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## Change in Physical Activity During Active Treatment in a Prospective Study of Breast Cancer Survivors

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### Abstract

Physical activity offers many benefits to breast cancer survivors, yet research on physical activity during the immediate period following a breast cancer diagnosis is limited. In a prospective cohort study of 1,696 women diagnosed with invasive breast cancer in the Kaiser Permanente Northern California Medical Care Program from 2006–2009, we describe change in self-reported physical activity levels from around diagnosis to six months post-diagnosis and determine factors associated with change. Participants completed a comprehensive physical activity questionnaire at baseline (2 months post-diagnosis) and at follow-up (8 months post-diagnosis). Predictors of physical activity change were determined by multivariable linear regression. Reductions in all physical activity levels were observed ( $P < 0.0001$ ); mean (SD) change (hours/week) of moderate-vigorous physical activity (MVPA) was  $-1.28$  (4.48) and sedentary behavior was  $-0.83$  (6.95). In fully-adjusted models, overweight and obesity were associated with greater declines in MVPA of  $-1.58$  hours/week (SD=0.92) and  $-1.29$  hours/week (SD=0.93), respectively ( $P=0.0079$ ). Receipt of chemotherapy only was also associated with a greater decrease in MVPA ( $-2.12$  hours/week; SD=0.92;  $P < 0.0001$ ), specifically for recreational activities ( $-1.62$  hours/week; SD=0.64;  $P=0.0001$ ). These data suggest challenges in maintaining physical activity levels during active treatment among women with breast cancer. Interventions to encourage physical activity in breast cancer survivors should be pursued.

### Keywords

Breast Cancer; Chemotherapy; Cohort Studies; Physical Activity; Exercise; Radiation Therapy; Sedentary Lifestyle; Cancer Survivorship

## INTRODUCTION

Nearly 2.5 million women are living after a diagnosis of breast cancer in the US today, and this number is expected to increase to 3.4 million by 2015 [1]. Physical activity has been associated with improved aerobic fitness, muscular strength, and quality of life, as well as reduced treatment-related side effects in breast cancer survivors [2, 3]. Furthermore, studies have suggested that physical activity might be related to better prognosis and/or survival after breast cancer diagnosis [4–21].

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Research on physical activity levels in breast cancer survivors during the immediate period (first six months) after breast cancer diagnosis has been relatively limited [22–28]. These primarily small- to modest-sized studies have reported decreases in physical activity in the proximate post-diagnosis period, yet how activity levels change from pre-diagnosis to post-diagnosis has only been explored in a few studies [22, 26, 28]. Furthermore, information is lacking on the associations of sociodemographic and clinical characteristics with change in activity levels after a breast cancer diagnosis.

In this study, we describe change in physical activity measures (moderate-vigorous and sedentary) from around diagnosis to approximately eight months post-diagnosis in a prospective cohort of 1,696 women diagnosed with invasive breast cancer in a large managed care setting. We also examine the associations of sociodemographic and clinical factors with change in activity levels. This study is the largest to date to examine physical activity change during the first six months after a breast cancer diagnosis, and identifies patient characteristics that are associated with changes in physical activity. This information may thus provide guidance on identifying groups of breast cancer survivors that may benefit from physical activity interventions.

## METHODS

The Pathways Study is an ongoing, prospective cohort study actively recruiting women recently diagnosed with invasive breast cancer from the Kaiser Permanente Northern California (KPNC) patient population [29]. As of December 31, 2010, 3,331 patients have been enrolled since recruitment began in January 2006. Briefly, cases are ascertained rapidly on a daily basis by automatic scanning of electronic pathology reports with subsequent verification of cancer diagnosis and patient notification by a medical record analyst. Eligibility criteria include: current KPNC membership; at least 21 years of age at diagnosis; diagnosis of first primary invasive breast cancer (all stages); no prior history of cancer other than non-melanoma skin cancer; ability to speak English, Spanish, Cantonese, or Mandarin; and residence within a 65-mile radius of a field interviewer. Passive consent is obtained from the patient's physician of record, followed by written informed consent from all participants before they are enrolled in the study. The study was approved by the Institutional Review Boards of KPNC and all collaborating institutions.

