Research Article

Cancer Prevention Research

Sedentary Behavior, Physical Activity, and Likelihood of Breast Cancer among Black and White Women: A Report from the Southern Community Cohort Study

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Abstract

Increased physical activity has been shown to be protective for breast cancer although few studies have examined this association in Black women. In addition, limited evidence to date indicates that sedentary behavior may be an independent risk factor for breast cancer. We examined sedentary behavior and physical activity in relation to subsequent incident breast cancer in a nested case–control study within 546 cases (374 among Black women) and 2,184 matched controls enrolled in the Southern Community Cohort Study. Sedentary and physically active behaviors were assessed via self-report at study baseline (2002–2009) using a validated physical activity questionnaire. Conditional logistic regression was used to estimate mutually adjusted ORs and corresponding 95% confidence intervals (CI) for quartiles of sedentary and physical activity measures in relation to breast cancer risk. Being in the highest versus lowest quartile of total sedentary behavior (≥12 vs. <5.5 h/d) was associated with increased odds of breast cancer among White women [OR, 1.94 (95% CI, 1.01–3.70); $P_{trend} = 0.1$] but not Black women [OR, 1.23 (95% CI, 0.82–1.83); $P_{trend} = 0.6$] after adjustment for physical activity. After adjustment for sedentary activity, greater physical activity was associated with reduced odds for breast cancer among White women ($P_{trend} = 0.03$) only. In conclusion, independent of one another, sedentary behavior and physical activity are risk factors for breast cancer among White women. Differences in these associations between Black and White women require further investigation. Reducing sedentary behavior and increasing physical activity are potentially independent targets for breast cancer prevention interventions. *Cancer Prev Res; 6(6); 566–76. ©2013 AACR.*

Introduction

In the United States, breast cancer incidence is lower in Black women than in White women, whereas mortality is higher in Black women (1). As a full understanding of the mechanisms underlying these differences remains elusive, there is a need to examine a wide range of relevant factors for cancer initiation, progression, and survival in racially diverse populations. Physical activity is one such factor that is particularly promising because activity behaviors are potentially modifiable, unlike many other risk factors for breast cancer identified to date such as age at menarche or age at menopause (2). Moderate-to-vigorous physical activity has been consistently linked to a reduced risk of postmenopausal breast cancer (3). Recently, time spent in sedentary behaviors has also been suggested as a risk factor for breast cancer, independent of physical activity (4). Supporting this hypothesis is evidence showing that sedentary behavior is associated with several risk factors associated with breast cancer including elevated body mass index (BMI) and waist circumference, circulating C-reactive protein and fasting insulin levels, and diabetes (5, 6). However, very few epidemiologic studies have examined sedentary behaviors in relation to breast cancer risk (7–9), and none have specifically examined the association in Black women. Furthermore, a limited number of studies have examined any physical activity measures in relation to breast cancer among Black women (10–13). Thus, the objective of this analysis was to examine both sedentary behaviors and physical activity in relation to incident breast cancer among Black and White women in a nested case–control study within the Southern Community Cohort Study (SCCS).

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Materials and Methods

Study population

The SCCS is a prospective cohort study focused on cancer disparities related to race, socioeconomic status, and other factors (14, 15). Between 2002 and 2009, nearly 86,000

residents of 12 southern states were enrolled in the cohort, most (86%) at one of 71 participating Community Health Centers (CHC), institutions which provide basic health and preventive services mainly to low income and uninsured persons (16). An additional 14% of participants responded to mailed questionnaires sent to residents of the 12 states randomly selected from general population sources between 2004 and 2006. All SCCS participants were required to be of age 40 to 79 years, speak English, and not be under treatment of cancer within the past 12 months. Informed consent was obtained from each participant upon enrollment into the SCCS. Institutional Review Boards at Vanderbilt University (Nashville, TN) and Meharry Medical College (Nashville, TN) approved the study.

Participants enrolled at CHCs were administered an in-person structured baseline interview by a trained interviewer at enrollment, whereas those recruited from the general population completed and returned a paper version of the same questionnaire. The study questionnaire (available online; ref. 17) contained questions about demographic, medical, familial, lifestyle, and other participant characteristics. It also contained a physical activity questionnaire (PAQ; ref. 18) and an 89-item food frequency questionnaire (19, 20).

Follow-up of the cohort for ascertainment of incident cancers is carried out via linkage to state cancer registries in 11 study enrollment states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia). For this analysis, a nested case–control study of incident breast cancer was conducted within the SCCS study population based on all cases of invasive breast cancer (International Classification of Disease for Oncology codes C50.0-C50.9) diagnosed after the date of SCCS enrollment. A longitudinal study design was determined to be infeasible due to uncertainties in complete follow-up time for many of the state cancer registries. Estrogen receptor (ER) status and progesterone receptor (PR) status were abstracted from the cancer registry data supplemented by available pathology reports and medical records when registry data were incomplete.

Female SCCS participants were eligible to be selected as controls for this study if they had not been diagnosed with invasive breast cancer at the time of their matched case's diagnosis. Four controls were matched to each case by age ($\pm$1 year), race (White, Black, or other), menopausal status (pre- or post-), and enrollment location (CHC for CHC-enrollees or state for general population enrollees).

