyperinsulinemia as a reflection of maternal glycemic control in insulin requiring women

with more severe forms of glucose intolerance and thus greater postmeal glucose excursions. Conversely, in women with diet-controlled mild gestational diabetes, fasting glucose, as a measure of basal metabolic function (without glucose load), may better correlate with increased risk for fetal adiposity. It is also plausible that glucose excursions in the time immediately preceding delivery may exert more significant influence on both growth trajectory and fat deposition in utero.

Although fasting glucose levels during the 2-week initiation of dietary treatment were not associated with neonatal birth weight, macrosomia, or higher rates of a large-for-gestational-age fetus, they were associated with both an elevated umbilical cord C-peptide level, a measure of fetal hyperinsulinemia, and neonatal fat mass as measured by anthropometry. We also identified that this association persisted when evaluating median fasting glucoses during the last 2 weeks before delivery. Furthermore, we were able to show that there was a higher rate of macrosomia and large for gestational age in women with higher median fasting glucoses during the last 2 weeks before delivery. The positive relationship between elevated C-peptide levels and increased fetal fat deposition has been previously established.⁹ Our results confirm those of Whitelaw¹⁰ demonstrating that maternal fasting glucose concentration correlated more closely with neonatal skinfold thickness than with birth weight. Fetal insulin production is a direct response to the underlying altered glucose metabolism present in the mother and a powerful growth factor for the fetus. This fuel-mediated process leads to excessive fetal growth and more significantly increased fetal fat accretion. Fetal fat mass may be a more sensitive marker of fetal overgrowth related to the diabetic pregnancy. Catalano et al¹¹ have shown that appropriately grown neonates born to women with gestational diabetes have increased skinfold measurements and greater fat mass despite normal birth weight. These findings were also present among large-for-gestational-age neonates born to gestational diabetic mothers.¹²

Although median fasting and 2-hour postprandial glucoses decreased over the treatment period, the 1-to 2-mg/dL differences observed in these levels between the first 2 weeks of dietary management and the entire study period are unlikely to be of clinical significance. We evaluated the association between glucose levels and neonatal outcomes, including the median glucose values for the first 2-week period after initiation of diet therapy as well as the change in blood glucose levels over the entire study period. This likely provides adequate time to establish whether a woman's glucose levels could be optimized with diet alone. Furthermore, this time period would most accurately reflect the metabolic function of women with mild gestational diabetes treated with diet alone, before the initiation of more aggressive medical management such as insulin. Based on our findings, the baseline maternal metabolic state during the early third trimester of pregnancy appears to influence the risk of excessive fetal growth in women with mild gestational diabetes. Once euglycemia is achieved and maintained throughout the remainder of pregnancy as demonstrated in this well-controlled population, the overall duration of the treatment does not appear to further influence neonatal outcome. However, there still appears to be a benefit for continued treatment, especially in the few weeks preceding delivery, because median fasting glucoses and 2-hour postprandial dinner glucoses immediately before birth were shown to be associated with both fetal overgrowth as defined as large for gestational age and macrosomia in addition to increased fat mass. These findings support the importance of establishing and maintaining tight glycemic control in women with even mild gestational diabetes so as to optimize neonatal outcomes.

In longitudinal population studies, fetal overgrowth and increased neonatal fat mass have been linked to the development of obesity and noninsulin-dependent diabetes mellitus in childhood and adolescence.¹³⁻¹⁶ Furthermore, fetal programming that occurs in response to an altered intrauterine metabolic milieu has been shown to predispose these neonates to

development of the metabolic syndrome in infancy and childhood.^{17,18} Recognizing that the regulation of fetal growth is a complex process, glucose remains the primary substrate contributing to fetal adiposity and glycemia thus remains the focus of clinical efforts in the treatment of diabetic pregnancy.¹ This strategy has immediate neonatal benefit and could potentially improve long-term health for these neonates as well.

