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Physical Activity, Obesity, and Diabetes in Pregnancy

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Gestational diabetes mellitus (GDM) is the most common medical complication of pregnancy. Women with GDM are at elevated risk for numerous maternal health complications, and their infants are at elevated risk for death and morbidity. Management of GDM has traditionally been through diet and close monitoring of glucose levels, with initiation of insulin therapy when diet alone fails to maintain euglycemia. Recently, however, it has been suggested that alternative treatment modalities, such as exercise, may overcome a peripheral resistance to insulin, thus preventing GDM or controlling hyperglycemia in women with GDM. In this study, conducted from October 1995 to July 1996, the authors used a population-based birth registry to determine whether exercise has a preventive role in the development of GDM in women living in central New York State. They used contingency tables and chi-square statistics to examine bivariate differences among maternal and demographic variables and the occurrence of GDM. When stratified by prepregnancy body mass index category, exercise was associated with reduced rates of GDM only among women with a body mass index greater than 33 (odds ratio = 1.9, 95% confidence interval 1.2–3.1). The effect of exercise in obese women was further complicated by insurance status. When the data were stratified by insurance status, it appeared that women of higher socioeconomic status who were obese and did not exercise were at a significantly elevated risk of GDM compared with their counterparts of lower socioeconomic status. The results of this study suggest that for some women exercise may play a role in reducing the risk that they will develop GDM during pregnancy. *Am J Epidemiol* 1997;146:961–5.

diabetes mellitus; exercise; obesity; pregnancy

Gestational diabetes mellitus (GDM) is a disorder of glucose utilization that complicates between 1 and 12 percent of pregnancies (1). Maternal hyperglycemia during pregnancy is associated with an increased risk for both maternal and infant morbidity. For instance, gestational diabetics with poor glycemic control are at greater risk for preeclampsia, infection, hydramnios, and postpartum hemorrhage (2). In addition, maternal hyperglycemia during pregnancy is associated with a greater risk of macrosomia and may be strongly influenced by maternal obesity (3), which is a strong risk factor for development of non-insulin-dependent diabetes mellitus (NIDDM) (4). Management of women with GDM is difficult and traditionally includes both diet and insulin therapy (5), with insulin being administered when euglycemia cannot be controlled by diet alone. More recently, however, exercise has been advocated as an alternative therapeutic intervention not only in the management of the gestational diabetes but also in the prevention of diabetes (6, 7). Studies have demonstrated that exercise, as a simpler and less costly management strategy either alone or when combined with dietary therapy, can achieve adequate control of glucose metabolism and reduce the risk of developing NIDDM (8–10). Further, exercise during pregnancy specifically has resulted in a reduction in the number of women whose GDM must be managed by insulin therapy (11). Despite initial concerns about possible deleterious effects of exercise in pregnant women, physical activity has been shown to be safe during pregnancy (12). To date, however, few studies have had sufficient power to detect significant differences in the prevention of complications during GDM pregnancies or significant differences in negative birth outcomes of these pregnancies (13).

The present retrospective study was carried out to assess whether exercise results in a lower prevalence of GDM and to investigate whether there is an asso-

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Abbreviations: BMI, body mass index; GDM, gestational diabetes mellitus; NIDDM, non-insulin-dependent diabetes mellitus.

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ciation between body mass index (BMI), exercise, and the prevalence of GDM. Understanding the association between these variables is an important first step in identifying the impact of exercise on GDM, since much remains to be studied about the underlying causal relations between exercise, adiposity, and insulin resistance during pregnancy.

MATERIALS AND METHODS

The Central New York Regional Perinatal Data System is a population-based birth registry through which information is collected on all livebirths that occur within the 15-county region of central New York State. Women who delivered a livebirth in this region between October 1, 1995, and July 31, 1996 (n = 14,367) were eligible for inclusion in this study. Women were excluded from the analysis if they had conditions that contraindicated exercise, according to the guidelines established by the American College of Obstetricians and Gynecologists (7). These included heart disease, multiple gestation, incompetent cervix, prior preterm delivery, prior low-birth-weight infant, uterine bleeding, and chronic hypertension. In total, 1,568 women (10.9 percent) were excluded from the analysis for these contraindications. This resulted in a total of 12,799 women who were included in the analysis. Information regarding study variables was obtained from personal interview and from abstraction of the medical records.