Measurement of sedentary behavior and physical activity

The baseline SCCS PAQ was developed specifically for the SCCS to assess both sedentary and active behaviors done at home, at work, and during leisure-time at the time of the interview. Time spent in sedentary behaviors was assessed by asking for the amount of time per day spent sitting in a car or bus, at work, watching television or seeing movies, using a computer at home, and for other reasons (e.g., sitting at meals, talking on the phone, reading, playing games, or sewing). Times spent in light, moderate, and strenuous activity at home and work were assessed separately for weekdays and weekends and then combined using weighted averages. During the interview, hand cards were given to the participants with examples of light work (e.g., standing at work, light office work, shopping, cooking, child care, etc.), moderate work (e.g., manufacturing work, cleaning house, gardening, mowing lawn, home repair, etc.), and strenuous work (e.g., loading trucks, construction work, farming, etc.). Two questions elicited time spent in moderate sports (e.g., bowling, dancing, golf, or softball) and vigorous sports (e.g., jogging, aerobics, bicycling, tennis, swimming, weight lifting, or basketball). Participants were also asked to recall time spent in light, moderate, and strenuous activity at home and work as well as in sports and exercise in their 30s.

The SCCS PAQ was evaluated in 118 participants (87 Black, 31 White) using test–retest reliability methodology and via comparisons with a physical activity monitor (accelerometer) and a last-month physical activity survey administered up to 4 times in each participant, and there was general consistency in the magnitude of correlations between Blacks and Whites in the validation study (18).

Sedentary behavior was analyzed in h/d, whereas physically active times were transformed from h/d into summary measures of energy expended, defined as metabolic equivalent (MET)-hours per day. Two MET-hours is roughly equivalent to walking at a moderate intensity (5 METs) for 0.5 hours or jogging at a vigorous intensity (8 METs) for 0.25 hours. MET values for specific activities and intensities were based on the values suggested in Compendium of Physical Activities (21).

The 2 primary exposures for this analysis were summary measures calculated as: (i) total sitting (sum of all individual sedentary behaviors in h/d), and (ii) total physical activity (sum of light, moderate, and strenuous household/occupational work as well as moderate and vigorous sports in MET-h/d).

Statistical methods

Women were categorized by quartiles of sedentary behavior (h/d) and active behaviors (MET-h/d) as calculated from the distribution of the control subjects. For total sports and sitting time at work, the distributions were so highly skewed that women were classified as: (i) none, (ii) less than the median value for non-0 values, or (iii) greater than or equal to the median value for non-0 values. Cases and controls were compared using χ^2 statistics for personal characteristics and using the nonparametric Wilcoxon rank sum test for sedentary behavior and physical activity measures.

Conditional logistic regression models were used to estimate OR and 95% confidence intervals (CI) for incident breast cancer in relation to categories of physical activity or sedentary behavior. Matching factors (age, race, menopausal status, and enrollment source) were accounted for in the conditional analysis, and additional covariates included education (<high school, high school, and vocational training/some college/college/graduate school), annual

household income (<$15,000, $15,000–24,999, $25,000–49,999, and $50,000+), BMI at age of 21 years, cigarette smoking (current, former, or never), ever use of hormone replacement therapy (yes or no), parity (nulliparous, 1, 2, 3, 4, and 5+), age at menarche (<12 or 12+ years), first-degree family history of breast cancer (yes or no), and having health insurance (yes or no). Alcohol consumption, BMI at study entry, total energy consumption, and age at first birth were also considered as potential covariates but their inclusion in the models did not change the ORs appreciably, and thus they are not included in the final models presented here. Total sedentary behavior and total physical activity were examined in separate multivariate models and then included in a single model as well. Hormone receptor–positive cancers were defined as all cases with either ER-positive or PR-positive receptors. Hormone receptor–negative cancers included all cases that were both ER-negative and PR-negative. Race-stratified models examining hormone receptor–positive and -negative cancers separately in relation to total activity and total sedentary behavior were assessed. Models limited to postmenopausal women were also examined as were models including activity measures during the 30s.

All analyses were conducted using SAS/STAT software, version 9.3 of the SAS System for Windows (SAS Institute Inc.).

Results

From July 2002 to August 2011, 546 incident breast cancer cases were ascertained among women in the cohort and were matched to 2,184 controls on race, menopausal status, age, and enrollment location. Approximately, 69% of the women were Black and three quarters were postmenopausal (Table 1). Having a mother or sister with breast cancer was more common in cases (14.5%) than in controls (10.9%; $P = 0.02$). Among the cases, 292 (53%) were ER-positive, 150 (27%) were ER-negative, and 104 (19%) were missing ER status; 238 (44%) were PR-positive, 198 (36%) were PR-negative, and PR status was missing for 108 (20%). Jointly, 307 of the cases were hormone receptor–positive (either ER-positive or PR-positive or both), whereas 140 were hormone receptor–negative (ER-negative and PR-negative).

Mean time spent in sedentary behaviors was 9.5 h/d in cases versus 9.2 hours in controls, and mean total physical activity time was 20.0 MET-h/d in cases and controls (Table 1). Quartiles for active and sedentary measures were computed in the entire group of controls (Black, White, and other race combined). Combined cutoff points for the behavior measures were used because the race-specific cutoff points were very similar to one another; for total activity (MET-h/d), the 25th, 50th and 75th percentiles were 10.3, 17.3, and 27.4, respectively, for White controls, and 8.6, 16.5, and 27.0 for Black controls, whereas for total sedentary behavior (h/d), these percentile values were 5.8, 8.5, and 12.0 for White controls and 5.5, 8.0, and 12.0 for Black controls.

