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Physical activity before and during pregnancy and risk of abnormal glucose tolerance among Hispanic women

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Abstract

Aim—Women diagnosed with abnormal glucose tolerance and gestational diabetes mellitus are at increased risk for subsequent type 2 diabetes, with higher risks in Hispanic women. Studies suggest that physical activity may be associated with a reduced risk of these disorders; however, studies in Hispanic women are sparse.

Methods—We prospectively evaluated this association among 1241 Hispanic participants in Proyecto Buena Salud. The Pregnancy Physical Activity Questionnaire was used to assess pre, early, and mid pregnancy physical activity. Medical records were abstracted for pregnancy outcomes.

Results—A total of 175 women (14.1%) were diagnosed with abnormal glucose tolerance and 57 women (4.6%) were diagnosed with gestational diabetes. Increasing age and body mass index were strongly and positively associated with risk of gestational diabetes. We did not observe statistically significant associations between total physical activity or meeting exercise guidelines and risk. However, after adjusting for age, BMI, gestational weight gain, and other important risk factors, women in the top quartile of moderate-intensity activity in early pregnancy had a decreased risk of abnormal glucose tolerance (odds ratio = 0.48, 95% Confidence Interval 0.27–0.88, $P_{\text{trend}} = 0.03$) as compared to those in the lowest quartile. Similarly, women with the highest levels of occupational activity in early pregnancy had a decreased risk of abnormal glucose tolerance (odds ratio = 0.48, 95% Confidence Interval 0.28–0.85, $P_{\text{trend}} = 0.02$) as compared to women who were unemployed.

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Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Conclusion—In this Hispanic population, total physical activity and meeting exercise guidelines were not associated with risk. However, high levels of moderate-intensity and occupational activity were associated with risk reduction.

Keywords

Epidemiology; Gestational diabetes; Hispanic; Physical activity; Prospective

1. Introduction

Both gestational diabetes mellitus (GDM) and milder glucose intolerance in pregnancy identify women who are at high risk for type 2 diabetes [1,2]; women with a history of GDM have a 7-fold risk for future type 2 diabetes [3]. Recently, studies designed to identify the diagnostic threshold between maternal hyperglycemia and adverse perinatal outcomes have observed a consistent, continuous increase in risk of adverse pregnancy outcomes over the range of maternal blood glucose levels, even at degrees not diagnostic of GDM [4].

Epidemiologic studies have been fairly consistent in showing a reduced risk of GDM for women who were active prior to pregnancy, while studies of activity during pregnancy have been somewhat less consistent [5]. However, these studies faced a number of limitations. The majority failed to use a physical activity questionnaire validated among pregnant women, limited their assessment to recreational activities only, measured activity only once during pregnancy or relied on measures of activity collected after pregnancy [6]. In addition, most studies were conducted among predominantly non-Hispanic white women [5]. During pregnancy, household and occupational activities constitute a significant proportion of physical activity [7], particularly among Hispanic women who report generally low levels of recreational physical activity during pregnancy [8].

The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women, in the absence of contraindications, engage in 30 minutes or more of physical activity of at least moderate intensity on most, if not all, days of the week [9]. Hispanics are half as likely as non-Hispanics whites to meet ACOG guidelines [8]. This is critical as Hispanics are the largest minority group in the U.S., with the highest birth and immigration rates of any minority group [10]. Hispanics from the Caribbean islands (i.e., Puerto Ricans and Dominicans) are the 2nd largest group of Hispanics living in the U.S. [10], the fastest growing subgroup, and the largest Hispanic subgroup in the northeast U.S. [11,12]. As compared to other Hispanics, Puerto Ricans and Dominicans experience the greatest health disparities, the highest prevalence of type 2 diabetes, and exhibit more adverse health behaviors such as poor nutrition [13–15].

Therefore, our objective was to prospectively examine the relationship between physical activity during pre, early, and mid pregnancy and risk of abnormal glucose tolerance (AGT) and GDM.

2. Methods

2.1. Setting

Proyecto Buena Salud was based in the ambulatory obstetrical practices of Baystate Health, an integrated health system in Western Massachusetts from 2006 to 2011. Details of the study have been previously published [16]. Briefly, the overall goals were to evaluate the association between psychosocial stress, physical activity and risk of GDM among Hispanic women. Bilingual interviewers recruited patients at a prenatal care visit early in pregnancy (up to 20 weeks gestation), informed them of the aims and procedures of the study, and obtained written informed consent as approved by the Institutional Review Boards of the University of Massachusetts-Amherst and Baystate Health. Interviews were conducted in Spanish or English (based on patient preference) in order to eliminate potential language or literacy barriers.

