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Diabetes, physical activity and breast cancer among Hispanic women

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Abstract

Purpose—We assessed the association between diabetes and breast cancer and whether physical activity modified the effect of diabetes on breast cancer in Hispanic women.

Methods—We used data from a case-control study of breast cancer among Hispanic women aged 30 to 79 conducted between 2003 and 2008 on the Texas-Mexico border. In-person interviews were completed with 190 incident breast cancer cases ascertained through surgeons and oncologists, and 979 controls who were designated as both high-risk (n=511) and low-risk (N=468) for breast cancer (with respective response rates of 97%, 83% and 74%).

Results—After adjustment for menopausal status and mammography screening, there was no effect of diabetes on breast cancer risk (high-risk control group odds ratio [OR] 1.02, 95% confidence interval [CI] 0.71–1.48; low-risk control group OR 0.87, 0.58–1.30). Women who had a diabetes history and did not exercise were at no risk of breast cancer (OR 0.96, 95% CI 0.63–1.48) or a slightly reduced breast cancer risk (low-risk control group OR 0.72, 95% CI 0.46–1.15) depending on the control group used, while women with diabetes who did exercise had significantly reduced breast cancer risk (OR 0.41, 95% CI 0.21–0.83) regardless of the control group used (high-risk control group p-value for interaction=0.013, low-risk control group p-value for interaction 0.183).

Conclusions—Should other studies confirm our results, physical activity should be explored as a means of reducing breast cancer risk in diabetic women.

Keywords

breast cancer; diabetes; physical activity; case-control study

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Introduction

Two recent meta-analyses of the association between diabetes and breast cancer reported summary relative risks of 1.20 (95% CI 1.12–1.28)1 and 1.15 (95% CI 1.12–1.19)2, respectively. Hispanic women, who have extremely high rates of diabetes and yet fairly low rates of breast cancer, were not well-represented in these meta-analyses. Diabetes was not associated with breast cancer risk in the Four Corners Breast Cancer Study, a study of Hispanic and Native American women combined (OR 0.92, 95% CI 0.71–1.20)3. Based on these findings, we hypothesized that we would not find an association between diabetes and breast cancer among Hispanic women in our study. Since physical activity is known to reduce the risk of breast cancer4 and diabetes5, we also hypothesized that physical activity would modify the effect of diabetes on breast cancer.

Patients and Methods

This clinic-based case-control study was conducted in the Lower Rio Grande Valley located at the southern tip of Texas on the Mexico border. Cases diagnosed with primary invasive breast cancer between November 2003 and August 2008 were identified through surgeons and oncologists shortly after diagnosis or treatment. Eligible cases were of Hispanic ethnicity based on self-report, aged 30–79, whose incident primary breast cancer was histologically confirmed and with no history of cancer, other than nonmelanoma skin cancer. A total of 190 breast cancer cases (97.0% of 196 eligible cases) completed a standardized in-person interview. Of potentially eligible cases, 3 refused (1.5%) and 3 were lost to follow-up (1.5%).

Control subjects were randomly selected from women receiving a diagnostic or screening mammogram at the mammography center where the case received her diagnostic mammogram. Two control groups were selected, a high-risk group of women receiving a diagnostic mammogram either due to inconclusive or abnormal results, and a low-risk group of women with no family history of breast cancer, no history of breast biopsy, and negative screening mammograms for the past two years. Two women from each control group were selected per case and frequency matched to the case on age. Eligible controls were Hispanic, aged 30–79 with no history of cancer, other than nonmelanoma skin cancer.

A total of 511 high-risk control subjects (83.0% of 616 eligible high-risk controls) and 468 low-risk control subjects (73.6% of 636 eligible low-risk controls) completed the interview. Of eligible high-risk controls, 61 refused (9.9%) and 44 (7.1%) were lost to follow-up. Of eligible low-risk controls, 127 refused (20.0%) and 41 (6.4 %) were lost to follow-up. For the present analysis we investigated the associations separately by type of control group.

Institutional Review Boards of the University of Texas at Brownsville and the University of Texas Health Science Center at Houston approved this study's protocol. Trained interviewers conducted in-person interviews with subjects who provided consent. The questionnaire collected information on demographic characteristics, suspected breast cancer risk and protective factors, and medical history including diabetes. Exposures pertained to the period prior to a reference date, the date of diagnosis for the cases and an assigned date for controls comparable to the date of diagnosis for the cases.