### Data collection

The baseline interview is conducted by a trained interviewer approximately two months after diagnosis. During the baseline interview, information is collected on demographic factors such as age at diagnosis, race/ethnicity, educational attainment, marital status, employment status, smoking history, and clinical factors including height, weight to calculate body mass index (BMI; normal <25 kg/m<sup>2</sup>, overweight 25–29 kg/m<sup>2</sup>, obese ≥30 kg/m<sup>2</sup>), menopausal status, use of hormone replacement therapy and oral contraceptives, family history of breast cancer, and lymphedema. Detailed physical activity information is collected as described below. A 6-month follow-up questionnaire (approximately eight months post-diagnosis) is mailed to participants asking for updates on the same information obtained at baseline.

**Physical activity**—Details on physical activity for the preceding six months is collected at the baseline interview (which covers the pre-diagnosis period) and 6-month follow-up using a questionnaire based on the Arizona Activity Frequency Questionnaire [6, 30]. The questionnaire queries domains of household activities (e.g., routine cleaning, taking care of infants and toddlers, and light yard work), recreational activities (e.g., running or jogging, aerobic dance or exercise class, and tennis), transportation activities (e.g., climbing up stairs,

riding a bicycle for transportation), and sedentary activities/behaviors (doing crafts, reading, socializing, attending group events, watching television, and playing games). Participants indicate how often they participate in each activity, and for activities participated in at least once per month, they select the usual duration of the activity (e.g., 15–30 minutes).

Each activity is assigned a standard MET (metabolic equivalent) value according to the Compendium by Ainsworth *et al.* [31]. To calculate total non-sedentary activity, a summary variable of MET-hours/week was created by multiplying the MET value of each activity by frequency and duration, and summing over all activities with a MET value. Moderate-to-vigorous physical activity (MVPA) was calculated in hours/week of activities of 3 METs or more, overall and within specific domains of related activities (household, recreational, and transportation). For sedentary behavior, only a summary variable in hours/week was calculated as no MET values were assigned to the activities/behaviors considered sedentary. Physical activity summary values were only assigned if  $\geq 23$  activities out of 45 (for total non-sedentary activity) and  $\geq 4$  activities out of 6 (for sedentary activity/behavior) had non-missing values. Meeting physical activity guidelines was defined as 2.5 hours/week or more of moderate to vigorous intensity activity according to the 2008 US Department of Health and Human Services Physical Activity Guidelines for Americans [32].

**Clinical characteristics**—Diagnostic characteristics are obtained from the KPNC Cancer Registry [33]. This includes data on stage of disease and tumor characteristics such as estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor 2 (Her2) status. Supplemental results from additional testing for equivocal Her2 expression are obtained directly from the KPNC regional cytogenetics laboratory. Information on breast surgery, chemotherapy, radiation therapy, and hormonal therapy are obtained from the KPNC Cancer Registry and KPNC electronic data sources.

### Statistical analysis

The present analysis was limited to 1,696 women enrolled in the cohort with complete baseline and 6-month follow-up physical activity information as of December 17, 2010; 81 women had already been excluded due to missing stage information. The mean (standard deviation [SD]) time from diagnosis to baseline into the study was 1.90 (0.63) months and from baseline to follow-up was 6.09 (1.55) months.

Physical activity measures (total non-sedentary, MVPA, and sedentary behavior) were summarized as MET-hours/week and hours/week using mean and SD, and median and interquartile (I-Q) range. Change in each measure was calculated as the difference between follow-up and baseline, where a positive or negative value indicates an increase or decrease in measure, respectively, compared to the reference measure at baseline. A one-sample paired t-test was used to compare baseline and follow-up measures.

