

# Postpartum Dietary Changes in Women With Previous Gestational Diabetes Mellitus

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## ABSTRACT

### OBJECTIVE

Women with gestational diabetes mellitus (GDM) are at high risk of developing type 2 diabetes. This study was conducted to determine whether nutrition education upon diagnosis of GDM resulted in dietary change and whether this change was sustained postpartum.

### METHODS

Women with GDM or impaired glucose tolerance of pregnancy ( $\leq 32$  weeks gestation) ( $n=19$ ) were recruited, and 4-day food records were collected pre-dietary intervention, 2 weeks post-dietary intervention, and 6 weeks and 6 months postpartum. Physical activity was assessed, and glucose tolerance and lipid profiles were also determined postpartum.

### RESULTS

After nutrition education there was a significant increase in protein (% kcal), milk and milk products (servings) and dietary fibre (g) intake, as well as meal frequency (number of meals/day). However, these changes were not subsequently sustained throughout the postpartum period. Physical activity levels did not change, and at 6 months postpartum, 26% of subjects had impaired glucose tolerance and 97% had at least 1 abnormal lipid variable.

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## RÉSUMÉ

### OBJECTIF

Les femmes atteintes de diabète gestationnel (DG) sont très exposées au diabète de type 2. Cette étude a été menée pour déterminer si l'éducation en matière de nutrition au moment du diagnostic de DG se traduisait par des modifications de l'alimentation et si ces modifications se maintenaient après l'accouchement.

### MÉTHODE

Des femmes atteintes de DG ou d'une intolérance au glucose associée à la grossesse ( $\leq 32$  semaines de gestation) ( $n = 19$ ) ont été inscrites à l'étude. On a recueilli les listes de tout ce que les participantes avaient mangé pendant 4 jours avant l'intervention diététique, 2 semaines après l'intervention et 6 semaines et 6 mois après l'accouchement.

### RÉSULTATS

Après la séance d'information en matière de nutrition, on a observé une augmentation significative de la consommation de protéines (% kcal), de lait et de produits laitiers (portions), de fibres alimentaires (g) de même que du nombre de repas par jour. Toutefois, ces modifications ne se sont pas maintenues pendant la période post-partum. Le degré d'activité physique n'a pas changé et, 6 mois après l'accouchement, il y avait une intolérance au glucose chez 26 % des participantes et au moins une des variables lipidiques était anormale chez 97 % d'entre elles.

### CONCLUSIONS

Les femmes atteintes de DG ont modifié leur alimentation pendant la grossesse, mais ces modifications n'ont pas été maintenues par la suite. On recommande que d'autres interventions diététiques soient faites pendant la période post-partum chez les femmes atteintes de DG pour que les modifications effectuées pendant la grossesse soient maintenues.

## CONCLUSIONS

Women with GDM made changes in eating patterns during pregnancy, but these were not maintained postpartum. Further intervention is recommended during the postpartum period for women with GDM to sustain changes made during pregnancy.

## KEYWORDS

Diet, gestational diabetes mellitus, intervention, nutrition, nutrition education

## MOTS CLÉS

Alimentation, diabète gestationnel, intervention, nutrition, éducation en matière de nutrition

## INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as any abnormal carbohydrate intolerance first recognized during pregnancy (1) and occurs in 2 to 4% of pregnant women (1). GDM is associated with risks to the fetus—such as macrosomia, hypoglycemia and jaundice at birth, and glucose intolerance and obesity in the long term—and also with increased risk to the mother of developing type 2 diabetes later in life. The risk of developing diabetes postpartum is approximately 50%, while the risk of developing impaired glucose tolerance (IGT) may be as high as 75% (2,3).

Interventions involving weight reduction and lifestyle changes, such as low-fat, high-fibre diets and increased physical activity, can reduce the incidence of diabetes by as much as 67% in high-risk populations (4,5). Women with GDM are an easily identifiable group at risk of developing diabetes and provide an accessible opportunity for disease prevention that should be a focus of attention.

Upon diagnosis, women with GDM should receive intensive diabetes education, including strategies for dietary and lifestyle modification, information on achieving glycemic control and, in some cases, insulin therapy (1). Ideally, they should be encouraged to continue the diet and lifestyle changes they make during gestation over the long term to prevent future development of diabetes (6), but there is little research to date to determine whether the lifestyle modifications initiated upon diagnosis of GDM are achieved and subsequently sustained throughout the postpartum period. Furthermore, the impact of these lifestyle choices on subsequent health outcomes has not been extensively studied. The purpose of this study was to evaluate whether nutrition education upon diagnosis of GDM or impaired glucose tolerance of pregnancy (IGTP) resulted in dietary modification during pregnancy, and whether this modification was sustained postpartum. The secondary purpose was to investigate the presence of diabetes risk factors during the postpartum period.