In multivariate models, increased time in sedentary behaviors was associated with significantly increased odds of breast cancer among White women but not among Black women [OR (95% CI), 2.04 (1.07–3.86) for Whites and 1.20 (0.81–1.77) for Blacks] comparing the highest vs. lowest quartiles of sitting; Table 2). Further adjustment for total activity (i.e., household and occupational activity and sports/exercise activity) did not notably affect the ORs for sedentary behavior (Table 2). An inverse trend was seen for increasing total physical activity in relation to odds of breast cancer among White women [OR (95% CI), 0.54 (0.29–1.01)] but not Black women [OR (95% CI), 1.14 (0.78–1.67); Table 2].

Subtypes of breast cancer based on ER and PR status were examined in relation to total activity and total sedentary behavior although small numbers of cases, particularly among White women, limited precision (Table 3). Both White and Black women with hormone receptor–positive tumors in the highest quartile of sedentary behavior had increased odds of breast cancer [OR (95% CI), 2.86 (1.15–7.11) for White women and OR (95% CI), 1.94 (1.09–3.44) for Black women). There was a significant inverse trend among White women with hormone receptor–positive cancers for the association between total physical activity and odds of breast cancer ($P = 0.05$; Table 3).

Individual components of physical activity (light household and occupational activity, moderate and vigorous household and occupational activity, and moderate and vigorous sports/exercise) and sedentary behaviors were examined in relation to breast cancer (Table 4). None of the individual physical activity behaviors was associated with significant decreases in breast cancer risk although there was some indication of reduced odds of developing breast cancer among White women with increasing moderate and vigorous activity ($P_{trend} = 0.06$). For individual sedentary behaviors, there was no increase in breast cancer risk as time spent viewing television or movies increased (Table 4).

In models limited to women who were postmenopausal at diagnosis (371 cases; data not shown), increased time spent in sedentary behaviors was positively associated with odds of breast cancer overall [OR (95% CI), 1.55 (1.08–2.23)], and the difference in magnitude between race groups was amplified, with ORs (95% CI) of 2.68 (1.30–5.53) for White women and 1.24 (0.80–1.93) for Black women for the highest versus lowest quartile. Total physical activity was not significantly associated with breast cancer risk in this subset of postmenopausal women in either race group although the ORs among White women with increasing activity level did show an inverse association [OR (95% CI), 0.82 (0.43–1.54), 0.75 (0.40–1.40), and 0.64 (0.32–1.27), for quartiles 2, 3, and 4 compared with the lowest activity quartile; $P_{trend} = 0.11$].

Most associations between physical activity during the participants' 30s and incident breast cancer were null (Table 5). Among Black women, there was some indication that women with the highest level of sports/exercise had a reduced risk of breast cancer [OR (95% CI), 0.73

Table 1. Descriptive characteristics of incident breast cancer cases and matched controls, SCCS

	Cases ($N = 546$)		Controls ($N = 2,184$)		
Covariates	**Mean**	**[SD]**	**Mean**	**[SD]**	***P* value[a]**
Age at enrollment	55.1	[8.9]	55.1	[8.8]	0.96
BMI at enrollment, kg/m^2	32.4	[8.0]	31.7	[8.1]	0.06
BMI at age 21 y, kg/m^2	22.5	[4.7]	22.6	[5.3]	0.81
Age at menarche	12.7	[1.8]	12.9	[1.9]	0.14
Total energy intake, kcal/d	2,106.4	[1,179.3]	2,146.1	[1,223.7]	0.51
	N(%)		*N* (%)		
Race[b]					
White	152 (27.8)		608 (27.8)		Matched
Black	374 (68.5)		1,496 (68.5)		
Other	20 (3.7)		80 (3.7)		
Enrollment source[b]					
CHC	464 (85.0)		1,856 (85.0)		Matched
General population	82 (15.0)		328 (15.0)		
Menopausal status at baseline[b]					
Pre	132 (24.2)		528 (24.2)		Matched
Post	414 (75.8)		1,656 (75.8)		
Highest educational attainment					
Less than high school	132 (25.1)		592 (27.9)		0.45
High school	171 (32.5)		670 (31.5)		
Some college, college, graduate school	223 (42.4)		864 (40.6)		
Annual household income					
<$15,000	275 (53.1)		1,185 (56.4)		0.52
$15,000–24,999	116 (22.4)		422 (20.1)		
$25,000–49,999	80 (15.4)		323 (15.4)		
$50,000+	47 (9.1)		173 (8.2)		
Health insurance coverage					
Yes	358 (68.2)		1,422 (67.0)		0.60
No	167 (31.8)		701 (33.0)		
Cigarette smoking					
Current	162 (30.6)		611 (28.8)		0.41
Former	115 (21.7)		518 (24.4)		
Never	252 (47.6)		995 (46.9)		
Alcohol consumption, drinks/d					
0	304 (58.7)		1,222 (58.2)		0.70
<1	156 (30.1)		664 (31.6)		
1+	58 (11.2)		214 (10.2)		
Use of female replacement hormone therapy					
Ever	191 (36.2)		727 (34.2)		0.37
Never	336 (63.8)		1,400 (65.8)		
Parity					
Nulliparous	51 (9.7)		233 (11.0)		0.46
1	85 (16.2)		291 (13.7)		
2	129 (24.5)		500 (23.5)		
3	112 (21.3)		429 (20.2)		
4	64 (12.2)		303 (14.3)		
5+	85 (16.2)		371 (17.4)		
Age at menarche, y					
<12	108 (20.7)		417 (19.8)		0.67
12+	415 (79.4)		1,686 (80.2)		