At the time of enrollment (mean = 12.4 weeks gestation), interviewers collected information on socio-demographic, acculturation, and behavioral factors including pre-pregnancy physical activity (one year prior to the pregnancy). Information on behavioral factors was updated in mid pregnancy (mean = 21.3 weeks gestation). After delivery, medical records were abstracted for medical and obstetric history and clinical characteristics of the current pregnancy.

2.2. Eligibility

Eligibility was restricted to women of Puerto Rican or Dominican Republic heritage (Caribbean Islanders). Women who:

- were themselves born in the Caribbean Islands, or;
- had a parent born in the Caribbean Islands, or;
- had at least 2 grandparents born in the Caribbean Islands were included.

Additional exclusion criteria included:

- current medications thought to adversely influence glucose tolerance;
- multiple gestation;
- history of diagnosis of diabetes, hypertension, heart disease or chronic renal disease;
- < 16 years of age or over 40 years of age.

A total of 1626 prenatal care patients were enrolled in Proyecto Buena Salud. For the current analysis, we excluded participants who experienced a miscarriage, did not deliver at Baystate, were not screened for GDM, or were missing information on physical activity during all pregnancy time periods resulting in a final sample of 1241 participants (Fig. 1). Reasons for missing physical activity information during pregnancy included lack of time due to being called into the medical exam, inability to locate women at the clinic or over the telephone (e.g., due to disconnected telephone), and preterm delivery.

2.3. Physical activity

Physical activity during pre-pregnancy (1 year prior) and early pregnancy was assessed at the time of enrollment and updated during the mid-pregnancy interview using a modified version of the Pregnancy Physical Activity Questionnaire (PPAQ), a semi-quantitative questionnaire validated for use during pregnancy [17]. The PPAQ evaluates participation in household/caregiving, occupational, sports/exercise, and transportation. The duration of time spent on each activity was summed and multiplied by its intensity as defined by the Compendium of Physical Activities [18]. Moderate-intensity activity was defined as 3–6 METs and vigorous activity as > 6 METs. Total physical activity (total MET-hrs/day) of light-intensity and above was also calculated. Each physical activity variable was then divided into quartiles with the highest (fourth) quartile reflecting the highest levels of activity. Due to low numbers of employed women during pregnancy, occupational activity was divided into 3 categories: unemployed, low (below the median MET-hrs/day among employed women) and high (above the median MET-hrs/day among employed women). Due to low participation in vigorous activity during pregnancy, this variable was dichotomized as yes, no.

Women with > 7.5 MET-hrs/week in sports/exercise activities of moderate-intensity or greater (i.e., 30 minutes per day of activity at 3 METs multiplied by 5 days per week) were considered to have met the ACOG physical activity guideline [9].

2.4. AGT and GDM

Baystate Health routinely screens all prenatal care patients for GDM between 24–28 weeks gestation (mean = 27.3 weeks gestation). The screening test consists of a non-fasting oral glucose challenge test in which venous blood is sampled 1 hour after a 50-g oral glucose load. If the plasma glucose concentration is > 135 mg/dL, a 3 hour 100-g glucose tolerance test is performed. Diagnosis of GDM was confirmed by an obstetrician who reviewed the medical records of each suspected case and defined as 2 or more elevated values at fasting, and 1, 2, and 3 hours, respectively, based on the American Diabetes Association criteria of 95, 180, 155, and 140 mg/dL [19]. Diagnosis of impaired glucose tolerance (IGT) was defined as exceeding one 1 or more elevated values at fasting, and 1, 2, and 3 hours, respectively. Finally, a positive screen (> 135 mg/dL) on the oral glucose challenge test was used to define AGT.

2.5. Covariates

At the time of enrollment, interviewers collected information on age, education, annual household income, marital status, living situation (i.e., with a partner/spouse), and number of children under 18 years and adults in the household. Interviewers also collected information on language preference for speaking/reading (English, Spanish) and generation in the Continental U.S. Alcohol consumption and cigarette smoking were assessed using questions designed by the Pregnancy Risk Assessment Monitoring System (PRAMS) [20]. Pre-pregnancy body mass index (BMI), gestational weight gain, parity, family history of type 2 diabetes, and clinical characteristics of the current pregnancy were abstracted from medical records. If pre-pregnancy weight was missing from the medical record, it was based upon self-reported pre-pregnancy weight collected at the time of enrollment.