## RESEARCH DESIGN AND METHODS

### Subjects

Participants for this study were recruited from September 2000 to December 2001 at the Royal Alexandra Hospital, the Grey Nuns Hospital and the Northern Alberta Clinical Trials

Research Centre in Edmonton, Alberta, Canada. It was a longitudinal pre-test/post-test design, in which the intervention group served as its own control. Nineteen women with GDM agreed to participate in the study.

Glucose tolerance was assessed between weeks 24 and 28 of gestation using the 1-hour 50-g glucose load test taken at any time during the day, with a subsequent 2-hour oral glucose tolerance test (OGTT) using the 75-g glucose load if necessary. A diagnosis of GDM was considered established if the glucose level 1 hour after the 50-g glucose load test was  $>10.3$  mmol/L (1). GDM was also diagnosed when  $\geq 2$  OGTT values were abnormal. IGTP was diagnosed if 1 OGTT value was abnormal. Abnormal OGTT values were defined as a fasting glucose  $\geq 5.3$  mmol/L, 1-hour glucose  $\geq 10.6$  mmol/L and 2-hour glucose  $\geq 8.9$  mmol/L, based on the Canadian Diabetes Association's clinical practice guidelines (1). Only women between 19 and 45 years of age with singleton pregnancies were eligible to participate, and enrollment was required by 32 weeks gestation to allow time for intervention and follow-up appointments. Exclusion criteria included previous diagnosis of GDM, IGT or diabetes, medical conditions that altered dietary practices or limited physical activity, pregnancy during the postpartum period and participation in another research study.

### Study design

Ethical approval was received from the Health Research Ethics Board of the University of Alberta. Participants provided informed consent before participating in the study. Participants were seen at 4 time points for study purposes: at baseline, 2 weeks post-intervention, 6 weeks postpartum and 6 months postpartum. Nutrition data were collected at each time point, and in addition, diabetes risk was assessed through physical activity, weight management and blood parameters at the 6-week and 6-month postpartum visits.

### Intervention component

The intervention component was carried out by diabetes clinic registered dietitians (RDs) trained in the area of GDM as part of standard practice. Each participant completed a diet history with the clinic RD, and a meal plan was pre-

scribed. Participants attended a group nutrition education session, which included the application of prescribed meal plans, meal frequency (i.e. 3 meals/3 snacks), the role of carbohydrates in diabetes, the use of non-nutritive sweeteners, increasing fibre intake, decreasing fat intake, increasing milk consumption, moderate fruit juice consumption and appropriate weight gain. They were also informed about the role of diet and exercise modifications in the prevention of type 2 diabetes (1).

### **Nutrition information**

Dietary intake was assessed using 4 day food records. Study participants were instructed by the study RD (KLF) on how to record their food and beverage intake for 4 consecutive days, including at least 1 weekend day. Food records were analyzed using Food Processor Nutrient Analysis Software version 7.50 (ESHA Research, Salem, Oregon, United States [US]). Mean daily intakes were calculated for energy, carbohydrate, total dietary fibre, protein, fat, saturated fat, vitamin D, folate, calcium and iron. Meal frequency and the number of servings from the 4 food groups of *Canada's Food Guide to Healthy Eating* were also assessed (7).

Diet quality was assessed using the Healthy Eating Index (HEI) developed by the US Department of Agriculture (8). The HEI assesses diet quality based on total fat, saturated fat, cholesterol and sodium intakes, as well as the number of servings from each food group and variety in the diet. Each component has a maximum score of 10 and a minimum score of 0, and a total score is calculated and assessed based on a maximum possible score of 100. An HEI score over 80 implies a "good" diet, a score between 51 and 80 implies a diet that "needs improvement," and a score of <51 implies a "poor diet" (9).

### **Physical activity**

Physical activity data were collected using lifestyle questionnaires. Questions assessed the frequency, duration and intensity of scheduled daily activity, and energy expenditure was calculated using the *Compendium of Physical Activities* (10).

### **Postpartum weight management and body composition**

Weight, height and body mass index (BMI) (weight [kg]/height [m]<sup>2</sup>) were determined after an overnight fast.