(Continued on the following page)

Table 1. Descriptive characteristics of incident breast cancer cases and matched controls, SCCS (Cont'd)

	Cases ($N = 546$)		Controls ($N = 2,184$)		
Covariates	**Mean**	**[SD]**	**Mean**	**[SD]**	***P* value[a]**
Family history of breast cancer[c]					
Yes	79 (14.5)		237 (10.9)		0.02
No	467 (85.5)		1,947 (89.2)		
Sedentary and physical activity measures	Mean	[SD]	Mean	[SD]	*P* value
Sitting, h/d					
Car or bus	1.3	[1.6]	1.2	[1.5]	0.25
At work	1.5	[2.6]	1.4	[2.5]	0.21
TV or movies	3.7	[2.9]	3.8	[3.0]	0.58
Home computer	0.5	[1.1]	0.5	[1.2]	0.43
Other[d]	2.5	[2.0]	2.4	[2.0]	0.15
Total	9.5	[4.8]	9.2	[5.2]	0.07
Household/occupational activity, MET-h/d					
Light	7.8	[6.1]	7.8	[6.1]	0.81
Moderate	9.2	[8.0]	9.1	[7.9]	0.82
Strenuous	2.3	[7.0]	2.6	[7.8]	0.23
Sports, MET-h/d					
Moderate	0.3	[0.8]	0.3	[0.9]	0.74
Vigorous	0.4	[1.3]	0.6	[1.8]	0.73
Total physical activity, MET-h/d[e]	20.0	[15.5]	20.3	[15.9]	0.98

NOTE: Among cases, missing values include $N = 20$ for education, $N = 28$ for income, $N = 21$ for health insurance, $N = 17$ for smoking, $N = 28$ for alcohol consumption, $N = 19$ for replacement hormone therapy, $N = 23$ for age at menarche, and $N = 20$ for parity. Among controls, missing values include $N = 58$ for education, $N = 81$ for income, $N = 61$ for health insurance, $N = 60$ for smoking, $N = 84$ for alcohol consumption, $N = 57$ for replacement hormone therapy, $N = 81$ for age at menarche, and $N = 57$ for parity.

[a]*P* values for covariates based on *t* tests and *P* values for sedentary and physical activity measures from Wilcoxon Mann–Whitney nonparametric tests.

[b]Matching factors.

[c]Mother or full sister.

[d]Other sitting activities include sitting at meals, talking on the phone, reading, playing cards, or sewing.

[e]Total physical activity includes light, moderate, and strenuous household/occupational activity as well as moderate and vigorous sports.

(0.51–1.05)] compared with women reporting no sports and exercise in this decade.

Discussion

This prospective study is to our knowledge the first to investigate associations between sedentary behaviors and breast cancer risk among Black and White middle age and older women and is one of only a few studies to date reporting on associations between physical activity and breast cancer in Black women. We found that longer time spent in sedentary behaviors was associated with increased odds of developing breast cancer among White but not Black women, and that increased amounts of total physical activity were associated with decreased odds of breast cancer only in White women as well.

Investigations of associations of physical activity and sedentary behaviors with breast cancer risk are of particular importance because these are potentially modifiable behaviors, in contrast to many other known risk factors for breast cancer such as family history, age at menarche, and parity (2). Although some individual studies have shown inconsistencies, the totality of the evidence indicates that physical activity reduces the risk of breast cancer (3, 22). Across 73 studies of breast cancer reviewed in 2010, an average 25% reduction in risk was observed in women engaged in the highest versus lowest level of physical activity (23). Our results for White women are consistent with the results of this review showing a modest but significant reduction in breast cancer risk in women engaged in the highest versus lowest levels of physical activity.

Although there is a large body of literature about associations between physical activity and breast cancer in White women, few studies have been conducted in Black women. We found no significant reduction in risk among Black women for increased physical activity at baseline but some indication that higher levels of sports and exercise in the 30s was associated with decreased risk for developing breast cancer later in life. Two prior studies limited to Black women reported reductions in breast cancer risk associated with strenuous exercise at age 21, 30, and 40 years

Table 2. ORs and 95% CI from conditional logistic regression models examining incident breast cancer in relation to total sedentary behavior (h/d) and total physical activity (MET-h/d)