With subjects' permission we abstracted their medical records for information on breast cancer screening, diagnosis and treatment, and diabetes diagnosis and treatment. A 10-hour fasting blood draw was collected prior to treatment. Serum glucose was analyzed using the hexokinase/glucose-6-phosphsate dehydrogenase method. Since associations have been established between insulin resistance, a precursor of diabetes, and breast cancer, we grouped borderline diabetes and diabetes, hereafter termed diabetes. To define diabetes, we

used serum glucose (available for 67 cases and 241 controls), followed by medical record information (available for an additional 25 cases and 116 controls), followed by information from the questionnaire (available for the remaining 98 cases and 622 controls). Women were considered diabetic if they had a fasting serum glucose concentration of ≥100 mg/dl, an indication of diabetes in their medical record, or they were told by their doctor they had diabetes. Diabetes was further categorized as occurring during pregnancy, other than pregnancy, or both during and other than pregnancy available from the questionnaire only. If women received both insulin and oral medications to treat diabetes, available from the medical record and then from the questionnaire, they were classified as having used insulin. Information on leisure-time physical activity, defined as having engaged in vigorous or moderate activity at least two hours a week for four months or more a year in the past three years, was available from the questionnaire. Examples of vigorous activity included basketball, jump rope, swimming laps, aerobic dance, running, jogging, bicycling on hills and some types of exercise equipment, while examples of moderate activity included brisk walking, golf, volleyball, bicycling on level ground, softball, dancing and gardening. Body mass index (BMI) at study entry was based on actual measurements of body weight and body height, while BMI at age 15 years was based on the questionnaire.

Statistical analyses were performed in SAS version 9.2. We assessed statistically significant (two-sided, $p<0.05$) differences between cases and controls for suspected breast cancer risk and protective factors using t-tests and chi-square tests. We used unconditional logistic regression to estimate the relative risk of breast cancer associated with the main effect of diabetes and the joint effects of diabetes and physical activity6. Interaction terms, the product of diabetes and putative effect modifiers (menopausal status and physical activity), were added to logistic regression models and likelihood ratio tests were performed to test for effect modification. Age, educational level, family history of breast cancer, age at menarche, menopausal status, number of full-term pregnancies, age at first pregnancy, breastfeeding history, BMI at study entry, BMI at age 15 years, use of oral contraceptives, use of hormone replacement therapy, alcohol intake (drinking at least one alcoholic beverage a month for 6 months or longer), mammography screening, comorbid conditions including heart disease, hypertension, myocardial infarction and stroke, and physical activity as categorized in Table 1 were evaluated as potential confounders. Missing data were not included in the variable percentages unless they contributed a large portion to the distribution as was the case for BMI at age 15 years. Variables were considered confounders if their addition to the model changed the unadjusted odds ratio by 10 percent or more. We performed a validation study of self-report of diabetes, including borderline diabetes, using both serum glucose and the medical record as gold standards. Sensitivities and specificities and their respective confidence intervals were calculated as measures of validity.

There was no evidence of effect modification by menopausal status; however, physical activity did modify the effect of diabetes on breast cancer risk. We adjusted for menopausal status and mammography screening which were confounders in our data.

Results

Cases were more likely than high-risk controls to be older, to be postmenopausal, not to have breastfed, and not to have used oral contraceptives; cases were more likely than low-risk controls to have a first-degree relative with breast cancer, to have a younger age at menarche, to have used hormone replacement therapy, and to have had more mammograms in the past 6 years; cases were more likely than both control groups not to have engaged in physical activity (Table 1).

There was no effect of diabetes on risk of breast cancer among high-risk (OR 1.02, 95% CI 0.71–1.48) or low-risk controls (OR 0.87, 95% CI 0.58–1.30) after adjustment for menopausal status and mammography screening (Table 2). In high-risk controls, we found that women with type 2 diabetes treated with insulin had a significant increase in breast cancer risk (OR 2.23, 95% CI 1.18–4.19), while women treated with oral medications (OR 0.72, 95% CI 0.42–1.23) or with neither insulin nor oral medications (OR 0.55, 95% CI 0.18–1.70) had non-significant decreases in risk. As similar pattern existed in low-risk controls, with a significantly lower risk of breast cancer associated with no treatment (OR 0.31, 95% CI 0.10–0.96). There was little effect of type of diabetes, age at diabetes onset or of family history of diabetes on breast cancer risk.

Relative to women who had no history of diabetes and did not engage in physical activity, women who had a diabetes history and did not exercise were at slightly reduced breast cancer risk (high-risk controls OR 0.96, 95% CI 0.63–1.48; low-risk controls OR 0.72, 95% CI 0.46–1.15) (Table 3). While women with diabetes who did exercise had significantly reduced breast cancer risk in both control groups (high-risk controls OR 0.40, 95% CI 0.21–0.79; low-risk controls OR 0.41, 95% CI 0.21–0.83) in comparison with women without diabetes who did engage in physical activity. This effect modification was significant for the high-risk control group (p-value for interaction=0.013), but not for the low-risk control group (p-value for interaction=0.183).