TABLE 1. Demographic and maternal characteristics of women with GDM,* central New York, 1995–1996

	Total no. of pregnancies	GDM present		GDM absent	
		%	No.	%	No.
Total	12,776	2.9	372	97.1	12,404
Maternal age (years)					
<20	1,538	0.7	11	99.3	1,527
20–34	9,851	3.0	295	97.0	9,556
≥35	1,387	4.8	66	95.2	1,321
Maternal race					
White	11,483	2.9	335	97.1	11,148
Black	779	1.9	15	98.1	764
Native American	86	3.5	3	96.5	83
Asian/Pacific Islander	297	4.7	14	95.3	283
Other	131	3.8	5	96.2	126
Parity					
0	5,471	2.4	130	97.6	5,341
1	4,192	3.0	124	97.0	4,068
2	1,970	3.8	75	96.2	1,895
≥3	1,143	3.8	43	96.2	1,100
Prepregnancy BMI*					
<19.8	1,759	1.2	21	98.8	1,738
19.8–26.0	6,615	1.8	117	98.2	6,498
26.1–29.0	1,660	4.0	67	96.0	1,593
29.1–33.0	1,261	4.4	55	95.6	1,206
>33.0	1,243	8.4	105	91.6	1,138
Gestational weight gain (pounds)†					
≤10	918	5.8	53	94.2	865
11–20	1,603	4.1	66	95.9	1,537
21–30	3,534	2.9	103	97.1	3,431
31–40	3,599	2.1	76	97.9	3,523
≥41	3,122	2.4	74	97.6	3,048
Insurance coverage					
Medicaid/self-pay	4,764	1.8	85	98.2	4,679
Private insurance	8,012	3.6	287	96.4	7,725

* GDM, gestational diabetes mellitus; BMI, body mass index.
† 1 pound = 0.454 kg.

Study variables

GDM. GDM was defined as glucose intolerance that developed or was discovered in the woman during the current pregnancy. GDM status was determined through abstraction of the medical record after the pregnancy was completed. Information on GDM status was available for 99.8 percent of the population (n = 12,776).

BMI. Prepregnancy BMI was calculated using prepregnancy weight and height abstracted from the medical record. Data required for the calculation of BMI were available for 98.0 percent of the population (n = 12,538). Institute of Medicine definitions (14) were used to classify women into BMI categories: ≤19.8, >19.8–≤26.0, >26.0–≤29.0, >29.0–≤33.0, and >33.0.

Exercise. Women were asked by personal interview how many times per week on average during their pregnancy they exercised for 30 minutes or more above their usual activities. Responses were collected as continuous variables. For analysis, exercise status was defined as any exercise (one or more times per week) versus no exercise. Information is also presented for women who indicated that they exercised once, twice, or three times or more per week. Data regarding exercise status were available for 96.0 percent of the women (n = 12,290). Women for whom information was missing regarding exercise status were not significantly different from other women for GDM status, BMI, and demographic and maternal variables.

Statistical analysis

Contingency tables and chi-square statistics were used to examine bivariate differences among maternal and demographic variables and occurrence of GDM (15). Odds ratios were calculated for GDM by exercise status, stratifying for BMI category. Statistical significance was determined by using 95 percent confidence intervals of the odds ratios. Potential confounders were identified as those variables associated (p < 0.10) with variables of interest and were controlled for using logistic regression. Variables evaluated for confounding included maternal age, maternal race, parity, prepregnancy BMI, gestational weight gain, and insurance coverage (as a proxy for deprivation). Interaction effects were evaluated by using stratified tables and χ^2 tests (15). SPSS for Windows (release 7.0) (SPSS, Inc., Chicago, Illinois) was used for analyses.