	All women		White women		Black women	
Quartiles[a]	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**
Total sedentary behavior, h/d)[b]						
<5.5	87	1.00 (Ref.)	19	1.00 (Ref.)	65	1.00 (Ref.)
5.5–8.1	125	1.27 (0.93–1.74)	36	1.52 (0.82–2.830)	86	1.24 (0.85–1.81)
8.2–11.9	114	1.23 (0.89–1.70)	35	1.79 (0.94–3.42)	76	1.08 (0.73–1.590
≥12	132	1.37 (0.99–1.90)	42	2.04 (1.07–3.86)	86	1.20 (0.81–1.77)
P_{trend}		0.81		0.06		0.41
Total sedentary behavior with adjustment for total activity, h/d						
<5.5	86	1.00 (Ref.)	19	1.00 (Ref.)	64	1.00 (Ref.)
5.5–8.1	124	1.29 (0.94–1.77)	35	1.50 (0.80–2.81)	86	1.26 (0.86–1.85)
8.2–11.9	113	1.25 (0.90–1.73)	35	1.71 (0.89–3.30)	75	1.09 (0.74–1.61)
≥12	132	1.41 (1.01–1.95)	42	1.94 (1.01–3.70)	86	1.23 (0.82–1.83)
P_{trend}		0.60		0.10		0.58
Total activity, MET-h/d[c]						
<9.0	104	1.00 (Ref.)	35	1.00 (Ref.)	67	1.00 (Ref.)
9.0–16.5	129	1.26 (0.94–1.70)	36	1.04 (0.60–1.83)	89	1.34 (0.93–1.92)
16.6–27.0	120	1.13 (0.83–1.53)	35	0.75 (0.42–1.32)	81	1.26 (0.86–1.83)
≥27.1	106	0.97 (0.71–1.33)	26	0.54 (0.29–1.01)	77	1.14 (0.78–1.67)
P_{trend}		0.27		0.02		0.96
Total activity with adjustment for total sedentary behavior, MET-h/d						
<9.0	103	1.00 (Ref.)	35	1.00 (Ref.)	66	1.00 (Ref.)
9.0–16.5	128	1.28 (0.94–1.73)	36	1.08 (0.61–1.90)	88	1.35 (0.94–1.950)
16.6–27.0	118	1.13 (0.83–1.53)	34	0.78 (0.44–1.38)	80	1.26 (0.86–1.83)
≥27.1	106	0.99 (0.72–1.36)	26	0.59 (0.31–1.11)	77	1.15 (0.78–1.69)
P_{trend}		0.27		0.03		0.93

NOTE: Analysis of all women includes women of other/mixed race. Matching factors (age, race, menopausal status, and enrollment source) were accounted for in the conditional analysis. Additional covariates included in the models were education, household income, BMI at age 21 years, cigarette smoking, ever use of hormone replacement therapy, parity, age at menarche, first-degree family history of breast cancer, and having health insur-ance (categories for all shown in Table 1).

[a]Quartiles were determined from the distribution of the controls.

[b]Total sedentary behavior includes sitting in a car or bus, sitting at work, watching television or movies, using a home computer, and other sitting (e.g., sitting at meals, talking on the phone, reading, playing games, or sewing).

[c]Total activity includes light, moderate, and vigorous household and occupational activity as well as moderate and vigorous sports/exercise.

(postmenopausal breast cancer only; ref. 11) and with vigorous physical activity (13). A case–control study including Black and White women in the San Francisco Bay Area examined lifetime moderate and vigorous activity (including activity that was recreational, related to transportation and chores, and occupational) and found modest reductions in breast cancer risk among pre- and postmenopausal Black and White women with the highest levels of activity compared with the lowest (10). In a large case–control study conducted in Atlanta, Detroit, Los Angeles, and Seattle, high lifetime exercise activity (defined as ≥3 hours of exercise per week vs. inactive) was found to be associated with a moderate reduction in breast cancer in both Black [OR (95% CI), 0.75 (0.61–0.93)] and White women [OR (95% CI), 0.83 (0.70–0.98); ref. 12]. In contrast to these 2 studies, in the SCCS, we found dissimilar patterns between Black and White women for total physical activity in relation to breast cancer. These differences between studies could be attributed to multiple factors such as those related to measurement including potentially differential reporting of activity between women of different races; differences in ascertainment of physical activity in terms of domain, type, duration, frequency, and timing between studies; or study timing. Differences in underlying biologic processes whereby physical activity may influence risk of breast cancer in White versus Black women (such as adipose-derived biomarkers or patterns of fat distribution) may also cause differences in observed associations, but are difficult to compare across studies.

Sedentary behavior, in contrast to physically active behaviors, is a relatively newly hypothesized risk factor for

Table 3. ORs and 95% CI from conditional logistic regression models examining incident breast cancer in relation to total sedentary behavior (h/d) and total physical activity (MET-h/d) according to hormone receptor status[a]