### **Laboratory parameters**

Blood samples for serum glucose were taken after fasting and 2 hours following consumption of 75 g of glucose. Blood samples were analyzed by a commercial kit radioimmunoassay. A fasting blood sample was collected for plasma lipid assessment. Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were analyzed in the hospital laboratory using standard methodology. Low-density lipoprotein cholesterol (LDL-C) level was then calculated (TC [mmol/L] – HDL-C [mmol/L] – [TG (mmol/L)/2.2]).

### **Statistical analysis**

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 11.0 (SPSS Inc., Chicago, Illinois, US). Dietary data were entered into SPSS files from the Food Processor Nutrient Analysis Software Program version 7.50. A sphericity test to assess normal distribution of the data was done prior to analysis using the Mauchly's test of sphericity (11). When sphericity was not achieved, Huynh-Feldt adjusted p values were reported. All dietary intakes were analyzed based on within-subject design using repeated measures (11). All variables were analyzed by general linear model repeated measures. Paired t tests were used to investigate whether dietary modifications were achieved and maintained throughout the postpartum period. Type 2 error was minimized for the paired t-tests by using an alpha of p<0.01.

## **RESULTS**

### **Subjects**

All 19 participants completed measurements up to and including the 6 week postpartum visit, and 11 completed the 6 month postpartum visit. Of the 8 participants who did not complete the 6 month follow-up, 1 became pregnant and was no longer eligible for the study. The 7 remaining participants were diagnosed with conditions such as type 2 diabetes (1 participant), high cholesterol (2 participants), IGT (2 participants) or both high cholesterol and IGT (2 participants); they received further interventions from their family physician and were therefore excluded from the final follow-up group.

Descriptive characteristics of participants at baseline are presented in Table 1. Participants were primarily White decent, with 26% representing minority groups. The mean age of participants was 29.8 years. Mean BMI was 28.5 kg/m<sup>2</sup>, and 51.7% of participants had a family history of diabetes. Mean gestational age at diagnosis was 28.0 weeks.

### **Nutrition information**

Table 2 shows dietary intakes of energy, macronutrients, fibre and selected micronutrients at each of the 4 assessment points. Energy, carbohydrate, fat, saturated fat, folate and iron intakes did not change significantly over the study period. There were significant increases in protein (p=0.01) and fibre (p=0.002) intakes at 2 weeks post-intervention compared to baseline, but intakes returned to baseline values at 6 weeks postpartum and continued to be low at the 6 month visit. Vitamin D and calcium intakes did not change significantly from baseline to 2 weeks post-intervention, but calcium intake decreased significantly at both the 6 week (p=0.001) and 6 month (p<0.001) postpartum visits, and vitamin D intake decreased significantly at the 6 month postpartum visit. It should be noted that mean fibre, folate and iron intakes were below desirable levels during the study in comparison with the dietary reference intakes. Calcium and vitamin D intakes were similar to requirements at baseline and at 2 weeks post-intervention, but were below requirements at 6 weeks and 6 months postpartum.

**Table 1. Characteristics of study participants**

Characteristic	Study participants
Age, years*	29.8±5.4
Height, cm*	160.7±6.7
Prepregnancy weight, kg*	73.8±21.5
Prepregnancy BMI, kg/m <sup>2</sup> †	28.5±7.3
GDM/ IGT onset, weeks of gestation*	28.0±2.6
Infant birth weight, g*	3500.3±481.7
Patients needing insulin during pregnancy, %	34.5
Prenatal multivitamin, %	89.5
Folic acid supplement, %‡	10.5
Postsecondary education, %	44.8
Family history of diabetes, %	51.7
Smoker, %	20.6
Breastfeeding at 6 months, %	50.0

\*Data are means±SD

†BMI based on self-reported prepregnancy weight.

‡Folic acid supplement was taken either alone or in conjunction with a prenatal multivitamin supplement that also contained folic acid.

