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Pregravid Physical Activity, Dietary Intake, and Glucose Intolerance During Pregnancy

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Abstract

Objectives: To ascertain prepregnancy physical activity and dietary intake from a sample of women in early pregnancy and estimate the effect of prepregnancy lifestyle behaviors on the 1-hour glucose challenge test (GCT).
Methods: We conducted a prospective analysis of a racially diverse urban-based sample of 152 pregnant women in the first trimester who were participants in the Parity, Inflammation and Diabetes (PID) study. Dietary intake before pregnancy was assessed using a modified version of the Block Rapid Food Screener, and leisure time physical activity before pregnancy was assessed using the Baecke questionnaire. Test results from a nonfasting oral GCT conducted between 26 and 28 weeks were abstracted from the medical record. Participants were classified as having a positive GCT if the blood glucose measurement was ≥140 mg/dL and as negative with a blood glucose measurement <140 mg/dL. We constructed a series of multiple logistic regression models, adjusting for potential confounders to determine if prepregnancy dietary intake and leisure activity were associated with response to the GCT.
Results: Women with higher prepregnancy leisure activity scores were 68% less likely to have a 1-hour GCT response ≥140mg/dL. However, there was no association between dietary intake and response to the GCT.
Conclusions: Our data suggest that prevention of an abnormal GCT result should include practices to encourage women of reproductive age to engage in leisure physical activity in advance of planning a pregnancy.

Introduction

Efforts to identify women at risk for developing gestational diabetes (GDM) have traditionally focused on sociodemographic characteristics, family history of type 2 diabetes, and maternal adiposity. There is an emerging body of literature investigating the effect of pregravid and early pregnancy lifestyle behaviors on the risk of developing GDM.[1–12] Growing interest in this area stems, in part, from early studies of predictive factors for developing type 2 diabetes. GDM is considered to be a transient unmasking of an underlying predisposition to type 2 diabetes, and like type 2 diabetes, GDM is characterized by β-cell dysfunction, impaired insulin secretion, and insulin resistance.

Promotion of healthy lifestyle behaviors is part of the effort to reduce adverse pregnancy outcomes among women with varying degrees of glucose intolerance during pregnancy that is less severe than overt diabetes. The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study confirmed findings from earlier work that varying levels of glucose intolerance, short of diabetes, affect fetal glucose metabolism, adiposity, and risk of cesarean delivery.[13] Although the biologic mechanisms underlying pregravid lifestyle behaviors and glucose intolerance are not entirely understood, it is postulated that both GDM and type 2 diabetes result from biologic interactions between genetic predispositions and acquired lifestyle behaviors, including dietary habits, physical activity, and gestational weight gain.

The role of physical activity in reducing the risk of GDM and gestational glucose intolerance has been fairly consistent. Several studies show that prepregnancy physical activity[2,3,5,6,8,11] and physical activity during early pregnancy reduced the risk of developing GDM[2,3,5,6,8] and few studies reported no association.[1,4] Few studies examined the role of physical activity among pregnant women with abnormal glucose tolerance (AGT) determined by the 1-hour glucose challenge test (GCT), and these studies reported no association.[1,14,15] In contrast, the role of diet in the reduction of GDM

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remains unclear, as studies thus far have found little consistency.[7,9,10,12] Furthermore, two studies examined the relationship between dietary intake and AGT and found no association.[14,16] Variations in study conclusions may be a result of limitations in study design, self-reported GDM rather than a diagnosis based on actual glucose levels, and incomplete adjustment for correlations between individual nutrients. In addition, prior studies have been conducted in samples with a high proportion of highly educated white women. There are few data on pregravid dietary patterns and glucose intolerance in a racially diverse sample or among disadvantaged populations.

