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Associations of Physical Activity and Inactivity Before and During Pregnancy With Glucose Tolerance

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Abstract

OBJECTIVE—To investigate associations of physical activity and television viewing before and during pregnancy with risk of gestational diabetes mellitus (GDM) and abnormal glucose tolerance, the combination of GDM with less severe impaired glucose tolerance.

METHODS—We assessed duration and intensity of physical activity and time spent viewing television both before and during pregnancy among 1,805 women enrolled in Project Viva, a cohort study in eastern Massachusetts. We identified 1,493 (83%) women with normal glucose tolerance and 312 (17%) with abnormal glucose tolerance, including 91 (5%) with GDM based on clinical glucose tolerance test results.

RESULTS—After adjustment for age, race or ethnicity, history of GDM, family history of diabetes, and prepregnancy body mass index, our data suggest that women who engaged in any vigorous physical activity in the year before pregnancy experienced a reduced risk of GDM (odds ratio [OR] 0.56, 95% confidence interval [CI] 0.33–0.95) and abnormal glucose tolerance (OR 0.76, 95% CI 0.57–1.00). Women who reported vigorous activity before pregnancy and light-to-moderate or vigorous activity during pregnancy appeared to have a lower risk of both GDM (OR 0.49, 95% CI 0.24–1.01) and abnormal glucose tolerance (OR 0.70, 95% CI 0.49–1.01) compared with women reporting these activities in neither time period. Walking and total physical activity provided modest benefits. We observed no association of television viewing before or during pregnancy with risk of GDM or abnormal glucose tolerance.

CONCLUSION—Physical activity, especially vigorous activity before pregnancy and at least light-to-moderate activity during pregnancy, may reduce risk for abnormal glucose tolerance and GDM.

Gestational diabetes mellitus (GDM) complicates 2–5% of pregnancies in the United States and is associated with increased rates of medical complications of pregnancy as well as longer-term risks such as obesity and type 2 diabetes for both mother and child.[1,2] An even larger proportion of pregnant women develop abnormal glucose tolerance, which incorporates the more common but less extreme impaired glucose tolerance as well as frank GDM and also confers increased risk of adverse maternal and offspring outcomes.[3–6] Other than maternal weight, established risk factors, including advanced maternal age, nonwhite race or ethnicity, parity, previous delivery of a macrosomic infant, and family history of diabetes,[1,7,8] are not

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readily amenable to change. Research to identify modifiable factors that might help prevent abnormal glucose tolerance and diabetes is of urgent public health importance.

Strong evidence from observational studies suggests that physical activity prevents type 2 diabetes in adult men and women,[9,10] whereas inactivity, especially television viewing, is associated with increased risk for diabetes.[11] Randomized trials among women with GDM have demonstrated that physical activity reduces glucose levels.[12,13] Some previous observational studies have found that physical activity before pregnancy reduces risk for GDM,[14,15] although none has evaluated associations with abnormal glucose tolerance.

The purpose of the present study was to examine the associations of physical activity and television viewing, both before and during pregnancy, with risk for GDM and abnormal glucose tolerance. We used data from Project Viva, a prospective cohort study with information about behaviors, both before and during pregnancy, as well as a wide set of potential confounding factors. We hypothesized that physical activity either before or during pregnancy would result in lower risks of both GDM and abnormal glucose tolerance.

PARTICIPANTS AND METHODS

We recruited women attending their initial prenatal visit at one of eight urban and suburban obstetric offices in a multispecialty group practice in eastern Massachusetts from 1999 to 2002, as summarized previously.[16,17] All mothers provided written informed consent, and all procedures were in accordance with ethical standards for human experimentation.[18] The human subjects committee of Harvard Pilgrim Health Care approved all study protocols.

We enrolled 63% of eligible participants, resulting in 2,128 women who delivered live infants. We excluded from analysis women with a history of type 1 or type 2 diabetes (n = 20), who had no measurement of blood glucose concentration during pregnancy (n = 24), who did not report any information on physical activity or television viewing (n = 259), or who had missing information on prepregnancy body mass index (BMI) or history of GDM (n = 20), leaving 1,805 available for inclusion in this analysis. Women not included were less likely to be white (37% versus 71% of those included), but rates of GDM and abnormal glucose tolerance did not differ among excluded compared with included white and nonwhite women. Among the 1,805 included participants, 1,638 women provided information about behaviors during the year before pregnancy, and 1,581 women provided information about behaviors during pregnancy.