BMI = body mass index

GDM = gestational diabetes mellitus

IGT = impaired glucose tolerance

Food-group analysis showed that milk-product consumption increased significantly from 2.5 servings/day at baseline to 3.5 servings/day at 2 weeks post-intervention ( $p=0.010$ ), then decreased to baseline values at 6 weeks postpartum ( $p<0.001$ ) and to 1.4 servings/day at 6 months postpartum ( $p=0.001$ ). Mean intakes of vegetables and fruit were similar at 5.3 and 5.8 servings/day at baseline and 2 weeks post-intervention, respectively, but decreased significantly at 6 weeks postpartum to 4.2 servings/day ( $p=0.001$ ) and remained low at 6 months postpartum. There was a significant increase in consumption from the “other” food group (high-fat, high-sugar, low-nutrient foods), from 8.5 servings/day at 2 weeks post-intervention to 15.7 servings/day at 6 weeks postpartum ( $p=0.002$ ), and mean intake remained high at 6 months postpartum (17.7 servings/day). No significant differences were observed in mean intakes of grain products and meat and alternatives. Daily meal frequency increased significantly from an average of 4.1

meals/day at baseline to 5.5 meals/day at 2 weeks post-intervention ( $p<0.001$ ), but frequency decreased to baseline values 6 weeks postpartum ( $p<0.001$ ) and remained at baseline levels at 6 months postpartum. Diet quality measured by HEI did not differ significantly over the course of the study, but mean HEI scores ranging from 65 to 74 indicated that the diets of participants needed improvement.

### Physical activity

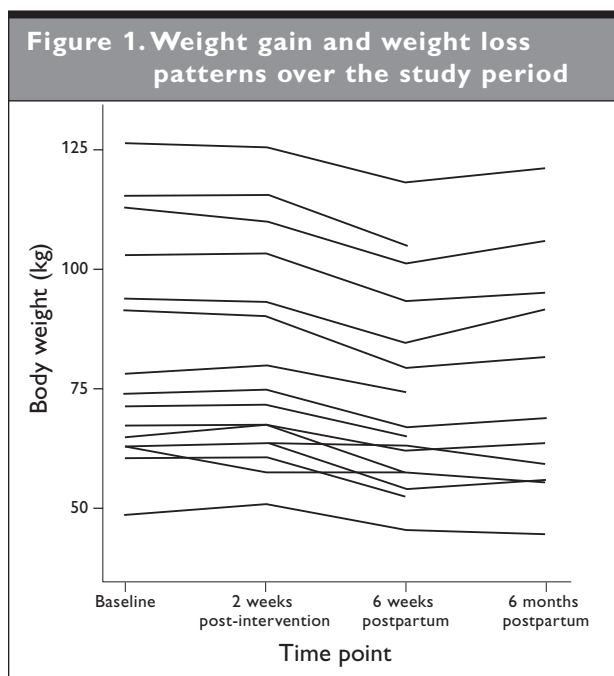
Regular exercise, defined as exercising at least once per week, was reported by 10 (53%) women at baseline, 11 (58%) at 6 weeks postpartum and 4 (37%) of the 11 remaining study participants at 6 months postpartum. Activities reported by participants in order of preference were walking, aerobics, yoga and circuit training. There were no significant differences over the study period in the frequency, time or energy spent doing physical activity. The majority of participants who reported exercising did so less than twice a week and for <1 hour per session.

### Weight management

Figure 1 shows weight gained and lost by each participant over the study period. Body weight did not change significantly over the course of the study, but it tended to increase throughout the pregnancy, decrease slightly at 6 weeks postpartum and increase slightly at 6 months postpartum. By the 6-week postpartum visit, 37% of participants had returned to their pregravid weight, and at the 6-month follow-up, 36% had returned to their pregravid weight.

### Laboratory parameters

Results for glucose and lipid parameters, along with normal values for these variables are shown in Table 3. Mean fasting



**Table 2. Dietary intake of energy, macronutrients, fibre and selected micronutrients**

<b>Variable</b>	<b>Baseline (n=19)</b>	<b>2 weeks post- intervention (n=19)</b>	<b>6 weeks postpartum (n=19)</b>	<b>6 months postpartum (n=11)</b>	<b>p value</b>
Calories, kcal	2004±434	2117±486	1977±467	2033±587	0.199
Carbohydrates, g	264±47	272±56	257±73	263±78	0.662
Protein, g	80±16 <sup>a</sup>	101±23 <sup>b</sup>	78±19 <sup>a</sup>	76±23 <sup>a</sup>	<0.001*
Total fat, g	72±29	75±28	74±22	76±27	0.426
Saturated fat, g	24±11	25±11	25±9	23±9	0.254
Dietary fibre, g	17±6 <sup>a</sup>	25±6 <sup>b</sup>	17±6 <sup>a</sup>	17±4 <sup>a</sup>	0.001*
Vitamin D, µg	5±3 <sup>a</sup>	7±4 <sup>a</sup>	4.5±2 <sup>a</sup>	3±2.5 <sup>b</sup>	<0.001*
Folate, µg	255±104	316±92	281±106	250±129	0.054
Calcium, mg	1041±369 <sup>a</sup>	1349±467 <sup>a</sup>	917±295 <sup>b</sup>	764±363 <sup>bc</sup>	<0.001*
Iron, mg	14±3	16±4.5	14±6	13±5	0.327