TABLE 2. Association between GDM,* prepregnancy BMI,* and physical activity, central New York, 1995–1996

	No.	% GDM	OR*	95% CI*
BMI ≤ 19.8				
Nonexercisers	1,010	1.2	1.3	0.5–4.1
Exercisers	673	0.9	Referent	
19.8 < BMI ≤ 26.0				
Nonexercisers	3,665	1.6	0.9	0.6–1.3
Exercisers	2,694	1.9	Referent	
26.0 < BMI ≤ 29.0				
Nonexercisers	929	3.2	0.6	0.4–1.1
Exercisers	680	5.0	Referent	
29.0 < BMI ≤ 33.0				
Nonexercisers	690	4.3	1.0	0.5–1.8
Exercisers	512	4.5	Referent	
BMI > 33.0				
Nonexercisers	720	10.3	1.9	1.2–3.1
Exercisers	473	5.7	Referent	
Total				
Nonexercisers	7,162	2.9	1.0	0.8–1.3
Exercisers	5,114	2.8	Referent	

* GDM, gestational diabetes mellitus; BMI, body mass index; OR, odds ratio; CI, confidence interval.

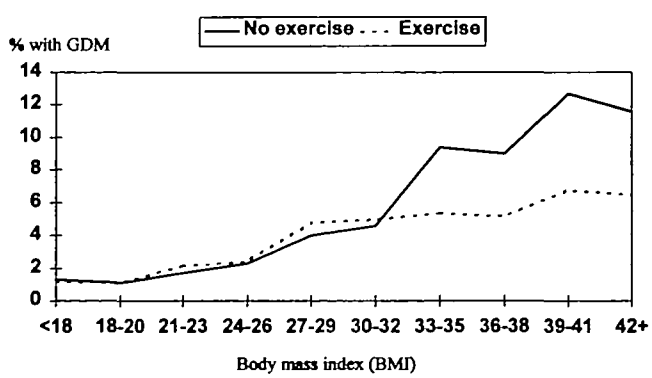

FIGURE 1. Prevalence of gestational diabetes mellitus (GDM) by body mass index (BMI) and exercise status, central New York, 1995–1996.

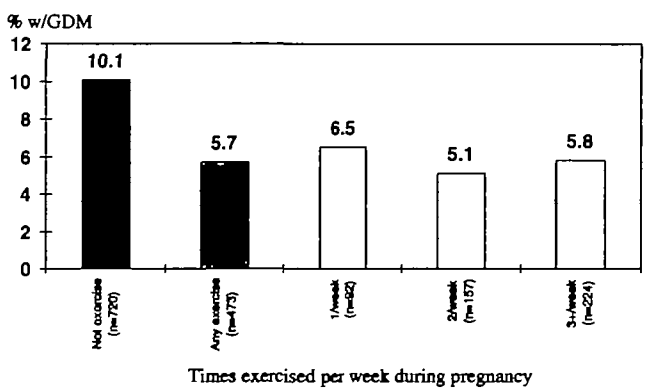

FIGURE 2. Prevalence of gestational diabetes mellitus (GDM) by number of times exercised per week during pregnancy in women with a body mass index of greater than 33, central New York, 1995–1996.

TABLE 3. **Stratified analysis of exercise status and GDM,* controlling for insurance coverage, women with BMI* > 33.0, central New York, 1995–1996**

	Medicaid coverage/no insurance					*Private insurance*				
	No.	GDM		OR*	95% CI*	No.	GDM		OR	95% CI
		%	No.				%	No.		
No exercise	299	5.4	16	0.8	0.4–1.9	421	13.8	58	2.9	1.5–5.8
Exercise	222	6.3	14	Referent		251	5.2	13	Referent	

* GDM, gestational diabetes mellitus; BMI, body mass index; OR, odds ratio; CI, confidence interval.

RESULTS

The prevalence of GDM in this population was 2.9 percent (table 1). Prevalence of GDM varied significantly by maternal age, parity, prepregnancy BMI, gestational weight gain, and insurance coverage.