2.6. Data analysis

Logistic regression was used to model the relation between physical activity at each pregnancy time point and AGT and GDM, respectively. Odds ratios (ORs) and 95% confidence intervals (CI) compared participants in each quartile of activity to those in the lowest quartile. Tests of trend were calculated by modeling physical activity quartiles as ordinal variables (i.e., 1, 2, 3, 4).

Multivariable logistic regression models included factors associated with GDM in the prior literature (i.e., age and BMI). Confounding was assessed by evaluating changes in the ORs for physical activity when each covariate was included in the regression model. A change of 10% or greater was used as an indicator of confounding. Based on this technique, age, pre-pregnancy BMI, educational status, and generation in the US were confounders of the relationship between physical activity and AGT. Gestational weight gain might be on the causal pathway between physical activity and AGT. Therefore, we included multivariable models with and without adjustment for gestational weight gain.

Statistical analysis was conducted using SAS 9.3 software by SAS Institute Inc. (SAS Campus Drive, Cary, North Carolina).

3. Results

Among the 1241 study participants, a total of 175 women (14.1%) were diagnosed with AGT and 57 women (4.6%) were diagnosed with GDM. Overall, the majority of participants (71%) were less than 24 years of age (Table 1). Approximately 42% of participants were nulliparous, 46% were overweight or obese, and 69% had a family history of diabetes. Although 89% of women were not married, approximately 50% were living with a spouse/partner. A total of 47% of participants were born outside the Continental US and 23% preferred Spanish for speaking/reading. Increasing age, pre-pregnancy BMI, and a prior history of GDM were strongly and positively associated with GDM risk (Table 1).

We first assessed the relationship between pre-pregnancy activity and risk of AGT and GDM (Table 2). In unadjusted analyses, there were no statistically significant associations between meeting ACOG guidelines for exercise and AGT or GDM risk. Similarly, there were no significant associations between total pre-pregnancy physical activity, or intensity or type of activity, and AGT or GDM risk. In multivariable analyses adjusting for age, BMI, and gestational weight gain, findings were essentially unchanged (Table 2).

We then examined the association between early pregnancy physical activity and risk of AGT and GDM (Table 3). After adjusting for age, pre-pregnancy BMI, educational status, and generation in the US, there were no statistically significant associations between meeting exercise guidelines or total physical activity and AGT or GDM risk. However, after adjusting for age, BMI, gestational weight gain, and other important risk factors, women in the top quartile of moderate intensity activity in early pregnancy had a decreased risk of AGT as compared to those in the lowest quartile (OR = 0.48, 95% CI 0.27–0.88, $P_{\text{trend}} = 0.03$). In addition, women with the highest levels of occupational activity had a decreased risk of AGT (OR = 0.48, 95% CI 0.28–0.85, $P_{\text{trend}} = 0.02$) as compared to women who were

unemployed. We did not observe statistically significant associations between vigorous-intensity activity, household/caregiving activity, or sports/exercise and AGT or GDM risk.

Findings for mid pregnancy activity were similar to those for early pregnancy activity but were attenuated and no longer statistically significant (Table 4). We did not observe significant associations between meeting exercise guidelines, total physical activity, or activities of other types and intensities and AGT or GDM risk.

We then repeated analyses using tertiles instead of quartiles of physical activity as well as dichotomizing physical activity variables at the median value; findings were virtually unchanged. We also repeated the analyses with IGT as the outcome variable of interest; however, as findings did not substantively differ from the analyses with GDM as the outcome variable, this data was not shown. Finally, participants missing physical activity information did not differ statistically from those not missing information in terms of age, education, income, insurance, marital status, number of children and adults in the household, generation in the U.S., alcohol consumption, cigarette smoking, BMI, parity, or history of GDM. However, they were more likely to prefer to speak/read English (81.5% vs. 74.4%, $P = 0.005$), be highly acculturated (23.8% vs. 18.4% $P = 0.034$), and have a family history of diabetes (31.0% vs. 27.2%, $P = 0.035$).