Table 4 presents results of our validation study which indicated very high sensitivities of self-report of diabetes in comparison with serum glucose (ranging from 88.4 to 92.3) and the medical record (ranging from 86.5 to 94.8), which were higher among cases than controls. Specificities for serum glucose were much lower (ranging from 51.3 to 67.3), while those for the medical record were comparable across study groups (ranging from 86.8 to 89.6). After restricting our analysis to diabetes only (data not shown), specificities were considerably stronger for serum glucose (cases 75.0, high-risk controls 90.9, low-risk controls 82.4).

Discussion

The Four Corners Breast Cancer Study, the one study that included a sufficient number of Hispanic women to stratify by ethnicity3, grouped Hispanic and Native American women so our studies are not strictly comparable. Nevertheless, we saw a similar association between diabetes and breast cancer risk (combined control groups OR 1.00) as the Four Corners Study (OR 0.92). Nor could we directly compare our findings on diabetes treatment (combined control groups insulin OR 1.82, oral medication OR 0.81, neither OR 0.43) with the Four Corners Study which grouped insulin and oral medications (either OR 0.91, neither OR 1.84), thus ours is the first study to report a significantly increased breast cancer risk associated with use of insulin among diabetics. We additionally adjusted our analyses for age, BMI at age 15 years, and number of full-term pregnancies which were confounders in the Four Corner Study to ensure our differing results were not due to confounding, but our findings did not materially change (data not shown).

The increased risk of breast cancer associated with insulin resistance and diabetes seen in most studies1, 2 is thought to be due to elevated levels of insulin that promote proliferative and antiapoptotic effects through the insulin receptor7. Metformin, an oral medication used to treat type 2 diabetes, has recently been proposed as a breast cancer chemopreventive agent8 as it may reduce insulin levels9 or activate AMP-dependent protein kinase thereby suppressing protein synthesis10. While the slightly reduced risk we saw for use of oral medications to treat type 2 diabetes provides support for the metformin mechanism, there was a greater reduction in risk among women who reported they took neither insulin nor oral

medications. This latter finding may have been due to hyperinsulinemia induced chronic anovulation11 which would result in lower cumulative estrogen exposure over time thereby placing a woman at lower risk of breast cancer. Alternatively this latter finding may have been due to chance since we had very few cases (n=4) who took neither insulin nor oral medications for diabetes treatment.

One of the meta-analyses of the association between diabetes and breast cancer stratified by physical activity, and found nearly identical relative risks among women who did (relative risk [RR] 1.16) and did not exercise (RR 1.20)1. In contrast, we found a substantially lower breast cancer risk among diabetic women who exercised (combined control groups OR 0.42) than among diabetic women who did not exercise (combined control groups OR 0.87) and this effect modification was significant (combined control groups p-value for interaction=0.034). A plausible biological mechanism for our finding of a substantially reduced breast cancer risk resulting from the joint effect of diabetes and physical activity may be the reduction in insulin resistance that accompanies physical activity5. A randomized clinical trial of the effect of metformin or lifestyle intervention (which included moderate intensity physical activity for at least 150 minutes per week) on subsequent diabetes among persons at high risk of diabetes reported reductions of 31% and 58% compared to placebo after 2.8 years of follow-up 12. The investigators surmised that these interventions could also delay or prevent complications from diabetes.

Our study was limited by potential detection bias since women identified through mammography centers as controls may have been more likely than cases to have been screened for both diabetes and breast cancer. Three studies conducted in the U.S.13–15 and one study conducted in Canada16 found lower mammography screening rates among diabetics than among non-diabetics. However, when McBean et al.15 examined the association in women of races/ethnicities other than white or black, there was no difference in mammography screening rates by diabetes status. Additional limitations of our study were self-report of physical activity for leisure-time only which did not include physical activity for housework or work outside the home and is prone to misclassification, our lack of study power to detect some main effects, and the higher percentage of cases than controls with additional sources of information on diabetes which may have resulted in differential misclassification.

To minimize detection bias and misclassification we used serum glucose available for 48% of cases and 37% of controls, followed by medical records available for 35% of cases and 25% of controls, followed by self-report available for the remaining 17% of cases and 38% of controls to define diabetes. We conducted a validation study of diabetes reporting utilizing serum glucose and medical records and found that sensitivity was quite high relative to specificity, and that reporting was slightly more accurate among cases than among controls. Additional strengths of the study were the focus on Hispanic women who have been understudied with regard to breast cancer, high response rates, adjustment for mammography screening to further reduce the likelihood of detection bias, and assessment of confounding for established breast cancer risk and protective factors.