Our objectives were to (1) describe pregravid dietary intake and leisure activity in a racially diverse cohort of pregnant women using validated questionnaires, (2) determine the presence and magnitude of association of dietary intake and leisure activity on glucose tolerance as measured by maternal response to the GCT, and (3) estimate the association among individual dietary components, leisure activity, and response to the GCT, independent of gestational weight gain at 26–28 weeks' gestation. Understanding the relationship between dietary intake and maternal glucose tolerance may elucidate pathways contributing to the diabetes epidemic and can inform the development of preconception interventions that reduce the risk of AGT in pregnancy and subsequent type 2 diabetes.

Materials and Methods

We conducted a prospective analysis of data from the Parity, Inflammation and Diabetes (PID) study to examine the association between prepregnancy dietary intake and leisure activity and response to the 1-hour GCT in a sample of urban pregnant women. This study was approved by the institutional review board of the Johns Hopkins School of Medicine.

The PID study is an ongoing prospective study of pregnant women recruited in the first trimester between 2006 and 2008 from an academic medical center. The goal of the PID study is to determine if maternal sociodemographic factors, clinical factors, and physiologic measures before pregnancy are predictive of the development of GDM in late pregnancy. Women were recruited at their first prenatal visit and were deemed eligible if they (1) were <14 weeks gestation, (2) had no self-reported or documented history of preexisting diabetes mellitus, and (3) were able to provide informed consent for participation in the study. An interview was administered, and a blood sample was taken. Nonfasting glucose and insulin levels were measured at baseline to identify participants with preexisting glucose intolerance at enrollment. Data were abstracted from the medical record, and blood samples were obtained at baseline, second trimester, third trimester, and after delivery. Of the 326 women recruited into the study, 236 met eligibility criteria. Of these, 198 had complete data at the time of the analysis. Participants without GCT results were excluded from the analysis ($n=37$), and 9 participants had missing values for variables of interest. The final sample for analysis was 152. The PID study was powered based on the continuous outcome of the 1-hour GCT response level. For this analysis, we assumed 80% power to detect a 10% difference in glucose levels by leisure activity score. A p value of <0.5 was considered significant. The women included in the analytic sample were similar to those excluded except that the excluded women had slightly lower dietary intake scores (all $p<0.05$).

Exposure variables

Dietary intake before pregnancy was assessed using a modified version of the Block Rapid Food Screener[17] at the baseline interview. The Rapid Food Screener developed by Block et al. is effective in identifying persons with high-fat intake or low-fruit/vegetable intake. The screener was compared to the gold standard, the 1995 Block 100-item Food Frequency Questionnaire (FFQ). The food screener ranked subjects similarly to estimates from the Block full-length FFQ. Spearman rank-order correlation coefficient ($r>0.60$) showed good ranking with respect to dietary intake from total fat, saturated fat, dietary cholesterol, and percent calories from fat. There was excellent correlation of the screener with servings of fruits and vegetables ($r=0.71$). We calculated screener scores for dietary intake of fruit and vegetables, meat, and snacks using the Block algorithm. These scores were used in the calculation of daily servings of fruit and vegetables, daily total fat intake (grams), daily saturated fat intake (grams) daily dietary cholesterol intake (grams) and daily percent fat intake using equations derived by Block et al.[17] All the dietary intake variables were left as continuous variables in the analysis.

Leisure time physical activity before pregnancy was assessed by interview at baseline using a questionnaire. This questionnaire, developed by Baecke et al.,[18] is commonly used in epidemiologic studies, is designed to measure habitual physical activity, and has reported test-retest reliability of the leisure time index as 0.74. A leisure activity index was derived at baseline that ranged from 1 (low activity) to 5 (high activity). We categorized this variable using the median (2.75) and compared low leisure activity (<2.75) with high leisure activity (≥ 2.75).