4. Discussion

In this prospective cohort of 1241 pregnant Hispanic women, we did not observe statistically significant associations between high levels of total physical activity or meeting exercise guidelines during pregnancy and risk of AGT or GDM. However, we found that women with high levels of moderate-intensity activity during early pregnancy had an approximately 50% decreased risk of AGT as compared to those in the lowest quartile. Similarly, women with the highest levels of occupational activity in early pregnancy had over a 50% decreased risk of AGT as compared to women who were unemployed. We did not observe significant associations between vigorous-intensity activity, household/caregiving activity, or sports/exercise and risk of AGT or GDM.

Our findings for early pregnancy activity are consistent with the majority of prior studies conducted among in non-Hispanic white women [5]. In the only prior study limited to Hispanic women, the Latina Gestational Diabetes Mellitus Study, Schmidt et al. similarly found that total physical activity was not associated with GDM. However, women in the highest quartile of pre-(OR = 0.2, 95% CI 0.1–0.8, $P_{\text{trend}} = 0.03$) and mid-(OR = 0.2, 95% CI 0.1–0.8, $P_{\text{trend}} = 0.004$) pregnancy household/caregiving activities had a reduced risk of GDM as compared to women in the lowest quartile [21]. Women with high levels of mid-pregnancy sports/exercise (0.1, 95% CI 0.0–0.7, $P_{\text{trend}} = 0.12$) had a comparable reduction in risk. However, physical activity was assessed via the Kaiser Physical Activity Survey (KPAS) [22] which uses a Likert-scale type measure of physical activity (ranging from 1–5) making it difficult to identify the actual amount of activity necessary to reduce risk.

To our knowledge, prior studies have not evaluated the relationship between occupational activity and GDM or AGT. Similarly, few studies have assessed the relationship between physical activity and AGT; several finding that physical activity either before or during

pregnancy decreased AGT risk [23–25] while others did not [26]. For example, in Project Viva, a cohort study of 1805 predominantly non-Hispanic women in Eastern Massachusetts, Oken et al. found that women who reported vigorous activity before pregnancy and light-to-moderate activity during pregnancy had a non-statistically significant lower risk of AGT (OR = 0.70, 95% CI 0.49–1.01) and GDM (OR = 0.49, 95% CI 0.24–1.01) as compared to those who did not report these activities in either time period [23]. Similarly, we found that women with high levels of moderate-intensity activity and occupational activity in early pregnancy had an approximately 50% reduced risk of AGT.

Differences in study findings are likely due to variation in the measures of physical activity as well as racial/ethnic and sociodemographic differences between study samples. In the current study, moderate-intensity activity was defined as any activity of 3–6 METs of any type (i.e., household/caregiving, sports/exercise, occupational activity, and transportation) and was not limited to sports/exercise only as in the majority of prior studies. Hispanic women are less likely to engage in vigorous-intensity activities and sports/exercise as compared to non-Hispanic white populations [8]. In the current study, 10 women with AGT and 2 women with GDM reported any vigorous intensity activity in mid-pregnancy as compared to 51 and 15 cases, respectively, in the Project Viva study population [23]. This may explain, in part, our lack of statistically significant associations with vigorous-intensity activity.

This study has several limitations. The small number of GDM cases overall constrained our ability to evaluate the association between physical activity and GDM risk. On the other hand, our observed rates of AGT (14.1%) and GDM (4.6%) were comparable to those observed in similarly designed prospective cohort studies. For example, Rudra et al. observed GDM rates of 4.6% in the Omega Study, a prospective cohort of predominantly white women in Washington State (0% Hispanic) [27]. Oken et al. observed incidence rates of 17.3% and 5.0% for AGT and GDM, respectively in Project Viva [23]. While the wide confidence intervals observed for total activity and sports/exercise do not rule out reduction in risk for more active women, at the same time, the majority of confidence intervals do not provide statistically significant evidence. Finally, given the relatively large number of physical activity variables, we cannot rule out chance as explanation for the observed positive findings. In this case, it is critical that the interpretation of the findings from each individual model be interpreted conservatively and in light of a feasible biologic rationale. However, only a minority of *P* values were statistically significant. In addition, we relied upon established cut points for intensity of physical activity as opposed to an approach derived from our dataset.

We relied on a self-reported measure of physical activity which may have resulted in misclassification and therefore biased our results towards the null. However, due to the prospective nature of the study, reporting of physical activity should not be influenced by AGT or GDM diagnosis. In addition, unlike the majority of prior studies, we used a measure of activity validated in pregnant women. Gestational weight gain might be on the causal pathway between physical activity and AGT. However, there was no substantive difference in findings with and without adjustment for gestational weight gain.