At the initial study visit (mean 10.4 weeks of gestation), participants completed a questionnaire regarding their physical activity habits during the 12 months before pregnancy. They reported average weekly hours spent in three classes of recreational activity, namely walking (“for fun or exercise, including to or from work, but not at work”), light-to-moderate physical activities (“such as yoga, bowling, stretching classes, and skating, not including walking”), and vigorous physical activities (“such as jogging, swimming, cycling, aerobic class, skiing, or other similar activities”). We used a questionnaire modified from the leisure time activity section of the Physical Activity Scale for the Elderly (PASE).[19] Modifications included the following: Instead of using the previous 7 days as the time referent, we asked women to average their weekly activity over the year before pregnancy and to report average hours per week rather than both days per week and hours per day. We also combined light and moderate activities. Our choice of examples of activities was influenced by the PASE, the Paffenbarger physical activity questionnaire,[20] and knowledge of activities common to women in the northeastern United States. Women also reported the average number of hours per week they had spent watching television or videos. At 26–28 weeks of gestation, using the same questions, women reported average physical activity and television viewing during the preceding 3 months.

To allow comparison with previously published studies, we classified light-to-moderate activity, vigorous activity, and combined light-to-moderate and vigorous activity as none versus any reported. Subdividing these variables into additional categories did not yield substantively different results. We defined total physical activity as time spent in walking, light-to-moderate activities, and vigorous activities combined and analyzed this exposure in categories that might translate to specific recommendations: 2 hours or less, 3–6 hours, 7–13 hours, and 14 hours or more weekly (less than 30 minutes, 30 minutes to less than 1 hour, 1 to less than 2 hours, and 2 or more hours daily). We defined sedentary lifestyle as 2 or fewer weekly hours of total physical activity, based upon current recommendations that adults, including pregnant women, should accumulate at least 30 minutes of exercise a day.[21,22]

In the study population women were routinely screened for gestational diabetes at 26–28 weeks of gestation with a nonfasting oral glucose challenge test in which venous blood was sampled 1 hour after a 50-g oral glucose load. If the 1-hour glucose result was at least 140 mg/dL, the participant was referred for a 100-g fasting glucose 3-hour tolerance test. Normal results were a blood glucose below 95 mg/dL at baseline, below 180 mg/dL at 1 hour, below 155 mg/dL at 2 hours, and below 140 mg/dL at 3 hours.[8] We categorized participants with a normal screening glucose challenge as having normal glucose tolerance and those who failed the challenge test as having abnormal glucose tolerance. We classified those with at least two abnormal results on the fasting glucose tolerance test as having GDM. For the 30 participants with an abnormal glucose challenge test but no 3-hour tolerance test performed, we reviewed all laboratory results, including random finger-stick glucose and the text of the clinical medical record, to identify 19 cases of GDM.

We collected information on maternal age, race/ ethnicity, parity, education, marital status, and smoking history, all reported by the women at their first study visit. We calculated prepregnancy BMI (kg/m^2) from self-reported height and weight. Each woman reported her history of gestational diabetes in prior pregnancies and whether her mother had a history of diabetes mellitus. We obtained clinically measured prenatal weights from the medical record and calculated gestational weight gain before 26 weeks as the difference between the last pregnancy weight before 26 weeks of gestation and the self-reported prepregnancy weight.

We used multivariable logistic regression to fit separate models investigating associations of physical activity with risk of abnormal glucose tolerance and GDM. Exposures of interest were walking, light-to-moderate activity, vigorous activity, combined light-to-moderate and vigorous activity, time spent in total physical activity, sedentary lifestyle, and time spent in television viewing, all assessed both before and during pregnancy. We evaluated associations between television viewing and physical activity using Spearman correlation.