Data are means ± SD

\*Indicates overall statistical significance

<sup>abc</sup>Indicate statistical significance of change between assessment points using paired t-tests (p<0.01)

**Table 3. Mean glucose and blood lipid levels**

<b>Variable</b>	<b>6 weeks postpartum (n=19)</b>	<b>6 months postpartum (n=11)</b>	<b>Normal values</b>
FPG, mmol/L	5.26±0.75	5.48±0.80	<6.1 mmol/L*
2 hour OGTT plasma glucose, mmol/L	6.55±1.68	7.59±3.38	<7.8 mmol/L*
TC, mmol/L	5.53±0.95	5.30±1.33	<5.18 mmol/L <sup>†</sup>
HDL-C, mmol/L	1.36±0.29	1.34±0.37	>1.04 mmol/L <sup>†</sup>
LDL-C, mmol/L	3.44±0.87	3.20±1.19	<2.60 mmol/L <sup>†</sup>
TG, mmol/L	1.84±1.29	1.69±0.98	<1.71 mmol/L <sup>†</sup>

Data are means ± SD

\*Canadian Diabetes Association (3)

<sup>†</sup>National Cholesterol Education Program (12)

FPG = fasting plasma glucose

HDL-C = high-density lipoprotein cholesterol

LDL-C = low-density lipoprotein cholesterol

OGTT = oral glucose tolerance test

TC = total cholesterol

TG = triglycerides

and 2-hour plasma glucose levels were within the normal range; however, 26% of study participants at 6 weeks postpartum, and 45% of the remaining 11 participants at 6 months postpartum had IGT. Furthermore, at 6 months postpartum, 1 participant met the criteria for diabetes mellitus.

All lipid parameters were assessed using reference values from the Third Report of the National Cholesterol Education Program (12). Mean total cholesterol (TC) levels at both 6 weeks and 6 months postpartum were slightly higher than normal. Normal TC levels were found in only 37% of participants at 6 weeks postpartum and 55% of participants at the 6 month assessment. Mean HDL-C values fell within the normal range at both assessment points, with 2 participants at the 6 week assessment and 1 participant at the 6 month assessment having low HDL-C levels. Mean LDL-C levels were above the optimal range at both 6 weeks and 6 months postpartum. High LDL-C values were seen in 7 participants at 6 weeks postpartum and 4 participants at 6 months postpartum. Mean TG levels at 6 weeks were slightly above normal, and at 6 months postpartum fell within the desirable range. Twenty-one percent of participants at 6 weeks and 27% of participants at 6 months postpartum had high TG levels. At 6 weeks postpartum, 97% of participants and, at 6 months postpartum, 64% of participants demonstrated increased levels in at least 1 of TC, LDL-C and TG.

## DISCUSSION

This study has revealed several important issues concerning the current treatment of GDM and IGTP and the prevention of future type 2 diabetes. This group of women with GDM or IGTP made favourable dietary changes after nutrition education, including increases in dietary protein, fibre, and milk-product intake and meal frequency. However, none of these changes were sustained in the postpartum period, and in addition, diet quality as assessed by the HEI was poor at all study points, showing no significant improvement with nutrition education. Physical activity, another important part of GDM management and type 2 diabetes prevention, did not change throughout the study period. Postpartum weight and lab parameters confirmed that study participants were at high risk of developing type 2 diabetes in the future. Similar results were found in a study by Stage and colleagues in which women with previous GDM reported that they continued eating high-fat diets, did not lose weight and did not increase their exercise levels 1 to 3 years after pregnancy (13). Both this study and the present study indicate that women with GDM may benefit from further postpartum counselling.

### Nutrition and physical activity

Epidemiological studies have shown that diet and exercise habits are closely related to type 2 diabetes risk. Results from the Nurses' Health Study showed that obesity, lack of physical activity and low-fibre, high-fat diets were associated with an increased risk of diabetes in women aged 30 to 55 years (14).