Hispanic women possess a number of breast cancer risk factors including diabetes and yet have a relatively low incidence of the disease. Very few breast cancer studies have focused on Hispanic women; however, the identification of protective factors against breast cancer may enlighten our understanding of the biological mechanisms of the disease. Our finding that physical activity modified the effect of diabetes on breast cancer in Hispanic women contributes to the sparse body of knowledge in this area and suggests hypotheses for further investigation. Should other studies confirm our results, physical activity should be explored as a means of reducing breast cancer risk in diabetic women.

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Table 1

Comparison of cases and controls for suspected breast cancer risk and protective factors, South Texas Women's Health Project, 2003–2008

Characteristic	Cases (n=190)		High-risk controls (n=511)			Low-risk controls (n=468)		
	N	%	N	%	p-value[a]	N	%	p-value[b]
Mean age (years) (standard deviation)	54.3 (11.1)		49.2 (10.1)		<0.001	55.1 (8.4)		0.371
Educational level								
Less than high school	111	58.4	261	51.2	0.160	242	51.8	0.304
High school	32	16.8	87	17.0		93	19.9	
More than high school	47	24.7	162	31.8		132	28.3	
Missing	0		1			1		
Breast cancer among first-degree relatives								
No	168	89.4	455	90.5	0.667	440	95.7	0.003
Yes	20	10.6	48	9.5		20	4.3	
Missing	2		8			8		
Age at menarche (years)								
≤12	99	52.4	250	49.1	0.070	220	47.1	0.048
13	32	16.9	127	25.0		121	25.9	
>13	58	30.7	132	25.9		126	27.0	
Missing	1		2			1		
Menopausal status								
Premenopausal	38	20.4	203	39.8	<0.001	77	16.7	0.267
Postmenopausal	148	79.6	307	60.2		383	83.3	
Missing	4		1			8		
Number of full-term pregnancies								
0	13	6.8	43	8.4	0.084	35	7.5	0.861
1–2	52	27.4	166	32.5		138	29.5	
3–4	80	42.1	222	43.4		197	42.1	
≥5	45	23.7	80	15.7		98	20.9	
Age at first pregnancy (years)								
<30	163	92.1	434	92.7	0.781	402	92.8	0.748
≥30	14	7.9	34	7.3		31	7.2	

Characteristic	Cases (n=190)		High-risk controls (n=511)			Low-risk controls (n=468)		
	N	%	N	%	p-value[a]	N	%	p-value[b]
Missing	13		43			35		
Breastfeeding history								
No	86	45.3	187	36.7	0.036	193	41.2	0.344
Yes	104	54.7	324	63.4		275	58.8	
Body mass index at study entry								
<25	21	11.3	82	16.1	0.075	62	13.4	0.818
25–29.9	55	29.6	170	33.5		137	29.7	
30–34.9	57	30.7	153	30.1		145	31.4	
≥35	53	28.5	103	20.3		118	25.5	
Missing	4		3			6		
Body mass index at age 15 years								
<20	92	48.4	225	11.0	0.591	188	40.2	0.220
20–25	59	31.0	187	36.6		176	37.6	
≥25	17	9.0	42	8.2		52	11.1	
Missing	22	11.6	57	11.2		52	11.1	
Use of oral contraceptives								
No	66	34.9	136	26.6	0.031	132	29.3	0.093
Yes	123	65.1	375	73.4		335	71.7	
Missing	1		0			1		
Use of hormone replacement therapy								
No	130	68.4	348	68.1	0.936	222	47.8	<0.001
Yes	60	31.6	163	31.9		242	52.2	
Missing	0		0			4		
Alcohol intake								
No	155	81.6	415	81.2	0.912	385	82.4	0.793
Yes	35	18.4	96	18.8		82	17.6	
Missing	0		0			1		
Number of mammograms in past 6 years								
0–1	39	20.5	91	17.9	0.392	6	1.3	<0.001
2–3	55	29.0	131	25.7		55	11.8	

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Characteristic	Cases (n=190)		High-risk controls (n=511)			Low-risk controls (n=468)		
	N	%	N	%	p-value[a]	N	%	p-value[b]
4–5	34	17.9	85	16.7		101	21.8	
≥6	62	32.6	202	39.7		302	65.1	
Missing	0		2			4		
Comorbid conditions								
No	84	44.2	248	48.5	0.308	178	38.1	0.148
Yes	106	55.8	263	51.5		289	61.9	
Missing	0		0			1		
Physical activity								
No	116	61.1	268	52.5	0.042	219	46.8	<0.001
Yes	74	38.9	243	47.5		249	53.2	

[a] P-value for comparison of cases and high-risk controls.