Minimally-adjusted associations of physical activity change and sociodemographic and clinical characteristics were calculated using multivariable linear regression [34], adjusting for age at diagnosis, cancer stage, and relevant baseline measure of PA. Multivariable linear regression was also used to assess the independent associations of each sociodemographic and clinical characteristic with physical activity change, with each covariate fully adjusted for all others under consideration. These covariates included age at diagnosis, season of diagnosis, race/ethnicity, education, partner status, employment, smoking history, menopausal status at baseline, BMI at baseline, AJCC stage, hormone receptor status, Her2 status, breast surgery, treatment, hormonal therapy, family history of breast cancer, oral contraceptive use, and lymphedema at follow-up.

## RESULTS

The characteristics of the study population overall and by quartile of change from baseline to 6-month follow-up (about eight months post-diagnosis) for total non-sedentary activity are given in Table 1. The average age at breast cancer diagnosis was 60.4 years, and 75% were postmenopausal at baseline. Participants were primarily white (72%) and highly educated, with 86% having at least some college education or more. Less than half (43%) were employed at the time of the baseline interview. About 56% never smoked, and 41% and 3% were former or current smokers at the baseline interview, respectively. Change in total non-sedentary activity was relatively similar across most sociodemographic variables.

The majority of women were diagnosed with early stage breast cancer (54% and 34% Stage I and II, respectively), and 83% had hormone receptor positive tumors (ER+ and/or PR+). About 63% of women had breast-conserving surgery only, while 37% had a mastectomy and less than 1% had no breast surgery. Approximately 33% received chemotherapy only and 33% received radiation therapy only, while 72% overall received hormonal therapy. Almost half (48%) of the women who had the greatest decline in total non-sedentary activity (Quartile 1) had chemotherapy only while 22% had an increase (Quartile 4). The opposite trend was observed for women who had radiation therapy only with almost 24% making up the lowest physical activity quartile and 40% the highest. No differences across quartile of change in activity levels were noted for type of breast cancer surgery and hormonal therapy. At the 6-month follow-up, 7% reported having lymphedema, yet no major differences across quartiles of change were apparent.

Overall, levels of physical activity decreased from baseline to 6-month follow-up (Table 2). Total non-sedentary activity decreased by a mean (SD) of  $-9.40$  (27.94) MET-hours/week ( $P < 0.0001$ ). Overall MVPA decreased by a mean (SD) of  $-1.28$  (4.48) hours/week ( $P < 0.0001$ ), and the individual MVPA domains also had similar patterns of decrease. Participants reported the greatest decrease in recreational activity ( $-0.74$  hours/week,  $SD=3.09$ ;  $P < 0.0001$ ), followed by household activity and transportation activity. About 4% and 7% of women reported no MVPA at baseline and follow-up, respectively. At baseline, about 70% of the cohort was meeting the US 2008 Physical Activity Guidelines while only 58% were doing so at follow-up. Sedentary behavior decreased by a mean (SD) of  $-0.83$  (6.95) hours/week ( $P < 0.0001$ ). Socializing had the largest reduction of  $-0.28$  hours/week ( $SD=2.52$ ;  $P < 0.0001$ ), followed by reading, doing crafts, attending group events, and playing games, while television watching increased by 0.32 hours/week ( $SD=2.25$ ;  $P < 0.0001$ ). Overall, those who had higher levels of activity at baseline also did at follow-up, and vice versa (not shown).