Finally, unemployed women served as the referent group for our evaluation of occupational activity. Differences in risk between employed and unemployed women may be confounded by income and other sociodemographic factors. While these factors were considered in our multivariable models for AGT, we were limited to adjusting for age and BMI for the GDM analysis.

In summary, in this prospective cohort study of Hispanic women, after controlling for important diabetes risk factors, moderate-intensity activity in early pregnancy was associated with a reduced risk of AGT, and occupational activity in early pregnancy was associated with a reduced risk of both AGT and GDM. Our observed associations are consistent with the findings of prior studies conducted among predominantly non-Hispanic white populations and suggest that early maternal lifestyle modifications in pregnant women might offer the opportunity not only for reduction in risk of GDM, but also reduction in risk of perinatal complications in their offspring. The impact of these maternal lifestyle modifications, if sustained postpartum, is likely to be greatest in ethnic groups, such as Hispanics, with consistently high incidence rates of type 2 diabetes.

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Fig. 1.
Recruitment and retention of participants; Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Table 1

Baseline participant characteristics by gestational diabetes mellitus (GDM); Proyecto Buena Salud, Western Massachusetts, 2006–2011.

	Total population				GDM			
	n ^b	%	n	%	Cases		Age-adjusted	
					n	%	OR	95% CI
Total	1241	100.0	57	4.6				
Age (years)								
< 19	390	31.4	8	2.1	1.01	0.40		2.59
19–23 years	493	39.7	10	2.0	1.00	Referent		
24–29 years	210	16.9	17	8.1	4.25	1.91		9.46
30	148	11.9	22	14.9	8.43	3.89		18.27
Educational status								
Less than high school	548	47.3	16	2.9	1.00	Referent		
High school graduate	381	32.9	23	6.0	1.75	0.90		3.44
Some college/graduate	229	19.8	13	5.7	1.35	0.62		2.94
Annual household income								
< \$15,000	346	27.9	21	6.1	1.00	Referent		
> \$15,000–\$30,000	173	13.9	14	8.1	1.13	0.55		2.33
> \$30,000	80	6.5	2	2.5	0.27	0.06		1.19
Don't know/Refused/Missing	642	51.7	20	3.1	0.56	0.29		1.08
Marital status								
Single/divorced/separated/widowed	1001	89.0	40	4.0	1.00	Referent		
Married	124	11.0	10	8.1	1.37	0.65		2.90
Live with spouse/partner								
No	568	49.7	17	3.0	1.00	Referent		
Yes	575	50.3	35	6.1	1.83	1.00		3.35
Pre-pregnancy body mass index (BMI)								
Underweight and normal (< 25 kg/m ²)	665	54.3	15	2.3	1.00	Referent		
Overweight (25–< 30 kg/m ²)	281	23.0	20	7.1	2.63	1.31		5.31
Obese (30 or greater kg/m ²)	278	22.7	22	7.9	2.87	1.44		5.73
Parity								

		GDM			
		Total population		Cases	
		n ^b	%	n	%
					Age-adjusted OR 95% CI
0		514	41.7	15	2.9
1		378	30.7	25	6.6
2		340	27.6	17	5.0
Family history of diabetes					
No		765	68.8	29	3.8
Yes		347	31.2	23	6.6
History of gestational diabetes mellitus					
No		1172	99.0	51	4.4
Yes		12	1.0	3	25.0
Language preference for speaking/reading					
English		959	77.3	34	3.5
Spanish		282	22.7	23	8.2
Generation in the continental US ^a					
First generation		564	46.9	36	6.4
Second generation		568	47.3	16	2.8
Third generation		70	5.8	1	1.4

^aFirst generation: born in Puerto Rico/Dominican Republic (PR/DR) or parent born in PR/DR; second generation: born in US but parents born in PR/DR; third generation: born in US, parents born in US, grandparents born in PR/DR.

^bNumbers may not total to 1241 due to missing data.