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Table 1

Clinical Characteristics of Women Diagnosed With Mild Gestational Diabetes on Dietary Treatment

	Total (N=460)	Diet Alone (n=424)	Received Insulin (n=36)
Maternal age (y)	29.2±5.7	29.2±5.7	29.3±5.8
	29 (15–45)	29 (15–45)	29 (20–42)
Gestational age at enrollment (wk)	28.8±1.6	28.8±1.5	28.6±1.7
	28.9 (25.1–31.9)	28.9 (25.1–31.9)	28.9 (25.1–31.6)
Gestational age at delivery (wk)	39.0±1.6	39.0±1.7	39.0±1.1
	39.1 (26.7–43.4)	39.1 (26.7–43.4)	39.1 (35.7–41.7)
Weight gain since enrollment (kg)	2.7±4.5	2.6±4.6	3.9±3.0
	2.7 (–14.1–14.0)	2.7 (–14.1–14.0)	3.4 (–1.6–10.0)
Race or ethnicity (%)			
African American	11.3	9.4	33.3
Caucasian	25.7	25.7	30.6
Hispanic	57.6	59.9	25.0
Other	5.4	5.0	11.1
Smoking (%)	7.8	7.1	16.7
Alcohol use (%)	4.3	4.5	2.8
Body mass index at enrollment (kg/m ²)	30.1±5.1	29.9±4.9	32.7±5.8
	29.4 (18.9–48.2)	29.2 (18.9–48.2)	32.5 (23.1–44.7)
50-g glucose screening value (mg/dL)	158.8±15.3	158.5±14.9	162.0±19.0
	156 (135–199)	156 (135–199)	159.5 (135–196)

Data are mean±standard deviation, median (range), or %.

Distribution of Median Glucose Values Based on Reflectance-Based Glucose Monitoring for the First 2 Weeks After Initiation of Dietary Management

Table 2

Glucose Value	n	Median	Minimum	25th Percentile	75th Percentile	Maximum
Fasting (mg/dL)	460	81.0	63.5	76.5	87.5	121.0
2-h postprandial breakfast (mg/dL)	460	96.0	70.0	89.0	106.3	154.5
2-h postprandial lunch (mg/dL)	456	102.0	69.5	93.0	110.0	163.0
2-h postprandial dinner (mg/dL)	458	105.5	69.0	98.0	115.0	156.5

Table 3

Distribution of Median Glucose Values Based on Reflectance-Based Glucose Monitoring for Women During the Entire Study Period

Glucose Value	n	Median	Minimum	25th Percentile	75th Percentile	Maximum
Fasting (mg/dL)	460	80.0	63.0	76.0	86.0	116.0
2-h postprandial breakfast (mg/dL)	460	94.5	69.0	87.5	101.0	137.0
2-h postprandial lunch (mg/dL)	460	100.0	73.0	94.0	107.5	139.0
2-h postprandial dinner (mg/dL)	460	105.5	80.0	99.0	113.0	149.0

Distribution of Median Glucose Values Based on Reflectance-Based Glucose Monitoring for Women During the 2 Weeks Before Delivery

Table 4

Glucose Value	n	Median	Minimum	25th Percentile	75th Percentile	Maximum
Fasting (mg/dL)	441	79.0	43.5	74.0	84.0	135.0
2-h postprandial breakfast (mg/dL)	441	92.5	59.0	83.5	102.0	145.5
2-h postprandial lunch (mg/dL)	438	99.0	65.0	91.0	107.0	174.5
2-h postprandial dinner (mg/dL)	433	105.0	71.0	96.0	116.0	186.5

Table 5
Adjusted Odds Ratios and Regression Coefficients for Fasting Glucose Levels and Selected Perinatal Outcomes (Entire Population, Diet-Controlled, and Insulin-Requiring)

Outcome	Median Fasting Glucose First 2 wk [*]	P	Change Over Time in Median Fasting Glucose [*]	P	Median Fasting Glucose 2 wk Before Delivery [†]	P
LGA	1.25 (1.00–1.57)	.05	1.27 (0.73–2.31)	0.40	1.27 (1.05–1.53)	.01
Macrosomia	1.24 (0.95–1.62)	.10	1.38 (0.71–2.77)	0.33	1.32 (1.04–1.65)	.02
High C-peptide	1.29 (1.09–1.52)	.003	1.20 (0.79–1.82)	0.38	1.19 (1.03–1.38)	.02
High fat mass	1.35 (1.09–1.66)	.006	1.01 (0.58–1.74)	0.97	1.21 (1.00–1.45)	.05
Birth weight	4.41±2.30	.06	−2.86±6.32	0.65	3.67±2.03	.07
Hypoglycemia	0.99 (0.82–1.18)	.89	1.33 (0.82–2.22)	0.25	1.02 (0.86–1.20)	.81

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

^{*} Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

[†] Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 6

Adjusted Odds Ratios and Regression Coefficients for Postprandial Breakfast Glucose Levels and Selected Perinatal Outcomes (Entire Population, Diet-Controlled, and Insulin-Requiring)