Outcome variable

Participants were screened by their clinician for GDM between 26 and 28 weeks' gestation as part of their routine obstetric care with a nonfasting oral GCT in which venous blood was sampled 1 hour after a 50-g oral glucose load. The GCT was administered without regard to the time elapsed since the last meal, in accordance with the American College of Obstetricians and Gynecologists (ACOG) practice recommendations. Test results were abstracted from the medical record. Participants were classified as having a positive GCT if the blood glucose measurement was ≥ 140 mg/dL and as negative with a blood glucose measurement <140 mg/dL.

Covariates

Maternal age, race (white non-Hispanic or Hispanic, black, other), marital status, years of education, and income were obtained via self-report in a personal interview. Marital status was categorized into two groups: single/separated/divorced and married. Years of education completed was categorized as <13 years, 13–16 years, and >16 years. Annual household income was categorized into four groups: $<$\$25,000, \$25,001–\$35,000, \$35,000–\$50,000, and $>$\$50,000. Parity was obtained by self-report and categorized into three groups: no previous live births, 1 live birth, and >1 live birth. Family history was obtained via self-report; participants were classified as having a family history of diabetes if they responded yes to having a first-degree relative (mother, father, or sibling) with diabetes. Prepregnancy weight, weight at the time of GCT, and height were abstracted from the medical record. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and categorized according to National Institutes of Health (NIH) guidelines: optimal, BMI $<25\,kg/m^2$; overweight, BMI 25–29.9 kg/m^2; obese, BMI $\geq 30\,kg/m^2$.

Statistical analysis

We conducted descriptive analyses (calculated mean and frequencies) for sociodemographics, health variables, dietary intake, and leisure activity for the study sample subsequently by BMI category. The distribution of participant sociodemographics, health variables, dietary intake, and leisure activity across BMI groups were compared using chi-square tests for categorical variables and analysis of variance (ANOVA) for continuous variables. To determine if prepregnancy dietary intake and leisure activity were associated with response to the GCT, we conducted an analysis using multiple logistic regression. We developed a series of models adjusting for potential confounders. Covariates were added to the model in a stepwise fashion: first sociodemographic variables (age, race, education, parity, gestational weight gain) then prepregnancy BMI were added. All analyses were conducted using STATA statistical software, version 9.0 (Stata Corporation, College Station, TX). All tests of significance were two-tailed.

Results

Participant characteristics

Overall, the mean age of the study participants was 30.1 years. Most of the participants were either black (30.9%) or white (45.4%), and approximately a quarter were categorized as other (Table 1). The study participants were well educated, with almost half (47.4%) having >16 years of education. The majority of the participants were married (76.5%), and 23.7% were single, divorced, or separated. More than half of the study population had an annual income >$50,000, and more than half were nulliparous (54.6%). In addition, almost 20% had a family history of diabetes. On average, participants' prepregnancy BMIs indicate that they were fairly lean ($25.8 \pm 6.4\,kg/m^2$), and they had gained 10.0 kg at the time of the GCT. The gestational weight gain decreased with increasing BMI category, with participants classified as normal weight having the highest weight gain (10.7 kg) and obese women having the least weight gain (8.2 kg).

The mean daily intake of fruits and vegetables among all the study participants was 4.8 servings per day. The mean daily intake of saturated fat was 25.6 g, and daily percent fat intake was 35.5%. Daily cholesterol intake was 265.2 g and daily total fat intake was 86.4 g. There was no significant difference in fruit and vegetable intake and daily cholesterol by BMI status, although there was a significant increase in daily saturated fat, percent fat, and total fat intake with increasing BMI category. The mean leisure activity score was 2.64 (range 1.25–4.25, median 2.75) for all participants. The mean response to the 1-hour oral GCT was 113.4 mg/dL (range 55–198, median 111.5 mg/dL). Although women with a prepregnancy BMI in the normal weight category had a lower mean response (110.5 ± 25.6 mg/dL) compared to overweight (116.6 ± 30.4 mg/dL) and obese women (119.8 ± 28.9 mg/dL), the difference was not statistically significant. Moreover, compared to participants with a leisure score <2.75 and participants with a leisure score ≥2.75, there was no significant difference in mean response to the 1-hour oral GCT by leisure activity category (111.8 ± 22.9 mg/dL vs. 115.15 ± 31.4 mg/dL).