We also evaluated the combined effects of activity before and during pregnancy. Because we believed it likely that many women who engaged in vigorous activity before pregnancy would continue activity during pregnancy but might reduce the intensity, we compared women who reported vigorous activity before pregnancy and light-to-moderate or vigorous activity during pregnancy with women who reported no vigorous activity before pregnancy and no light-to-moderate or vigorous activity during pregnancy.

We included as covariates participant characteristics that have previously been reported to be important predictors of gestational diabetes, namely age (less than 25, 25–34, 35–39, and 40 years or older), race/ethnicity (white, nonwhite), history of gestational diabetes (yes, no, nulliparous), prepregnancy BMI (continuous), and mother's history of diabetes (yes, no, unknown). Adjustment for other characteristics, including education, marital status, smoking, and weight gain before 26 weeks of gestation, did not result in material changes in the magnitudes of the observed associations between physical activity and outcomes, and thus we did not include these variables in the final models. Although we did assess diet during pregnancy, we did not include dietary factors such as intake of total energy, fat, carbohydrates, fiber, or glycemic load in the present analysis because diet was not associated with glucose tolerance in this cohort.

We explored whether prepregnancy BMI might modify associations of physical activity and television viewing with risk of abnormal glucose tolerance using multiplicative interaction terms and stratification.[23] Because of small numbers within strata, we could not perform analyses stratified by BMI using GDM as an outcome. Because parous women might change their behaviors based on experiences in prior pregnancies, we also performed analyses restricted to nulliparous women.

We report adjusted odds ratios for each exposure compared with the reference category. To obtain the *P* value for trend across categories of total physical activity, we analyzed the median number of hours of activity within each category as a continuous predictor. We used estimates from the multivariate models and the observed population means and prevalence to calculate the adjusted risk difference and its reciprocal, the “number needed to treat.” We used SAS 8.2 (SAS Institute, Cary, NC) for all analyses.

RESULTS

Among the 1,805 study participants, we identified 1,493 (83%) women with normal glucose tolerance and 312 (17%) with abnormal glucose tolerance, including 91 (5%) with GDM. Approximately one third of the participants were nonwhite, including 13% black and 6% Hispanic women. Mean (standard deviation [SD]) age was 32.1 (5.0) years, and prepregnancy BMI was 24.6 (5.2) kg/m^2. Compared with women who had normal glucose tolerance, women with GDM or abnormal glucose tolerance were more likely to be older, to be overweight or obese, to be Hispanic or Asian, to have a history of GDM in a previous pregnancy, and to have reported a history of diabetes in their own mothers (Table 1). Mean (SD) weight gain at 26 weeks of gestation was 8.06 (3.9) kg. Women with GDM were somewhat more likely to gain less than 8 kg by 26 weeks of gestation, but women with abnormal glucose tolerance had no difference in weight gain (Table 1).

Thirteen percent of women reported less than 2 weekly hours of walking, and walking frequency did not change appreciably from prepregnancy to during pregnancy (Table 2). The prevalences of both any light-to-moderate and any vigorous activity decreased from before pregnancy to during pregnancy, and sedentary lifestyle increased (Table 2). One third (34%) of participants viewed at least 2 hours of television daily both before and during pregnancy.

On multivariable analysis, walking 2 or more hours daily either before or during pregnancy was associated with somewhat reduced risk for both GDM and abnormal glucose tolerance (Table 3), although confidence intervals did not exclude 1. Light-to-moderate activity before pregnancy did not appear to be associated with reduced risk for GDM or abnormal glucose tolerance (Table 3), whereas light-to-moderate activity during pregnancy was associated with a somewhat reduced risk for GDM (adjusted odds ratio [OR] 0.70, 95% confidence interval [CI] 0.41–1.21) and abnormal glucose tolerance (OR 0.79, 95% CI 0.60–1.05).