Outcome	Median Breakfast Postprandial Glucose First 2 wk*	P	Change Over Time in Median Breakfast Postprandial Glucose*	P	Median Breakfast Postprandial Glucose 2 wk Before Delivery†	P
LGA	1.10 (0.95–1.28)	.20	1.07 (0.66–1.64)	.78	1.01 (0.99–1.04)	.43
Macrosomia	1.10 (0.93–1.28)	.27	1.33 (0.78–2.14)	.26	1.01 (0.98–1.03)	.73
High C-peptide	1.01 (0.90–1.12)	.89	1.14 (0.84–1.56)	.40	1.04 (0.94–1.14)	.45
High fat mass	1.08 (0.94–1.24)	.28	0.83 (0.51–1.32)	.45	1.15 (1.02–1.30)	.02
Birth weight	0.63±1.43	.66	4.34±3.9	.27	0.53±1.28	.68
Hypoglycemia	1.01 (0.89–1.14)	.94	1.17 (0.83–1.64)	.37	1.03 (0.93–1.14)	.59

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

† Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 7

Adjusted Odds Ratios and Regression Coefficients for Postprandial Lunch Glucose Levels and Selected Perinatal Outcomes (Entire Population, Diet-Controlled, and Insulin-Requiring)

Outcome	Median Lunch Postprandial Glucose First 2 wk*	P	Change Over Time in Median Lunch Postprandial Glucose*	P	Median Lunch Postprandial Glucose 2 wk Before Delivery [†]	P
LGA	1.09 (0.92–1.27)	.31	1.14 (0.75–1.71)	.54	1.04 (0.91–1.18)	.52
Macrosomia	1.06 (0.87–1.28)	.54	0.85 (0.47–1.45)	.57	0.98 (0.83–1.16)	.85
High C-peptide	0.99 (0.88–1.10)	.80	1.07 (0.81–1.42)	.62	1.00 (0.91–1.10)	.98
High fat mass	1.26 (1.09–1.47)	.003	1.36 (0.91–2.01)	.12	1.13 (0.99–1.27)	.06
Birth weight	2.03±1.54	.19	5.81±3.91	.14	1.39±1.29	.28
Hypoglycemia	0.98 (0.86–1.12)	.79	01.94 (0.69–1.28)	.70	0.98 (0.88–1.09)	.70

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

[†] Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 8

Adjusted Odds Ratios and Regression Coefficients for Postprandial Dinner Glucose Levels and Selected Perinatal Outcomes (Entire Population, Diet Controlled, and Insulin-Requiring)

Outcome	Median Dinner Postprandial Glucose First 2 wk*	P	Change Over Time in Median Dinner Postprandial Glucose*	P	Median Dinner Postprandial Glucose 2 wk Before Delivery [†]	P
LGA	1.23 (1.06–1.42)	.005	1.65 (1.08–2.53)	.02	1.17 (1.06–1.31)	.003
Macrosomia	1.18 (0.99–1.40)	.06	1.37 (0.83–2.24)	.22	1.19 (1.04–1.35)	.009
High C-peptide	1.06 (0.96–1.17)	.28	1.00 (0.77–1.30)	.98	1.04 (0.96–1.13)	.32
High fat mass	1.30 (1.13–1.50)	.0004	2.22 (1.48–3.41)	.0002	1.25 (1.12–1.39)	<.0001
Birth weight	2.18±1.36	.11	5.75±3.60	.11	2.36±1.13	.04
Hypoglycemia	1.10 (0.98–1.23)	.10	1.33 (0.99–1.81)	.06	1.10 (1.01–1.21)	.03

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

[†] Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 9

Adjusted Odds Ratios and Regression Coefficients for Fasting Glucose Levels and Selected Perinatal Outcomes (Diet-Controlled Only)

Outcome	Median Fasting Glucose First 2 wk [*]	P	Change Over Time in Median Fasting Glucose [*]	P	Median Fasting Glucose 2 wk Before Delivery [†]	P
LGA	1.32 (0.98–1.78)	.06	2.03 (0.89–4.70)	.10	1.31 (1.07–1.59)	.008
Macrosomia	1.43 (1.04–1.99)	.03	2.84 (1.03–7.42)	.04	1.37 (1.07–1.72)	.009
High C-peptide	1.32 (1.08–1.62)	.007	1.39 (0.83–2.36)	.20	1.15 (0.98–1.34)	.08
High fat mass	1.41 (1.08–1.85)	.01	1.34 (0.62–3.00)	.47	1.20 (0.97–1.45)	.08
Birth weight	5.07±2.70	.06	4.62±7.64	.55	2.79±2.19	.20
Hypoglycemia	0.99 (0.79–1.24)	.95	1.51 (0.79–3.03)	.23	0.98 (0.81–1.16)	.81