	All women		White women		Black women	
Quartiles[b]	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**
Total sedentary behavior[c]						
Hormone receptor–positive						
<5.5	37	1.00 (Ref.)	9	1.00 (Ref.)	26	1.00 (Ref.)
5.5–8.1	71	1.67 (1.06–2.65)	21	2.02 (1.80–5.10)	48	1.81 (1.04–3.15)
8.2–11.9	71	1.86 (1.18–2.93)	24	2.95 (1.19–7.29)	46	1.62 (0.93–2.82)
≥12	81	2.10 (1.32–3.34)	28	2.86 (1.15–7.11)	51	1.94 (1.09–3.44)
P_{trend}		0.05		0.04		0.31
Hormone receptor–negative						
<5.5	31	1.00 (Ref.)	8	1.00 (Ref.)	22	1.00 (Ref.)
5.5–8.1	30	0.89 (0.48–1.65)	5	0.45 (0.09–2.22)	25	1.09 (0.52–2.29)
8.2–11.9	26	0.64 (0.34–1.22)	5	0.79 (0.10–6.47)	21	0.77 (0.36–1.61)
≥12	30	0.80 (0.43–1.51)	10	1.83 (0.37–9.06)	20	0.73 (0.34–1.56)
P_{trend}		0.45		0.34		0.27
Total activity[d]						
Hormone receptor–positive						
<9.0	52	1.00 (Ref.)	20	1.00 (Ref.)	31	1.00 (Ref.)
9.0–16.5	80	1.63 (1.08–2.45)	28	1.44 (0.68–3.06)	50	1.84 91.10–3.09)
16.6–27.0	68	1.22 (0.81–1.85)	19	0.79 (0.37–1.69)	47	1.51 (0.87–2.57)
≥27.1	60	1.00 (0.65–1.56)	15	0.61 (0.26–1.47)	43	1.26 (0.72–2.19)
P_{trend}		0.05		0.05		0.30
Hormone receptor–negative						
<9.0	29	1.00 (Ref.)	6	1.00 (Ref.)	23	1.00 (Ref.)
9.0–16.5	31	1.02 (0.55–1.890)	3	0.40 (0.05–2.87)	28	1.18 (0.59–2.37)
16.6–27.0	25	0.78 (0.41–1.50)	9	2.21 (0.38–12.90)	15	0.59 (0.27–1.290
≥27.1	32	0.96 (0.52–1.76)	10	2.16 (0.37–12.50)	22	0.84 (0.42–1.70)
P_{trend}		0.99		0.71		0.78

NOTE: Analysis of all women includes women of other/mixed race. Matching factors (age, race, menopausal status, and enrollment source) were accounted for in the conditional analysis. Additional covariates included in the models were education, household income, BMI at age 21 years, cigarette smoking, ever use of hormone replacement therapy, parity, age at menarche, first-degree family history of breast cancer, and having health insur-ance (categories for all shown in Table 1).

[a]Hormone receptor–positive cases include all cases that are either ER-positive or PR-positive. Hormone receptor negative cases include all cases that are both ER-negative and PR-negative.

[b]Quartiles were determined from the distribution of the controls.

[c]Total sedentary behavior includes sitting in a car or bus, sitting at work, watching television or movies, using a home computer, and other sitting (e.g., sitting at meals, talking on the phone, reading, playing games, or sewing). Models adjusted for total activity.

[d]Total activity includes light, moderate, and vigorous household and occupational activity as well as moderate and vigorous sports/exercise. Models adjusted for total sitting.

cancer. A 2010 review identified 11 studies examining some measure of sedentary behavior with a cancer outcome (not limited to breast), with 8 showing a positive association (24). To date, very few studies have examined sedentary behavior specifically in relation to breast cancer risk. In a case–control study of White women in Poland, with accelerometer-based measures of sedentary behavior, elevated ORs for breast cancer were found in the highest versus lowest quartile of sedentary behavior (OR = 1.81), a finding very similar to our results among White women (9). Two other studies have examined self-reported television viewing time as a proxy for sedentary behavior in relation to breast cancer; in a hospital-based case–control study in India, television viewing was not associated with incident breast cancer (8), whereas in the U.S.-based NIH-AARP Diet and Health Study, television viewing did show a modest, positive but not statistically significant association with incident breast cancer risk (7). Another component of sedentary behavior, occupational sitting time, has been assessed in relation to breast cancer risk. In the Shanghai Women's Health Study, women with the most sitting at work were found to have increased risk of breast cancer

Table 4. ORs and 95% CI from conditional logistic regression models examining incident breast cancer in relation to individual components of sedentary behavior and physically active behaviors