Vigorous activity during the year before pregnancy was associated with a reduced risk for GDM (OR 0.56, 95% CI 0.33–0.95) and abnormal glucose tolerance (OR 0.76, 95% CI 0.57–1.00). The adjusted prevalence of GDM was 4.7% among women not engaging in vigorous activity before pregnancy and 2.7% among women engaging in vigorous activity. The adjusted prevalence of abnormal glucose tolerance was 17.6% among women not engaging in vigorous activity before pregnancy and 13.9% among women engaging in vigorous activity. If an intervention to promote vigorous exercise before pregnancy resulted in effect sizes similar to what we found in this observational study, then one case of GDM would be prevented for every 49 women engaging in vigorous activity. One case of abnormal glucose tolerance would be prevented for every 28 women engaging in vigorous activity. Vigorous activity during pregnancy had a weaker beneficial effect (Table 3). Participating in either light-to-moderate or vigorous activity during pregnancy was associated with somewhat reduced risk for GDM (OR 0.73, 95% CI 0.43–1.25) and abnormal glucose tolerance (OR 0.76, 95% CI 0.57–1.00). The consequence of multivariable adjustment was to slightly attenuate effect estimates, mainly because of the influence of prepregnancy BMI (data not shown). Additional adjustment for weight gain at 26 weeks of gestation did not influence results (data not shown).

Greater duration of total activity showed a suggestion of benefit and sedentary lifestyle a suggestion of harm, although neither exposure achieved statistical significance (Table 3). Television viewing was directly correlated with walking (Spearman ρ 0.13, $P < .001$, before pregnancy) and inversely correlated with vigorous activity (Spearman ρ –0.10, $P < .001$), but television viewing before and during pregnancy was not associated with outcomes (Table 3). Estimates for television did not appreciably change with additional adjustment for walking or vigorous physical activity (data not shown).

When we restricted analysis to nulliparous women (n = 821 with data before pregnancy and n = 796 during pregnancy), physical activity appeared even more beneficial. For example, in this subgroup the adjusted odds ratio for vigorous physical activity before pregnancy was 0.50 (95% CI 0.26–0.96) for GDM and 0.62 (95% CI 0.41–0.93) for abnormal glucose tolerance, and during pregnancy the odds ratio was 0.77 (95% CI 0.34–1.74) for GDM and 0.66 (95% CI 0.41–1.06) for abnormal glucose tolerance. Sedentary lifestyle before pregnancy was associated with increased risk for GDM (OR 1.93, 95% CI 0.80–4.71) and abnormal glucose tolerance (OR 1.89, 95% CI 1.07–3.35), as was sedentary lifestyle during pregnancy (OR 2.11, 95% CI 1.01–4.40 for GDM and OR 1.71, 95% CI 1.07–2.73 for abnormal glucose tolerance).

We next investigated whether the effect of physical activity on abnormal glucose tolerance varied according to prepregnancy BMI. Multiplicative interaction terms were significant ($P < .05$) only for BMI with vigorous activity during pregnancy ($P = .004$) and BMI with total activity before pregnancy ($P = .005$). Among women with prepregnancy BMI less than 25.0 kg/m^2 (n = 1,043), vigorous activity during pregnancy was protective against development of abnormal glucose tolerance (adjusted OR 0.56, 95% CI 0.36–0.88), whereas among women with BMI of 25.0 kg/m^2 or above (n = 538), vigorous activity was not beneficial (adjusted OR 1.03, 95% CI 0.59–1.79). Similarly, total activity before pregnancy was beneficial among women with normal prepregnancy BMI (adjusted OR 0.49, 95% CI 0.26–0.95, for 14 or more versus 2 or fewer weekly hours, P for trend across categories = .04) but not among women who were overweight or obese (adjusted OR 1.34, 95% CI 0.68–2.63, P for trend = .30).

We had information on activity both before and during pregnancy for 1,414 women. Compared with women who reported no vigorous activity before pregnancy and no light-to-moderate or vigorous activity during pregnancy, those who reported activity at both time points had a somewhat reduced risk for both GDM (adjusted OR 0.49, 95% CI 0.24–1.01) and abnormal glucose tolerance (0.70, 95% CI 0.49–1.01). Women who engaged in vigorous activity only before pregnancy, or light-to-moderate or vigorous activity only during pregnancy, did not have a reduced risk for either outcome (Table 4).

DISCUSSION

In this cohort study including over 1,800 pregnant women, we found that women who engaged in vigorous physical activity before pregnancy and light-to-moderate or vigorous activity during pregnancy experienced a reduced risk for developing gestational diabetes mellitus and abnormal glucose tolerance. Women who were active both before and during pregnancy particularly benefited. Walking appeared somewhat protective and sedentary lifestyle somewhat harmful. Physical activity was particularly beneficial among nulliparous women.