Table 1. Sociodemographic Characteristics of Participants in Parity, Inflammation and Diabetes Study (n = 152)

Sociodemographic characteristics[a]	
Age, years	30.1 ± 5.2
Marital status	
Single/divorced/separated	36 (23.7)
Married	116 (76.5)
Education, years[b]	
<13	23 (15.1)
13–16	57 (37.5)
>16	72 (47.4)
Race	
White	69 (45.4)
Black	47 (30.9)
Other	36 (23.7)
Income[b]	
<$25, 000	15 (11.4)
$25,001–$35,000	13 (9.9)
$35,001–$50,000	20 (15.2)
>$50,000	84 (63.6)
Parity	
No previous live births	83 (54.6)
1	50 (32.9)
>1	19 (12.5)
Family history of type 2 diabetes	
Yes	30 (19.7)
No	122 (80.3)
Prepregnancy weight (kg)	68.0 ± 17.3
Prepregnancy body mass index (kg/m^2)	25.8 ± 6.4
Gestational weight gain (kg)[c]	10.0 ± 4.4
Dietary scores	
Fruit and vegetables score	15.2 ± 4.9
Fruit and vegetable (servings per day)	4.8 ± 1.8
Meat score	22.4 ± 8.6
Saturated fat (g)	25.6 ± 7.6
Percent fat (%)	35.5 ± 5.2
Cholesterol (g)	265.2 ± 63.1
Total fat (g)	86.4 ± 20.7
Physical activity	
Leisure activity score	2.64 ± 0.6
Glucose response	
1 hour response to 50-g oral glucose tolerance test (mg/dL)	113.4 ± 27.3

[a]All results presented an n (%) or mean ± standard deviation.
[b]$n = 132$.
[c]Gestational weight gain up to the time of glucose challenge test ~26–28 weeks.

Multivariable associations

In the unadjusted analysis, there were no statistically significant relationships between dietary intake variables and

Table 2. Multivariable Associations of Prepregnancy Dietary Intake and Leisure Activity and Glucose Tolerance in Parity, Inflammation and Diabetes Study (n = 152)

	Unadjusted	*Model 1*[a]	*Model 2*[b]
Dietary variables			
Fruit and Vegetables score	1.01 (0.92-1.11)	1.00 (0.91-1.10)	1.01 (0.91-1.12)
Meat score	1.01 (0.96-1.06)	1.02 (0.96-1.08)	1.02 (0.96-1.08)
Fruit and vegetable (servings per day)	1.03 (0.81-1.31)	1.01 (0.78-1.29)	1.03 (0.78-1.37)
Saturated fat	1.01 (0.95-1.07)	1.02 (0.96-1.09)	1.02 (0.96-1.09)
Percent fat	1.01 (0.93-1.10)	1.04 (0.94-1.14)	1.03 (0.94-1.14)
Cholesterol	1.00 (0.99-1.01)	1.00 (1.00-1.01)	1.00 (0.99-1.01)
Total fat	1.00 (0.98-1.02)	1.01 (0.98-1.03)	1.01 (0.98-1.03)
Physical activity			
Leisure activity score ≥ 2.75 vs. < 2.75[c]	0.31* (0.12-0.79)	0.30* (0.11-0.82)	0.32* (0.12-0.86)

[a]Model 1 includes race, age, parity, gestational weight gain.
[b]Model 2 includes covariates in model 1 and prepregnancy body mass index.
[c]Leisure activity score was categorized using the median 2.75.
*$p < 0.05$.

the 1-hour GCT response ≥ 140mg/dL (Table 2). Compared to participants with leisure score < 2.75, however, participants with a leisure score ≥ 2.75 were 69% less likely to have a 1-hour GCT response > 140 mg/dL. After adjustment for sociodemographic factors (age, race, parity) and gestational weight gain, compared to participants with leisure score < 2.75, participants with a leisure score ≥ 2.75 were 70% less likely to have a 1-hour GCT response > 140 mg/dL. After the addition of prepregnancy BMI to the model, there was a slight attenuation in that participants with a leisure score ≥ 2.75 were 68% less likely to have a 1-hour GCT response >140 mg/dL compared to participants with a leisure score < 2.75.