Table 2

Unadjusted and multivariable odds ratios of abnormal glucose tolerance (AGT) and gestational diabetes mellitus (GDM) according to pre-pregnancy physical activity; Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Physical activity variable ^a	AGT				GDM							
	Cases		Adjusted ^c		Adjusted ^d		Cases		Age and BMI-adjusted		Adjusted ^d	
	n	%	OR	95% CI	OR	95% CI	n	%	OR	95% CI	OR	95% CI
Met exercise guidelines ^b												
Yes	100	13.9	1.00	Referent	1.00	Referent	33	4.7	1.00	Referent	1.00	Referent
No	61	14.5	1.09	0.76	1.56	1.49	19	4.6	1.01	0.55	1.83	0.52
Total physical activity												
1st quartile	42	15.7	1.00	Referent	1.00	Referent	12	4.5	1.00	Referent	1.00	Referent
2nd quartile	30	11.5	0.67	0.40	1.13	0.67	13	5.1	1.20	0.52	2.76	1.17
3rd quartile	38	13.9	0.81	0.49	1.33	0.82	14	5.2	1.13	0.50	2.57	1.15
4th quartile	39	14.7	0.94	0.57	1.53	0.96	9	3.4	0.79	0.32	1.97	0.84
P-trend			0.95			0.97			0.64			0.76
Moderate-intensity												
1st quartile	44	15.9	1.00	Referent	1.00	Referent	15	5.5	1.00	Referent	1.00	Referent
2nd quartile	44	15.7	1.07	0.67	1.72	1.08	13	4.7	0.97	0.44	2.14	1.00
3rd quartile	32	11.7	0.72	0.43	1.19	0.71	14	5.2	1.07	0.49	2.35	1.08
4th quartile	36	13.2	0.91	0.56	1.50	0.95	9	3.3	0.69	0.29	1.66	0.75
P-trend			0.40			0.47			0.51			0.63
Vigorous-intensity												
No	107	13.8	1.00	Referent	1.00	Referent	36	4.7	1.00	Referent	1.00	Referent
Yes	56	14.9	1.05	0.73	1.51	1.06	16	4.3	0.90	0.48	1.69	0.91
Household/caregiving												
1st quartile	40	14.0	1.00	Referent	1.00	Referent	13	4.6	1.00	Referent	1.00	Referent
2nd quartile	40	13.8	0.88	0.54	1.44	0.90	18	6.3	1.25	0.58	2.69	1.27
3rd quartile	40	14.4	0.91	0.56	1.49	0.93	11	4.0	0.73	0.31	1.71	0.75
4th quartile	42	14.5	0.89	0.55	1.45	0.91	10	3.5	0.61	0.26	1.45	0.64
P-trend			0.70			0.77			0.13			0.17
Occupational												

Physical activity variable ^a	AGT						GDM					
	Cases			Adjusted ^c			Adjusted ^d			Age and BMI-adjusted		
	n	%	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
1st quartile	45	15.6	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
2nd quartile	41	14.9	1.12	0.68	1.82	1.12	0.68	1.83	1.8	6.6	2.98	1.26
3rd quartile	35	12.7	0.97	0.58	1.64	0.97	0.58	1.63	8	2.9	1.38	0.51
4th quartile	36	13.0	0.97	0.58	1.64	0.82	0.49	1.37	15	5.5	2.05	0.86
P-trend			0.38			0.38				0.34		
Sports/exercise												
1st quartile	37	13.1	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
2nd quartile	46	16.2	1.18	0.72	1.92	1.18	0.72	1.93	19	6.7	1.76	0.78
3rd quartile	41	13.9	0.98	0.59	1.62	1.03	0.62	1.72	11	3.8	0.96	0.39
4th quartile	37	13.3	1.01	0.61	1.68	1.06	0.64	1.77	12	4.4	1.26	0.52
P-trend			0.85			0.97				0.95		

^a Each physical activity variable was included independently in individual regression models.

^b Meeting American College of Obstetricians and Gynecologists guidelines of > 7.5 MET hrs/week in sports/exercise activities of moderate-intensity or greater.

^c Adjusted for age (continuous), pre-pregnancy BMI, educational status, and generation in the US.

^d Additionally adjusted for total gestational weight gain according to 2009 Institute of Medicine guidelines.