These results extend to pregnancy the protective effect of physical activity against the development of diabetes, which has previously been demonstrated among adult men and nonpregnant women.[9,10] Independent of exercise levels, sedentary behavior, especially television viewing, has been directly associated with risk of type 2 diabetes in nonpregnant adults[11] and in one study with risk for GDM.[14] In the present study, we did not observe that television viewing, either before or during pregnancy, influenced risks.

Several aspects of our results merit specific attention. Our finding that vigorous physical activity is particularly important for reducing risks parallels the reduction in diabetes risk from more intense physical activity previously demonstrated among nonpregnant adults as well as among pregnant women.[10,24] Skeletal muscle contraction triggers glucose uptake and promotes insulin sensitivity, and more intense exercise has a stronger hypoglycemic effect.[25] Because many women reduce the intensity of their physical activity when they are pregnant, our finding that even light-to-moderate activity during pregnancy reduces risks allows for recommendations that many pregnant women will likely be able to follow.

Associations of physical activity with abnormal glucose tolerance were generally similar to, although perhaps slightly weaker than, associations with GDM. Because a much larger proportion of pregnant women have abnormal glucose tolerance than GDM[26] and abnormal glucose tolerance is associated with similarly adverse outcomes,[6] interventions to promote physical activity among women may have substantial population impact.

We found a particular benefit of physical activity among women of normal prepregnancy BMI (less than 25 kg/m^2). This finding contrasts with previous studies, which have found either no difference in the effect of exercise according to maternal BMI[14,24] or a benefit only among obese women,[27] and merits additional study before targeted recommendations can be made. The slight attenuation of effect estimates that we observed with inclusion of prepregnancy BMI in statistical models suggests that the effect of physical activity on GDM risk is only partially mediated by an influence of physical activity on body weight. We observed generally stronger benefits of physical activity among nulliparous women, with effect sizes similar to those reported by Dempsey et al,[15] from a cohort study of primarily nulliparous women. It is possible that parous women changed their behaviors based upon their experiences in previous pregnancies. For example, a woman with previous GDM might have increased her exercise without substantially reducing her subsequent risk for GDM, which would attenuate the observed benefit of physical activity.

Our results support and extend upon data from the Nurses' Health Study recently reported by Zhang et al,[14] in which women in the highest quintile of physical activity had approximately a 20% risk reduction for developing GDM (relative risk 0.81, 95% CI 0.68–1.01 for total activity, and RR 0.77, 95% CI 0.69–0.94 for vigorous activity). However, in that study physical activity was assessed in fixed years, not standardized relative to the onset of pregnancy, and estimates of activity during pregnancy were not included.

Other previously published studies have been smaller in sample size but generally supportive of a protective effect of physical activity.[15,24,28] In one exception, Dye et al[27] did not observe any overall benefit of exercise during pregnancy. However, in that study physical activity throughout pregnancy was assessed after delivery, which might have led to some differential misclassification because women with GDM may have initiated exercise after their diagnoses.

Several limitations to our study should be considered. Women, particularly those who were more sedentary or overweight, may have inaccurately reported their physical activity and television viewing behaviors. Recall bias is unlikely because we collected exposure information before women knew their glucose test results. We did not assess occupational physical activity, which may have led to some exposure misclassification. Study participants were predominantly white and generally well educated, and all resided in Massachusetts. Therefore, results may not be generalizable to other populations. As with any observational study, we cannot eliminate residual confounding by unmeasured factors. However, we were able to include information on factors previously identified as important risk factors for GDM and abnormal glucose tolerance, such as age, prepregnancy BMI, and race/ethnicity, and to consider other characteristics such as sociodemographics, weight gain during pregnancy, and prenatal smoking.

In summary, we have found that that vigorous physical activity before pregnancy and continuation of activity from before pregnancy into early pregnancy may reduce a woman's risk for developing abnormal glucose tolerance and GDM. With few exceptions, regular physical activity is salutary for everyone, including pregnant women.[21] Clinicians should consider recommending vigorous physical activity to their patients who are contemplating pregnancy or are in early pregnancy to promote normal glucose tolerance and to establish healthy lifelong habits.