	All women		White women		Black women	
Quartiles[a]	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**
Sedentary behaviors						
Sitting in a car or bus, h/d						
<0.33	108	1.00 (Ref.)	27	1.00 (Ref.)	77	1.00 (Ref.)
0.33–0.99	198	0.88 (0.66–1.18)	61	0.85 (0.47–1.54)	131	0.90 (0.64–1.28)
1.0–1.99	83	1.06 (0.74–1.51)	27	1.28 (0.62–2.64)	53	0.97 (0.63–1.50)
≥2.0	68	1.05 (0.72–1.53)	16	1.26 (0.56–2.85)	52	1.06 (0.68–1.65)
P_{trend}		0.20		0.20		0.25
Sitting at work, h/d						
None	285	1.00 (Ref.)	80	1.00 (Ref.)	195	1.00 (Ref.)
>0–2.9	86	1.15 (0.85–1.56)	18	1.14 (0.58–2.27)	65	1.13 (0.80–1.61)
≥3	88	1.13 (0.82–1.560	34	1.64 (0.90–2.99)	54	0.96 (0.65–1.44)
P_{trend}		0.63		0.10		0.54
Watching television or movies, h/d						
<2	182	1.00 (Ref.)	59	1.00 (Ref.)	119	1.00 (Ref.)
2–2.9	88	1.01 (0.75–1.37)	31	1.41 (0.79–2.52)	55	0.86 (0.59–1.27)
3–4.9	98	0.91 (0.68–1.23)	19	0.75 (0.39–1.42)	74	0.90 (0.64–1.28)
≥5	91	0.97 (0.70–1.35)	23	1.13 (0.59–2.19)	66	0.95 (0.64–1.39)
P_{trend}		0.31		0.45		0.45
Other sitting, h/d[b]						
<1	112	1.00 (Ref.)	21	1.00 (Ref.)	90	1.00 (Ref.)
1–1.9	111	1.27 (0.93–1.73)	29	1.42 (0.74–2.72)	79	1.17 (0.82–1.68)
2–3.9	144	1.30 (0.97−1.74)	54	1.97 (1.08–3.63)	84	1.03 (0.72–1.46)
≥4	90	1.28 (0.91–1.80)	28	1.56 (0.77–3.14)	59	1.13 (0.75–1.71)
P_{trend}		0.52		0.11		0.63
Physically active behaviors						
Light household and occupational activity, MET-h/d[c]						
<3.3	112	1.00 (Ref.)	31	1.00 (Ref.)	78	1.00 (Ref.)
3.3–5.8	102	1.04 (0.76–1.43)	32	1.27 (0.70–2.31)	68	0.96 (0.65–1.41)
5.9–11.1	128	1.02 (0.74–1.39)	38	1.24 (0.68–2.28)	86	0.92 (0.63–1.36)
≥11.2	115	1.00 (0.72–1.40)	31	1.08 (0.57–2.02)	80	0.96 (0.64–1.43)
P_{trend}		0.95		0.82		0.91
Moderate and vigorous household and occupational activity, MET-h/d[d]						
<4	89	1.00 (Ref.)	33	1.00 (Ref.)	53	1.00 (Ref.)
4–7.9	107	1.15 (0.83–1.61)	33	1.01 (0.54–1.89)	72	1.24 (0.82–1.88)
8–15.6	158	1.24 (0.91–1.71)	39	0.73 (0.40–1.33)	114	1.48 (1.00–2.19)
≥15.7	102	0.97 (0.69–1.38)	27	0.60 (0.31–1.18)	72	1.14 (0.74–1.76)
P_{trend}		0.46		0.06		0.84
Moderate and vigorous sports/exercise, MET-h/d						
None	332	1.00 (Ref.)	91	1.00 (Ref.)	229	1.00 (Ref.)
>0–2.0	63	1.15 (0.83–1.59)	20	1.97 (1.03–3.74)	42	0.99 (0.67–1.46)
≥2.1	61	0.93 (0.67–1.29)	20	0.96 (0.52–1.77)	41	0.98 (0.66–1.47)
P_{trend}		0.17		0.21		0.56

NOTE: Each model examining an individual sedentary behavior is also adjusted for other sedentary behaviors as well as total activity. Each model examining an individual physically active behavior is also adjusted for the other physically active behaviors as well as total sedentary time. Matching factors (age, race, menopausal status, and enrollment source) were accounted for in the conditional analysis. Additional covariates included in the models were education, household income, BMI at age 21 years, cigarette smoking, ever use of hormone replacement therapy, parity, age at menarche, first-degree family history of breast cancer, and having health insurance (categories for all shown in Table 1).

[a]Quartiles were determined from the distribution of the controls. Because of highly skewed distributions, the cutoff points used for total sports/exercise and sitting at work were none, <median, and median+ (median = 2.1 MET-h/wk for total sports/exercise and median = 3 h/d for sitting at work).

[b]Other sitting includes using a computer at home, sitting at meals, talking on the phone, reading, playing games, or sewing.

[c]Examples of light household and occupational activity were standing at work, light office work, shopping, cooking, and child care.

[d]Examples of moderate and vigorous household and occupational activity were manufacturing work, cleaning house, gardening, mowing lawn, home repair, loading trucks, construction work, and farming.

Table 5. ORs and 95% CI from conditional logistic regression models examining incident breast cancer in relation to physical activity behaviors during the 30s

	All women		White women		Black women	
Quartiles[a]	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**	**Cases**	**OR (95% CI)**
Total activity, MET-h/d[b]						
<30.4	101	1.00 (Ref.)	22	1.00 (Ref.)	75	1.00 (Ref.)
30.4–45.6	122	1.19 (0.87–1.63)	38	1.69 (0.90–3.19)	83	1.14 (0.77–1.66)
45.6–68.0	117	1.06 (0.77–1.46)	37	1.27 (0.67–2.42)	76	1.01 (0.69–1.49)
≥68.1	108	1.02 (0.73–1.45)	33	1.59 (0.78–3.23)	72	0.92 (0.61–1.39)
P_{trend}		0.76		0.32		0.41
Light household and occupational activity, MET-h/d[c]						
<9.2	101	1.00 (Ref.)	31	1.00 (Ref.)	68	1.00 (Ref.)
9.2–16.0	131	1.02 (0.74–1.40)	34	0.89 (0.48–1.65)	94	1.12 (0.76–1.65)
16.1–18.4	113	0.95 (0.69–1.31)	27	0.90 (0.47–1.73)	81	0.99 (0.67–1.45)
≥18.5	104	1.05 (0.75–1.49)	38	1.27 (0.69–2.34)	63	1.02 (0.66–1.59)
P_{trend}		0.87		0.96		0.67
Moderate and vigorous household and occupational activity, MET-h/d[d]						
<12	77	1.00 (Ref.)	21	1.00 (Ref.)	55	1.00 (Ref.)
12–27.9	150	1.43 (1.02–2.00)	39	1.51 (0.78–2.92)	107	1.47 (0.97–2.21)
28–47.9	109	1.18 (0.83–1.69)	37	1.83 (0.92–3.64)	67	0.98 (0.64–1.52)
≥48	113	1.23 (0.85–1.78)	33	1.74 (0.81–3.74)	77	1.10 (0.71–1.71)
P_{trend}		0.72		0.34		0.83
Moderate and vigorous sports/exercise, MET-h/d						
None	156	1.00 (Ref.)	36	1.00 (Ref.)	112	1.00 (Ref.)
>0–2.0	143	0.90 (0.68–1.19)	42	1.23 (0.70–2.17)	98	0.85 (0.60–1.19)
≥2.1	149	0.79 (0.59–1.06)	52	1.09 (0.62–1.90)	96	0.73 (0.51–1.05)
P_{trend}		0.13		0.80		0.09