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

^{*} Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

[†] Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Adjusted Odds Ratios and Regression Coefficients for Postprandial Breakfast Glucose Levels and Selected Perinatal Outcomes (Diet-Controlled Only)

Table 10

Outcome	Median Breakfast Postprandial Glucose First 2 wk*	P	Change Over Time in Median Breakfast Postprandial Glucose*	P	Median Breakfast Postprandial Glucose 2 wk Before Delivery†	P
LGA	1.04 (0.87–1.23)	.64	1.14 (0.69–1.79)	.58	1.00 (0.98–1.03)	.67
Macrosomia	1.02 (0.84–1.22)	.86	1.41 (0.81–2.29)	.20	1.00 (0.96–1.03)	.79
High C-peptide	1.00 (0.89–1.13)	.99	1.07 (0.77–1.48)	.69	1.02 (0.92–1.13)	.71
High fat mass	1.02 (0.87–1.19)	.82	0.82 (0.48–1.34)	.43	1.14 (1.10–1.31)	.05
Birth weight	0.38±1.58	.81	5.08±4.16	.22	0.09±1.39	.95
Hypoglycemia	0.97 (0.84–1.11)	.66	1.08 (0.75–1.53)	.68	1.0 (0.89–1.12)	.99

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

† Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 11

Adjusted Odds Ratios and Regression Coefficients for Postprandial Lunch Glucose Levels and Selected Perinatal Outcomes (Diet-Controlled Only)

Outcome	Median Lunch Postprandial Glucose First 2 wk*	P	Change Over Time in Median Lunch Postprandial Glucose*	P	Median Lunch Postprandial Glucose 2 wk Before Delivery [†]	P
LGA	1.08 (0.90–1.29)	.39	1.11 (0.71–1.72)	.64	0.99 (0.85–1.15)	.92
Macrosomia	1.07 (0.87–1.32)	.52	0.83 (0.44–1.47)	.55	0.94 (0.77–1.13)	.54
High C-peptide	0.99 (0.87–1.12)	.85	1.05 (0.79–1.40)	.73	0.96 (0.85–1.06)	.42
High fat mass	1.27 (1.07–1.52)	.006	1.27 (0.82–1.92)	.26	1.07 (0.92–1.23)	.39
Birth weight	1.51±1.69	.37	5.54±4.10	.18	0.14±1.44	.92
Hypoglycemia	0.97 (0.84–1.12)	.71	0.87 (0.63–1.20)	.41	0.98 (0.86–1.10)	.68

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

[†] Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.

Table 12

Adjusted Odds Ratios and Regression Coefficients for Postprandial Dinner Glucose Levels and Selected Perinatal Outcomes (Diet-Controlled Only)

Outcome	Median Dinner Postprandial Glucose First 2 wk*	P	Change Over Time in Median Dinner Postprandial Glucose*	P	Median Dinner Postprandial Glucose 2 wk Before Delivery†	P
LGA	1.18 (0.99–1.39)	.06	1.48 (0.92–2.36)	.10	1.15 (1.02–1.30)	.02
Macrosomia	1.17 (0.96–1.41)	.11	1.25 (0.72–2.11)	.41	1.16 (1.00–1.34)	.04
High C-peptide	1.04 (0.93–1.17)	.48	0.86 (0.63–1.17)	.34	1.04 (0.95–1.14)	.38
High fat mass	1.22 (1.04–1.44)	.02	2.01 (1.30–3.15)	.002	1.21 (1.08–1.37)	.002
Birth weight	1.60±1.51	.29	6.30±4.24	.14	1.83±1.26	.15
Hypoglycemia	1.10 (0.97–1.25)	.13	1.26 (0.90–1.75)	.17	1.12 (1.02–1.24)	.02

LGA, large for gestational age.

Data are odds ratio (95% confidence interval) or beta±standard error unless otherwise specified. Adjusted odds ratios are for outcomes associated with a 5-mg/dL unit increase in glucose levels.

* Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery, median glucose for the first 2 weeks, and change over time in median glucose.

† Covariates included in the regression models were maternal race and ethnicity, maternal age, gestational age at enrollment, parity, prepregnancy body mass index category, gestational age at delivery and median glucose before delivery.