Table 3

Unadjusted and multivariable odds ratios of abnormal glucose tolerance (AGT) and gestational diabetes mellitus (GDM) according to early pregnancy physical activity; Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Physical activity variable ^a	AGT				GDM							
	Cases		Adjusted ^c		Adjusted ^d		Cases		Age and BMI-adjusted		Adjusted ^d	
	n	%	OR	95% CI	OR	95% CI	n	%	OR	95% CI	OR	95% CI
Met exercise guidelines ^b												
Yes	38	13.7	1.00	Referent	1.00	Referent	14	5.1	1.00	Referent	1.00	Referent
No	85	14.5	1.12	0.73	1.73	1.15 0.74	1.78	26	4.5	0.91	0.45	1.83 0.93 0.46
Total physical activity												
1st quartile	36	17.8	1.00	Referent	1.00	Referent	12	5.9	1.00	Referent	1.00	Referent
2nd quartile	27	13.2	0.70	0.40	1.24	0.74 0.41	1.31	5	2.5	0.43	0.14	1.27 0.45 0.15
3rd quartile	28	13.0	0.60	0.34	1.07	0.63 0.35	1.12	12	5.6	0.92	0.39	2.18 1.00 0.42 2.40
4th quartile	28	14.4	0.63	0.36	1.12	0.64 0.36	1.14	9	4.7	0.69	0.27	1.73 0.72 0.28 1.83
P-trend			0.10			0.11			0.72			0.80
Moderate-intensity												
1st quartile	39	18.8	1.00	Referent	1.00	Referent	11	5.3	1.00	Referent	1.00	Referent
2nd quartile	30	13.4	0.61	0.35	1.05	0.60 0.34	1.04	13	5.9	1.12	0.47	2.65 1.10 0.46 2.65
3rd quartile	31	14.6	0.65	0.38	1.12	0.63 0.36	1.10	9	4.3	0.76	0.30	1.94 0.74 0.29 1.92
4th quartile	23	11.7	0.49	0.27	0.89	0.48 0.27	0.88	7	3.6	0.64	0.24	1.76 0.64 0.23 1.77
P-trend			0.03			0.03			0.29			0.29
Vigorous-intensity												
No	113	14.7	1.00	Referent	1.00	Referent	35	4.6	1.00	Referent	1.00	Referent
Yes	11	11.2	0.70	0.35	1.39	0.71 0.36	1.41	5	5.2	1.07	0.39	2.89 1.10 0.40 2.99
Household/caregiving												
1st quartile	35	16.8	1.00	Referent	1.00	Referent	6	2.9	1.00	Referent	1.00	Referent
2nd quartile	29	13.4	0.65	0.37	1.14	0.65 0.37	1.16	15	7.0	2.75	0.99	7.58 2.88 1.02 8.13
3rd quartile	26	12.3	0.58	0.32	1.03	0.57 0.31	1.02	7	3.3	1.08	0.34	3.41 1.10 0.34 3.51
4th quartile	32	15.6	0.67	0.38	1.18	0.66 0.37	1.16	12	6.0	1.88	0.66	5.36 1.87 0.65 5.39
P-trend			0.16			0.14			0.71			0.76
Occupational												

Physical activity variable ^a	AGT						GDM					
	Cases			Adjusted ^c			Cases			Age and BMI-adjusted		
	n	%	OR	95% CI	OR	95% CI	n	%	OR	95% CI	OR	95% CI
Unemployed	66	16.4	1.00	Referent	1.00	Referent	23	5.8	1.00	Referent	1.00	Referent
Low	36	15.1	0.92	0.57	1.47	0.92	11	4.7	0.82	0.38	1.77	0.84
High	22	10.0	0.47	0.27	0.82	0.48	6	2.7	0.39	0.15	0.99	0.41
<i>P</i> -trend			0.01		0.02				0.05			0.07
Sports/exercise												
1st quartile	54	13.4	1.00	Referent	1.00	Referent	18	4.5	1.00	Referent	1.00	Referent
2nd quartile	6	18.2	1.70	0.64	4.52	1.40	2	6.1	1.51	0.31	7.30	1.19
3rd quartile	35	15.3	1.25	0.77	2.03	1.27	10	4.4	1.11	0.49	2.51	1.13
<i>P</i> -trend	28	14.2	1.04	0.62	1.74	1.02	10	5.1	1.07	0.47	2.44	1.05
<i>P</i> -trend			0.68		0.69				0.85			0.86

^a Each physical activity variable was included independently in individual regression models.

^b Meeting American College of Obstetricians and Gynecologists guidelines of > 7.5 MET hrs/week in sports/exercise activities of moderate-intensity or greater.

^c Adjusted for age (continuous), pre-pregnancy BMI, educational status, and generation in the US.

^d Additionally adjusted for total gestational weight gain according to 2009 Institute of Medicine guidelines.