NOTE: Analysis of all women includes women of other/mixed race. Matching factors (age, race, menopausal status, and enrollment source) were accounted for in the conditional analysis. Quartiles of baseline total physical activity and total sedentary behavior were included in the models. Additional covariates included in the models were education, household income, BMI at age 21 years, cigarette smoking, ever use of hormone replacement therapy, parity, age at menarche, first-degree family history of breast cancer, and having health insur-ance (categories for all shown in Table 1).

[a]Quartiles were determined from the distribution of the controls.

[b]Total activity includes light, moderate, and vigorous household and occupational activity as well as moderate and vigorous sports/exercise.

[c]Examples of light household and occupational activity were standing at work, light office work, shopping, cooking, and child care.

[d]Examples of moderate and vigorous household and occupational activity were manufacturing work, cleaning house, gardening, mowing lawn, home repair, loading trucks, construction work, and farming.

compared with women with more active jobs (25), whereas in the Netherlands Cohort Study, the association between sitting time at work and breast cancer was null (26). Few of these studies examined a broad range of sitting behaviors, and this may explain the larger magnitude of the findings in the SCCS, which included multiple types of sitting activities.

Beyond the few epidemiologic studies of cancer outcomes, sedentary behavior has also been associated with physiologic risk factors for breast cancer including increased adiposity, insulin resistance, and increased inflammation (5, 27). In laboratory studies, prolonged sedentary time led to fewer skeletal muscle contractions causing rapid reductions in lipoprotein lipase activity, which in turn leads to decreased high-density lipoprotein (HDL) cholesterol production as well as reduced triglyceride uptake (28, 29). Another documented physiologic consequence of sedentary behavior is increased insulin response to glucose loading (30). Sedentary behavior has also been linked to increased waist circumference, BMI, and weight gain (24, 31). These pathways, and possibly others yet to be explored may mediate the effect of increased sedentary behavior on risk of breast cancer (24).

In a recent review of studies of physical activity and breast cancer that have examined effect modification by ER/PR status, the authors determined that there was not clear evidence of effect modification by hormone receptor status (3). In the present study, there was some indication of breast cancer risk reduction related to higher physical activity levels among White women with hormone receptor–

positive tumors but not receptor-negative tumors. This finding is consistent with some previous reports but not all (3). Our findings are among the first to examine sedentary behavior in relation to subtypes of breast cancer, and while precision was low due to the small numbers of cases, the data were suggestive that hormone receptor–positive cancers may have as strong or stronger associations with sedentary behavior than hormone receptor–negative cancers in White women. Additional follow-up in the SCCS as well as examination of both physical activity and sitting behaviors in other large, diverse study populations are needed to better understand the associations within specific subtypes of breast cancer.

An important strength of this study is the ascertainment of a broad range of physical activity and sedentary behaviors. In many previous reports analyzing sedentary behavior, television viewing has been used as a proxy for all sedentary behaviors. In contrast to using only this proxy measure, we collected information on sitting at work, in transportation, while viewing television or movies, using a computer, and other sitting activities. Among the controls of this study, television and movie viewing was the largest contributor to the total sedentary behavior time, but it represented only 40% of all sedentary behavior. The relatively low correlation between all sitting activities reported and television/movie viewing (0.59) indicate that television/movie time is not an ideal proxy for all sedentary behaviors. A second strength of our study is that our PAQ included questions about light, moderate, and vigorous household and occupational work as well as time spent in sports and exercise, which allowed us to distinguish true sedentary behavior from light activity, a distinction that has not been possible in many previous studies.

Our study also has limitations, which first include that physical activity was self-reported rather than objectively measured. Second, it is possible that the different results between races observed in this study were due to differences in reporting errors for Black and White women. However, our evaluation of the PAQ used in this study as compared with an accelerometer did not reveal notable racial differences (18). Third, we did not measure lifetime physical activity level. However, we did assess physical activity during the 30s, which ameliorated this deficiency at least in part. Finally, this study was limited by the lack of power to examine effect modification by potentially important factors such as body size or hormone replacement therapy.

In conclusion, this study found that increased time spent in sedentary behaviors is associated with increased breast cancer risk, and that this association may be different in Black and White women of middle to older age. Unlike many known risk factors for breast cancer, physical activity and sedentary behavior represent promising targets for public health interventions to reduce the burden of breast cancer due to their modifiable nature.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The contents of this publication are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention (CDC) or the Mississippi Cancer Registry.

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