Discussion

We conducted a prospective analysis to estimate the effect of prepregnancy dietary intake and physical activity on subsequent response to the 1-hour GCT in an urban-based sample. We found that women with higher prepregnancy leisure activity scores were less likely to have a 1-hour GCT result ≥140 mg/dL. However, we found no association between dietary intake and response to the 1-hour GCT.

Our finding of an association between prepregnancy leisure activity and response to the GCT is not consistent with three earlier studies that discount the influence of physical activity on GCT.[1,14,15] However, our finding is consistent with earlier studies examining the relationship between prepregnancy physical activity and GDM. These studies consistently report a reduction in risk of GDM with increasing levels of physical activity during pregnancy.[2,3,5,6,8] Our findings are also consistent with studies focused on groups at high risk for type 2 diabetes. Diabetes prevention trials using exercise and weight reduction interventions have shown a 56% reduction in the incidence of diabetes in a population with impaired glucose tolerance.[19,20] Therefore, it is feasible that increased prepregnancy leisure activity may be related to lower levels of glucose with the GCT. Participants with higher prepregnancy leisure activity scores may be more likely to maintain a substantial level of physical activity throughout pregnancy.[21] In addition, participants with higher prepregnancy leisure activity scores may be leaner, and maintaining physical activity during pregnancy may prevent excessive weight gain during pregnancy, a known risk factor for the development of GDM. Moreover, participants with higher prepregnancy leisure activity scores may have healthier lifestyles that protect against altered glucose metabolism. An alternative explanation for the association of prepregnancy activity and the 1-hour GCT response may involve neuroendocrine pathways. Emerging evidence suggests that insulin resistance can affect neurohormonal mechanisms and the ability to engage in regular physical activity.

We found no association between prepregnancy dietary intake and response to the 1-hour GCT. This lack of association was also reported by two previous studies that examined dietary food intake in early pregnancy and response to the GCT.[14,16] Our results, however, differ from other studies that reported that a diet high in total fat [9] and saturated fat[22] was associated with increased risk of GDM, whereas diets high in polyunsaturated fats[10,22] were associated with decreased risk of GDM.

Our study has several strengths. This is a prospective longitudinal study of a group of urban women in the Baltimore metropolitan area. To our knowledge, this is one of few studies to assess the association between prepregnancy dietary intake and leisure activity and response to the GCT. Other studies have examined the relationship between prepregnancy dietary intake or early pregnancy dietary intake and GDM.

There are several limitations that deserve comment. Prepregnancy weight was self-reported, and it is known that heavier women tend to underestimate their weight.[23] Women with higher BMI tend to underreport intake of all foods and nutrients.[24,25] This may bias the observed relationship between dietary intake and response to the 1-hour GCT to the null. We did not assess occupational activity because there was no variation in the physical demands of the occupations reported by the participants. Finally, study participants were well educated, with fairly high incomes, and, therefore, results may not be generalizable to other populations.

Our data suggest that prevention of an abnormal GCT result should include practices to encourage women of reproductive age to engage in leisure physical activity in advance of planning a pregnancy. Avenues of access to promote health include educational programs discussing the need to increase physical activity to build leaner bodies that metabolize food more efficiently. In the obstetric areas, preconception counseling about the consequences of overweight and obesity and a sedentary lifestyle before and during pregnancy need to be addressed.

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Disclosure Statement

The authors have no conflicts of interest to report.

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