Change in MVPA and sedentary behavior levels from baseline to 6-month follow-up by sociodemographic and clinical characteristics were minimally adjusted for age at diagnosis, AJCC stage, and relevant baseline physical activity measure (data not shown). For MVPA, being non-married ( $-2.24$  hours/week for single women,  $-1.73$  hours/week for separated/divorced women, and  $-1.62$  hours/week for widows) was associated with a greater decrease compared to married ( $-1.35$  hours/week). Similarly, being postmenopausal at baseline ( $-1.78$  hours/week) was associated with a greater decrease in MVPA compared to premenopausal ( $-1.05$  hours/week), as well as being overweight and obese at baseline ( $-1.89$  and  $-1.70$  hours/week, respectively) compared to normal weight ( $-1.09$  hours/week). Women of all cancer stages experienced a decline in activity, although the largest declines were observed in women diagnosed with Stage III ( $-2.01$  hours/week) tumors. Women who had chemotherapy and/or radiation therapy also had decreases in activity, yet the greatest reductions were among those who had chemotherapy only ( $-2.15$  hours/week) and both chemotherapy and radiation therapy ( $-1.63$  hours/week).

For sedentary behavior, Asians and Hispanics (−1.59 and −2.11 hours/week, respectively) experienced more of a decrease compared to Whites, Blacks, and Other races/ethnicities (−0.20, −0.34, and −0.19 hours/week, respectively) (data not shown). Being employed was also associated with a larger decline in sedentary behavior (−0.91 hours/week) compared to unemployed (−0.10 hours/week), as well as being postmenopausal at diagnosis (−0.82 hours/week) vs. premenopausal (0.10 hours/week). Women who had breast-conserving surgery had an increase in sedentary behavior (0.17 hours/week) compared to those who had a mastectomy (−0.27 hours/week).

Table 3 gives multivariate regression models for change in MVPA and sedentary behavior levels, adjusting for all covariates of interest. For MVPA, being overweight and obese at baseline continued to be associated with more of a decrease (−1.58 and −1.29 hours/week, respectively) compared to normal weight (−0.84 hours/week;  $P = 0.0079$ ). Having chemotherapy only (−2.12 hours/week) and both chemotherapy and radiation therapy (−1.60 hours/week) also continued to be associated with a decrease in MVPA compared to no treatment (−0.60 hours/week;  $P < 0.0001$ ). Radiation therapy only (−0.62 hours/week) had a similar level of decline as no treatment (−0.60 hours/week). Partner status, menopausal status, and AJCC stage were no longer associated with MVPA change.

For sedentary behavior, Asians, Hispanics, and Blacks (−2.12, −2.43, and −1.81 hours/week, respectively) experienced more of a decrease compared to Whites and Other races/ethnicities (−0.77 and −0.76 hours/week, respectively;  $P = 0.014$ ) (Table 3). Being employed continued to be associated with more of a decline in sedentary behavior (−1.97 hours/week) compared to unemployed (−1.19 hours/week;  $P = 0.031$ ) while being postmenopausal at baseline remained associated with a greater decrease in sedentary behavior (−2.26 hours/week) compared to premenopausal (−0.89 hours/week;  $P = 0.019$ ). Women who had any breast surgery had an increase in sedentary behavior (1.09 hours/week for conserving and 0.43 hours/week for mastectomy) whereas the small group who had no surgery experienced a decrease (−6.25 hours/week;  $P = 0.019$ ). While not observed in the minimally-adjusted models, more education (−0.83 hours/week for post-graduate level vs. −2.48 hours/week for high school or less;  $P = 0.0068$ ) and higher BMI were each associated with less of a decrease in sedentary behavior (−1.36 hours/week for obese women vs. −2.11 hours/week for normal weight women;  $P = 0.063$ ).

Table 4 gives change in levels of MVPA by domain, and sedentary behavior by activity, within each treatment group (chemotherapy only, radiation therapy only, both, none) adjusted for all covariates of interest. For each MVPA domain, reductions were observed in each treatment group, yet for recreational activity, the greatest decrease was among women who had chemotherapy only (−1.62 hours/week), followed by both chemotherapy and radiation, radiation only, and no treatment (−1.26, −0.71, and −0.68 hours/week, respectively;  $P = 0.0001$ ). For the sedentary behavior activities, there was a suggestion that women experienced increases in doing crafts and watching television, and decreases in reading (except for chemotherapy only), socializing, attending group events, and playing games.