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Table 1

Participant Characteristics According to Glucose Tolerance During Pregnancy

Participant Characteristics	Number (%) of Participants		
	Normal Glucose Tolerance (n = 1,493)	**Abnormal Glucose Tolerance (n = 312)**	**GDM (n = 91)**
Age (y)			
14–24	129 (9)	10 (3)	2 (2)
25–34	957 (64)	198 (63)	68 (75)
35–39	354 (24)	79 (25)	14 (15)
40–44	53 (4)	25 (8)	7 (8)
Race/ethnicity			
White	1,056 (71)	224 (72)	56 (62)
Black	201 (14)	34 (11)	10 (11)
Hispanic	82 (6)	29 (9)	12 (13)
Asian	84 (6)	21 (7)	12 (13)
Other	63 (4)	3 (1)	1 (1)
Married/cohabiting	1,381 (93)	290 (93)	87 (96)
Single	112 (7)	22 (7)	4 (4)
Some college or less	453 (30)	98 (32)	33 (36)
College graduate	1,033 (70)	213 (68)	58 (64)
Nulliparous	757 (51)	146 (47)	48 (53)
Prior GDM	7 (less than 1)	26 (8)	21 (23)
No prior GDM	729 (49)	140 (45)	22 (24)
Smoked in pregnancy	150 (10)	40 (13)	15 (17)
Nonsmoker	1,295 (90)	264 (87)	73 (83)
Prepregnancy BMI (kg/m^2)			
Less than 25	1,003 (67)	168 (54)	41 (45)
25–29.9	309 (21)	76 (24)	25 (27)
30 or more	181 (12)	68 (22)	25 (27)
Family history of diabetes			
Yes	84 (6)	39 (13)	11 (12)
No	1,293 (87)	248 (79)	72 (79)
Missing/unknown	116 (8)	25 (8)	8 (9)
Weight gain at 26 weeks			
8 kg or less	737 (49)	155 (50)	53 (58)
More than 8 kg	756 (51)	157 (50)	38 (42)

GDM, gestational diabetes mellitus; BMI, body mass index.

Table 2

Frequency of Physical Activity Among Women Enrolled in Project Viva

	Number (%) of Women	
Weekly Hours Spent in Activity	**Before Pregnancy (n = 1,638)**	**During Pregnancy (n = 1,581)**
Walking		
0–1	208 (13)	229 (14)
2 or more	1,430 (87)	1,352 (86)
Light/moderate		
0	620 (38)	846 (54)
1 or more	1,018 (62)	735 (46)
Vigorous		
0	681 (42)	1,201 (76)
1 or more	957 (58)	380 (24)
Light/moderate or vigorous		
0	429 (26)	751 (48)
1 or more	1,209 (74)	830 (52)
Total activity		
2 or fewer	209 (13)	330 (21)
3–6	434 (27)	616 (39)
7–13	620 (38)	456 (29)
14 or more	375 (23)	179 (11)
Sedentary lifestyle		
Sedentary	209 (13)	330 (21)
Not sedentary	1,429 (87)	1,251 (79)
Television viewing		
13 or fewer	1,075 (66)	1,035 (66)
14 or more	557 (34)	543 (34)

Table 3

Multivariable Associations of Physical Activity Before and During Pregnancy With Gestational Diabetes Mellitus and Abnormal Glucose Tolerance