[b] P-value for comparison of cases and low-risk-controls.

Table 2

Odds ratios and 95% confidence intervals for the associations of diabetes with incident invasive breast cancer, South Texas Women's Health Project, 2003–2008

Characteristic	Cases (n=190)		High-risk controls (n=511)		OR[a]	(95% CI)	Low-risk controls (n=468)		OR[a]	(95% CI)
	N	%	N	%			n	%		
History of diabetes										
No	125	65.8	354	69.3	1.00	(referent)	306	65.5		(referent)
Yes	65	34.2	157	30.7	1.02	(0.71–1.48)	161	34.5	0.87	(0.58–1.30)
Missing	0						1			
Type of diabetes										
Gestational	3	1.7	19	3.9	0.21	(0.03–1.64)	8	1.8	0.26	(0.03–2.31)
Type 2	47	26.9	112	23.1	1.00	(0.66–1.51)	129	29.1	0.77	(0.49–1.23)
Missing	15		26				24			
Age at diabetes onset (years)[b]										
<35	3	1.7	12	2.6	0.79	(0.21–2.96)	11	2.6	0.66	(0.17–2.61)
≥35	44	25.6	99	21.3	0.96	(0.63–1.47)	115	26.6	0.80	(0.51–1.26)
Missing	0		1				3			
Diabetes treatment[b]										
Insulin	22	12.8	25	5.4	2.23	(1.18–4.19)	37	8.5	1.24	(0.66–2.31)
Oral med.	21	12.2	71	15.2	0.72	(0.42–1.23)	64	14.7	0.77	(0.43–1.38)
No insulin or oral med.	4	2.3	16	3.4	0.55	(0.18–1.70)	28	6.4	0.31	(0.10–0.96)
Family history of diabetes										
No	59	31.6	160	31.6	1.00	(referent)	154	33.3	1.00	(referent)
Yes	128	68.4	346	63.4	1.02	(0.71–1.49)	309	66.7	1.16	(0.77–1.74)
Missing	3		5				5			

[a] Odds ratio (OR) and 95% confidence interval (95% CI) adjusted for menopausal status and mammography screening.

[b] Among women with type 2 diabetes.

Table 3

Odds ratios for breast cancer associated with joint effects of diabetes and physical activity, South Texas Women's Health Project, 2003–2008

Characteristic										
Did not engage in physical activity	**Cases (n=116)**		**High-risk controls (n=268)**		**OR[a]**	**(95% CI)**	**Low-risk controls (n=219)**		**OR[a]**	**(95% CI)**
	N	**%**	**N**	**%**			**n**	**%**		
History of diabetes										
No	69	59.5	185	69.0	1.00	(referent)	136	62.4	1.00	(referent)
Yes	47	40.5	83	31.0	0.96	(0.63–1.48)	82	37.6	0.72	(0.46–1.15)
Missing	0		1				1			
Did engage in physical activity	Cases (n=74)		High risk-controls (n=243)		OR[a]	(95% CI)	Low-risk controls (n=249)			
	N	%	N	%						
History of diabetes										
No	56	75.7	169	69.6	1.00	(referent)	170	68.3	1.00	(referent)
Yes	18	24.3	74	30.4	0.40	(0.21–0.79)	79	31.7	0.41	(0.21–0.83)
P-value for interaction						0.013				0.183

[a]Odds ratio (OR) and 95% confidence interval (95% CI) adjusted for menopausal status and mammography screening.

Table 4

Validation of self-report of diabetes by serum glucose and medical record, South Texas Women's Health Project, 2003–2008

	Sensitivity (95% CI)[a]	Specificity (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
	Cases (n=67)		High-risk controls (n=120)		Low-risk controls (n=121)	
Serum glucose	92.3 (78.0–98.0)	57.1 (37.4–75.0)	90.1 (81.0–95.3)	51.3 (35.0–67.3)	88.4 (77.9–94.5)	67.3 (52.8–79.3)
	Cases (n=92)		High-risk controls (n=157)		Low-risk controls (n=200)	
Medical record	94.8 (84.7–98.7)	88.2 (71.6–96.2)	86.5 (77.2–92.5)	86.8 (75.9–93.4)	91.9 (85.2–95.8)	89.6 (80.0–95.1)

[a] 95% confidence interval (95% CI)