## DISCUSSION

In this prospective cohort study of 1,696 breast cancer survivors, we found that physical activity levels, including sedentary behavior, decreased from the time around diagnosis to the period encompassing active treatment, assessed approximately eight months post-diagnosis. Having chemotherapy and being overweight or obese were the strongest independent predictors of experiencing a significant decline in moderate-vigorous physical activity. Being non-white, employed at diagnosis, postmenopausal at diagnosis, and having

no breast surgery were independently related to a larger decrease in sedentary behavior, while being more educated and overweight or obese at diagnosis were associated with less of a decrease. Our results confirm findings from other studies reporting declines in physical activity after a breast cancer diagnosis. However, we were able to further characterize these changes by treatment status and other sociodemographic and clinical factors, and more closely examine the role of sedentary behavior.

Previous studies that have examined physical activity (usually non-sedentary or recreational) changes before and after a breast cancer diagnosis have generally reported decreases in activity immediately after diagnosis [22, 26, 28] and then increases at six months post-treatment [22] or 12–18 months post-diagnosis [28], although these increases did not reach pre-diagnosis levels. Younger age at diagnosis (<40 years and 40–49 years compared to ≥50 years) and lower BMI (<25 kg/m<sup>2</sup>) have been found to be associated with greater reductions in physical activity from pre-diagnosis to 12 months post-diagnosis [28]. In contrast, another study found that obese and overweight women had greater reductions in physical activity compared to normal weight women [26], which is in general agreement with our results. Studies have also reported that the amount of change in physical activity was dependent on pre-diagnosis activity levels [26, 28]. Our results reflected similar trends of women starting in the highest category of physical activity experiencing the greatest reduction while women in the lowest category having the least reduction.

Receipt of adjuvant breast cancer therapy can induce treatment-related side effects such as fatigue, nausea, pain, and other physiologic distress, which can disrupt a woman's normal activity levels [3]. We found that women who had chemotherapy only and both chemotherapy and radiation therapy experienced the largest declines in non-sedentary activity from baseline to 6-month follow-up. Similarly, a small prospective study of 231 breast cancer patients reported decreases in leisure-time exercise activity both in women who had radiation therapy only and chemotherapy plus radiation therapy from pre-diagnosis to completion of adjuvant therapy (chemotherapy only was not examined) [22]. Our results also support findings from another breast cancer survivor cohort study of 812 women that reported the greatest reductions in non-sedentary activity among those who had surgery and chemotherapy, and surgery, chemotherapy, and radiation therapy from pre-diagnosis to 4–12 months post-diagnosis, yet these groups also had the largest increases in sedentary behavior [26].

Sedentary behavior is a growing area of interest in chronic disease and breast cancer research [35–40], which may reduce overall energy expenditure [41] and lead to adverse effects on various breast cancer-related biological pathways, including decreased estrogen metabolism [42, 43] and increased insulin resistance and inflammation [44–46]. Yet, some sedentary behaviors could facilitate social support, such as socializing and attending group events, and thus might be encouraged to improve quality of life in survivors [47]. In contrast to the results reported in the breast cancer survivor cohort study of 812 women [26], pathways women overall experienced a general decline in sedentary behavior from around diagnosis to eight months post-diagnosis. The decrease was a mixture of less time spent reading, socializing, attending group events, and playing games, which require more active focus, with more time watching television, which is more passive in nature. Some predictors of change in sedentary behavior in our population might be related to higher functional and physical status after a breast cancer diagnosis (e.g., employed, normal weight, no breast surgery). These factors could represent an active, labor-intensive lifestyle, thereby decreasing the likelihood of engaging in sedentary behaviors.

The importance of exercise in cancer prevention and control has emerged over the last 20 years [48, 49], and its physical and mental benefits to cancer survival are now recognized

[50]. The American College of Sports Medicine has concluded that exercise can be safe during and after cancer treatments and can improve aerobic fitness, muscular strength, quality of life, and fatigue in certain survivor groups, including breast cancer [3]. We also recently reported in the Pathways Study that physical activity is associated with improved quality of life during the first several months after cancer diagnosis [51]. For individuals with chronic conditions such as cancer, being as physically active as their abilities and conditions allow and avoiding inactivity is advised [32].