Table 4

Unadjusted and multivariable odds ratios of abnormal glucose tolerance (AGT) and gestational diabetes mellitus (GDM) according to mid-pregnancy physical activity; Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Physical Activity Variable ^a	AGT				GDM							
	Cases		Adjusted ^c		Adjusted ^d		Cases		Age and BMI-adjusted		Adjusted ^d	
	n	%	OR	95% CI	OR	95% CI	n	%	OR	95% CI	OR	95% CI
Met exercise guidelines ^b												
Yes	41	14.6	1.00	Referent	1.00	Referent	12	4.3	1.00	Referent	1.00	Referent
No	75	14.9	0.99	0.64	1.53	0.63	1.51	23	4.7	1.06	0.49	2.28
Total physical activity												
1st quartile	27	15.1	1.00	Referent	1.00	Referent	5	2.8	1.00	Referent	1.00	Referent
2nd quartile	30	15.7	0.94	0.52	1.71	0.98	1.78	11	5.9	1.83	0.59	5.67
3rd quartile	25	13.2	0.75	0.40	1.38	0.76	1.41	9	4.8	1.26	0.39	4.06
4th quartile	27	14.0	0.82	0.45	1.51	0.83	1.52	8	4.3	1.24	0.38	4.05
P-trend			0.40			0.41			0.999			0.997
Moderate-intensity												
1st quartile	35	18.7	1.00	Referent	1.00	Referent	7	3.8	1.00	Referent	1.00	Referent
2nd quartile	26	13.4	0.68	0.38	1.21	0.69	1.23	10	5.3	1.63	0.57	4.65
3rd quartile	22	11.3	0.51	0.28	0.92	0.51	0.93	8	4.2	0.99	0.33	2.95
4th quartile	31	16.1	0.81	0.46	1.43	0.81	1.42	9	4.8	1.17	0.40	3.45
P-trend			0.32			0.31			0.96			0.96
Vigorous-intensity												
No	107	15.4	1.00	Referent	1.00	Referent	33	4.9	1.00	Referent	1.00	Referent
Yes	10	11.0	0.75	0.37	1.53	0.74	1.51	2	2.2	0.55	0.12	2.43
Household/caregiving												
1st quartile	31	16.5	1.00	Referent	1.00	Referent	8	4.3	1.00	Referent	1.00	Referent
2nd quartile	30	14.9	0.70	0.39	1.24	0.70	1.25	12	6.1	0.94	0.35	2.55
3rd quartile	26	13.0	0.63	0.35	1.13	0.63	1.15	7	3.6	0.64	0.21	1.93
4th quartile	27	13.8	0.66	0.36	1.19	0.65	1.17	8	4.2	0.67	0.23	1.95
P-trend			0.16			0.15			0.35			0.37
Occupational												

Physical Activity Variable ^a	AGT						GDM					
	Cases			Adjusted ^c			Cases			Age and BMI-adjusted		
	n	%	OR	95% CI	OR	95% CI	n	%	OR	95% CI	OR	95% CI
Unemployed	57	14.3	1.00	Referent	1.00	Referent	15	3.8	1.00	Referent	1.00	Referent
Low	27	14.4	1.09	0.65	1.83	1.07	7	3.8	1.07	0.41	2.81	1.06
High	30	15.8	1.08	0.64	1.81	1.06	12	6.5	1.49	0.64	3.46	1.46
<i>P</i> -trend			0.75			0.81			0.37			0.40
Sports/exercise												
1st quartile	47	15.5	1.00	Referent	1.00	Referent	15	5.1	1.00	Referent	1.00	Referent
2nd quartile	7	10.6	0.64	0.26	1.57	0.66	3	4.8	0.88	0.22	3.53	0.87
3rd quartile	32	15.0	1.00	0.60	1.67	1.01	9	4.2	0.88	0.36	2.16	0.84
4th quartile	30	15.1	1.05	0.63	1.78	1.08	8	4.1	0.89	0.35	2.27	0.87
<i>P</i> -trend			0.80			0.74			0.77			0.72

^a Each physical activity variable was included independently in individual regression models.

^b Meeting American College of Obstetricians and Gynecologists guidelines of > 7.5 MET hrs/week in sports/exercise activities of moderate-intensity or greater.

^c Adjusted for age (continuous), pre-pregnancy BMI, educational status, and generation in the US.

^d Additionally adjusted for total gestational weight gain according to 2009 Institute of Medicine guidelines.