When differences in prevalence of GDM by BMI were examined controlling for exercise (figure 1), it was apparent that women with a BMI of 30 or less who exercised had rates of GDM that were similar to women who did not exercise during pregnancy. However, women with a BMI of more than 30 who exercised during pregnancy had rates of GDM that were lower than those of their nonexercising counterparts. When stratifying by BMI status using the standard Institute of Medicine criteria (table 2), lack of exercise remained significantly associated with prevalence of GDM only among women with BMIs classified as morbidly obese (>33).

Further examination of the group of women with a BMI of greater than 33 is illustrated in figure 2 and shows that significant differences in rates of GDM were observed only when nonexercisers are compared with exercisers. GDM in this group did not vary by frequency of exercise, but only by the presence or absence of exercise.

Overall, exercise was not associated with a reduction in the occurrence in GDM (table 2). When stratified by prepregnancy BMI category, exercise was associated with reduced rates of GDM only among women with a BMI of greater than 33 (odds ratio = 1.9, 95 percent confidence interval 1.2–3.1). After this association for potential confounders was evaluated, only insurance status remained significantly associated with both exercise status and GDM (table 3). When stratified by insurance status, nonexercisers with private insurance coverage remained at significantly elevated risk of GDM when compared with exercisers with Medicaid coverage. Exercise and GDM were not associated among women with Medicaid coverage. Because of this interaction effect, adjusted odds ratios were not calculated.

DISCUSSION

The results of this study revealed that women with BMIs of 33 or less had similar rates of GDM that were not associated with whether or not they had exercised during their pregnancies. In contrast, women who were morbidly obese (BMI > 33) and who exercised were much more likely to have lower rates of GDM compared with women who were morbidly obese and did not exercise. This observation may reflect an important underlying relation between adiposity and GDM and the magnitude of the potential impact of exercise given the relation between these two variables. In obese individuals, aerobic exercise decreases the hyperinsulinemia of obesity and decreases fasting plasma glucose levels (16). With the improvement of insulin sensitivity, there is an increase in the suppression of hepatic glucose production, resulting in an increase in insulin-stimulated glucose uptake. Thus, morbidly obese women who exercise while pregnant may have a decreased likelihood of developing GDM during their pregnancy. In addition, the University of Pennsylvania Alumni Study (9) and the Physician's Health Study (10) observed that the strongest protective effect of exercise in preventing NIDDM occurred among individuals with the highest BMI categories. Further support for this hypothesis comes from the work of Green et al. (17), who showed that when maternal BMI is controlled for, the relation between maternal response to an oral glucose tolerance test and infant birth weight was "modest," suggesting that increased maternal adiposity must be present in addition to GDM to result in an increase risk for macrosomia.

The results of this study suggest that exercise as an alternative therapeutic intervention for women with GDM may be particularly relevant for those women who have a BMI of greater than 33. If so, the initial incorporation of an exercise program into the management of the pregnant, obese woman may have important implications for the reduction of the prevalence of GDM in these women, as well as for the maternal and infant morbidity associated with these pregnancies.

Interestingly, the effect of exercise on the prevalence of GDM in morbidly obese women was complicated by insurance status. Insured, obese women who did not exercise were almost three times more likely to have GDM as were their insured counterparts who did exercise. This effect was not observed among women with Medicaid funding. Assuming that insurance provides an accurate indication of socioeconomic status, this observation suggests that wealthier women who do not exercise and are morbidly obese are at a greater risk for developing GDM. It may be that yet another factor or factors influences the impact that exercise will have on the development of GDM. Alternatively, GDM may be diagnosed with greater consistency in women of higher compared with lower socioeconomic status. Other limitations of this study, including the use of self-reported exercise data and the manner in which GDM was defined, must also be taken into consideration.

The data from this study suggest that further investigation is needed to understand the effect of exercise on the development of GDM. Despite the increased emphasis on fitness and nutrition, obesity in America is an increasing, not a decreasing, health problem with specific public health goals for its prevention (18). If exercise does indeed play a role in reducing the risk that morbidly obese women who become pregnant will develop GDM, it is critical that this relation and its correlates be explored further.

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