	Before Pregnancy (n = 1,638)				During Pregnancy (n = 1,581)			
	GDM		Abnormal Glucose Tolerance		GDM		Abnormal Glucose Tolerance	
Physical Activity	**Cases (n)**	**Adjusted OR[*] (95% CI)**	**Cases (n)**	**Adjusted OR[*] (95% CI)**	**Cases (n)**	**Adjusted OR[*] (95% CI)**	**Cases (n)**	**Adjusted OR[*] (95% CI)**
Walking (h/wk)								
1 or less	16	1.0 (Referent)	45	1.0 (Referent)	18	1.0 (Referent)	53	1.0 (Referent)
More than 1	60	0.67 (0.34–1.34)	231	0.77 (0.52–1.13)	59	0.67 (0.35–1.30)	218	0.71 (0.49–1.02)
Light/moderate activity								
None	27	1.0 (Referent)	97	1.0 (Referent)	48	1.0 (Referent)	160	1.0 (Referent)
Any	49	1.16 (0.67–1.99)	179	1.15 (0.86–1.53)	29	0.70 (0.41–1.21)	111	0.79 (0.60–1.05)
Vigorous activity								
None	40	1.0 (Referent)	132	1.0 (Referent)	62	1.0 (Referent)	220	1.0 (Referent)
Any	36	0.56 (0.33–0.95)	144	0.76 (0.57–1.00)	15	0.90 (0.47–1.70)	51	0.73 (0.52–1.03)
Light/moderate or vigorous activity								
None	21	1.0 (Referent)	73	1.0 (Referent)	43	1.0 (Referent)	146	1.0 (Referent)
Any	55	0.91 (0.51–1.65)	203	1.00 (0.73–1.37)	34	0.73 (0.43–1.25)	125	0.76 (0.57–1.00)
Total (h/wk)								
2 or less	13	1.0 (Referent)	41	1.0 (Referent)	22	1.0 (Referent)	66	1.0 (Referent)
3–6	22	0.78 (0.34–1.76)	77	0.84 (0.54–1.31)	28	0.72 (0.37–1.40)	110	0.94 (0.65–1.34)
7–13	26	0.63 (0.28–1.39)	102	0.82 (0.53–1.25)	17	0.59 (0.28–1.23)	71	0.80 (0.54–1.19)
14 or more	15	0.70 (0.30–1.68)	56	0.79 (0.49–1.26)	10	0.91 (0.37–2.21)	24	0.68 (0.40–1.16)
P (trend)		.46		.40		.71		.10
Sedentary lifestyle (total activity 2 h/wk or less)								
Not sedentary	63	1.0 (Referent)	235	1.0 (Referent)	55	1.0 (Referent)	205	1.0 (Referent)
Sedentary	13	1.44 (0.70–2.96)	41	1.22 (0.83–1.81)	22	1.43 (0.79–2.59)	66	1.18 (0.85–1.63)
Television viewing (h/d)								
Less than 2	46	1.0 (Referent)	184	1.0 (Referent)	47	1.0 (Referent)	174	1.0 (Referent)
2 or more	30	1.28 (0.75–2.18)	92	0.99 (0.74–1.32)	29	1.03 (0.59–1.78)	95	1.01 (0.75–1.35)

GDM, gestational diabetes mellitus; OR, odds ratio; CI, confidence interval.

[*] All odds ratios are adjusted for participant's age, race/ethnicity, prepregnancy body mass index, history of GDM in a previous pregnancy, and mother's history of diabetes.

Table 4

Associations of Physical Activity Both Before and During Pregnancy With Gestational Diabetes Mellitus and Abnormal Glucose Tolerance

Reported Activity	Gestational Diabetes Mellitus		Abnormal Glucose Tolerance	
	Cases (n)	Adjusted OR* (95% CI)	Cases (n)	Adjusted OR* (95% CI)
No vigorous activity before pregnancy and neither vigorous nor light-to-moderate activity during pregnancy	23	1.0 (Reference)	79	1.0 (Reference)
No vigorous activity before pregnancy; vigorous or light-to-moderate activity during pregnancy	10	1.28 (0.54–3.02)	33	1.19 (0.74–1.91)
Vigorous activity before pregnancy; neither vigorous nor light-to-moderate activity during pregnancy	12	0.83 (0.36–1.90)	44	1.04 (0.67–1.60)
Both vigorous activity before pregnancy and vigorous or light-to-moderate activity during pregnancy	17	0.49 (0.24–1.01)	79	0.70 (0.49–1.01)

OR, odds ratio; CI, confidence interval.

*All odds ratios are adjusted for participant’s age, race/ethnicity, prepregnancy body mass index, history of gestational diabetes mellitus in a previous pregnancy, and mother’s history of diabetes.