Furthermore, intervention studies have shown that lifestyle interventions can delay or prevent the occurrence of type 2 diabetes in high-risk individuals. Results from the Finnish Diabetes Prevention Study have shown that with dietary and physical activity counselling and circuit training, 9% of intervention participants developed diabetes within 3 years vs. 20% of controls (15). Similarly, a Japanese intervention involving men with IGT found that dietary and physical activity counselling sessions resulted in a 67% decrease in diabetes risk over 4 years (5). In the present study, women with GDM made dietary changes as a result of nutrition education, including increases in protein, fibre and milk-product intake, as well as in meal frequency, but these changes were not maintained in the postpartum period. Furthermore, overall diet quality was low throughout the study, and decreased milk-product and vegetable and fruit intakes as well as increased intakes from the "other" food group indicate that diet quality may have decreased postpartum. Physical activity, which has been shown to greatly reduce diabetes risk (16), did not change throughout the study, and activity levels were generally low. However, the low levels of physical activity seen in this study could be due to the stresses of pregnancy and caring for a newborn child. A study by Symons and colleagues (17) found that women reported being too tired to exercise during pregnancy and did not have time for activity postpartum. This could explain the low levels of physical activity seen in the present study.

### Weight management

Studies have shown that women with GDM who have a higher BMI after pregnancy (6,18) or with weight gain following pregnancy (19) are at particularly high risk for developing type 2 diabetes in the future. In the present study, body weight did not differ significantly over time, over 60% of participants did not return to their pregravid weight, and some participants gained weight between the 6 week and 6 month postpartum visits. Although longer-term studies are required to better describe this population's weight loss and weight gain patterns postpartum, the absence of weight loss and in some cases weight gain seen in this group may put these women at higher risk for developing type 2 diabetes in the future.

### Laboratory parameters

Although mean blood glucose levels were in the normal range in the present study, 26% of women at the 6 week assessment and 45% of women at the 6 month assessment had IGT. It is well established that the presence of increased glucose values postpartum predict future diabetes in women with GDM (2).

Changes in lipid metabolism have been observed in GDM, but research in this area is scarce, and consistent patterns have not yet been shown. The most commonly shown lipid abnormality is elevated TG levels (20-22), but other studies have also found changes in very low-density lipoprotein (23) and HDL-C (22) levels. In the present study, 4 participants at the

6 week assessment and 3 participants at the 6 month assessment had elevated TG levels, and 2 participants at the 6 week assessment and 1 participant at the 6 month assessment had HDL-C levels below the recommended value. High LDL-C, TG and TC values were common, with all but 2 participants displaying at least 1 abnormal lipid value at 6 weeks postpartum. The blood lipid levels seen in these women may indicate that they are at higher risk of developing diabetes and cardiovascular disease.

### LIMITATIONS

The main limitation of this study is its small sample size. Other limitations include the lack of reference standards for pregnant and lactating women for some variables. HEI, physical activity, blood glucose and blood lipid results were compared to healthy standards for nonpregnant women, which may not be appropriate for this group. For example, in a study by Pick and colleagues, it was found that HEI was a good general measure of diet quality in pregnant women, but did not account for their greater need for some micronutrients, such as folate and iron (24). More research is needed to determine healthy standards for women who are pregnant or in the postpartum period.

### CONCLUSIONS

This study found that women with GDM or IGTP made some appropriate dietary modifications after receiving nutrition education; however, these changes did not result in optimal lifestyle habits conducive to diabetes prevention, and the changes that were made were not sustained over the postpartum period. In addition, more than 60% of participants failed to return to their prepregnancy weight, abnormal blood lipid profiles were found in 97% of participants, and 45% of participants had IGT at postpartum assessments. These data confirm that the women in this study had markers for a high risk of developing type 2 diabetes in the future. The small sample size of the study does not allow generalization of the present results to be made about the population of interest; however, in this group of women, appropriate and sustained postpartum education stressing the importance of nutrition, physical activity and weight management for diabetes prevention may have been beneficial in decreasing risk for diabetes over the long term. Larger, longer-term studies of women with GDM are required to determine the effectiveness of the current diabetes education program for women with GDM and if postpartum education would decrease their future risk of diabetes.

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### AUTHOR DISCLOSURES

No dualities of interest declared.

### AUTHOR CONTRIBUTIONS

KLF contributed to the design of the study and was responsible for all data collection as well as data analysis and interpretation of the data. LEK prepared the manuscript and was responsible for some data analysis and interpretation. LJM contributed significantly to the design and conception of the project and was responsible for critically evaluating content. RCB contributed significantly to the design and conception of the project and was responsible for critically evaluating content. EAR contributed significantly to the original design and original conception of the project and was responsible for critically evaluating content.

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