While a breast cancer diagnosis and subsequent treatment can disrupt a woman's normal activity levels [52], it can be an opportune time to educate and motivate the individual to adopt healthier lifestyle changes, including physical activity, to promote long-term health as a cancer survivor [53, 54]. Identifying women who could benefit most from physical activity interventions could facilitate and guide the health education process. We report several possible factors such as high BMI and receipt of chemotherapy that are associated with greater declines in non-sedentary activity in the immediate post-diagnosis period and during adjuvant therapy. We also confirm that women who were the most active before their cancer diagnosis experienced the largest decline while those who were the least active had the smallest decline. Despite the latter group having the lowest decline, these women should still be encouraged to increase their post-diagnosis activity levels.

Several limitations of the study should be noted. Physical activity was self-reported after breast cancer diagnosis, thus over-reporting (or under-reporting) of physical activity is possible. Nonetheless, this potential bias would not have altered the qualitative estimated change in activity levels over time, as the same instrument was used at baseline and follow-up, and regardless of activity levels, the relative ranking of individuals would not have been affected. While two studies have shown that physical activity levels eventually increase but do not return to pre-diagnosis levels among breast cancer survivors [25, 28], we did not explore this area of long-term physical activity change since the scope of the present paper was on short-term change. Future analyses from this cohort will focus on greater longitudinal change in activity levels as data become available at other follow-up periods. Despite these limitations, notable strengths of the study include being the largest prospective study to date of physical activity change from around the time of diagnosis to about eight months post-diagnosis in breast cancer survivors, and capturing non-recreational sources of physical activity as well as sedentary behavior.

In conclusion, an overall decrease in physical activity, both moderate-vigorous and sedentary, from around diagnosis to about eight months post-diagnosis was observed in this prospective study of breast cancer survivors. Women with higher body mass and who had received chemotherapy were more likely to have larger decreases in moderate-vigorous activity levels. This information points to specific groups of women after a breast cancer diagnosis for whom attention to activity may be particularly important. Our findings also indicate that the active treatment period is characterized by overall decreases in physical activity among women with breast cancer. Given the growing knowledge that physical activity improves quality of life [51] and long-term outcomes in women with breast cancer [4–8], encouragement of continued physical activity in the absence of clear contraindications, even in the early post-diagnosis months, may be warranted.

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## Abbreviations

<b>BMI</b>	body mass index
<b>ER</b>	estrogen receptor
<b>Her2</b>	human epidermal growth factor receptor 2
<b>I-Q</b>	interquartile
<b>KPNC</b>	Kaiser Permanente Northern California
<b>MET</b>	metabolic equivalent
<b>MVPA</b>	moderate-vigorous physical activity
<b>SD</b>	standard deviation
<b>PR</b>	progesterone receptor

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**Table 1**

Characteristics of study participants, overall and by quartiles of change in total non-sedentary activity from baseline to 6 month follow-up, Pathways Study (n=1,696), 2006–2010

	Total <sup>a</sup>		Change in Total Non-Sedentary Activity (MET-hours/week) <sup>b, c</sup>									
	n	%	Quartile 1 (-207.38 to -22.70)	Quartile 2 (-22.70 to -7.03)	Quartile 3 (-7.03 to 5.47)	Quartile 4 (5.47 to 224.76)	n	%	n	%	n	%
<b>Sociodemographic Factors</b>												
Age at diagnosis (years)	60.42 (11.61)		58.99 (11.58)	61.20 (11.55)	60.63 (11.65)	60.72 (11.63)						
Mean (SD)												
Season of Diagnosis												
1 <sup>st</sup> quarter (Jan–Mar)	449	26.47	102	119	118	108	24.34	28.47	28.23	25.84		
2 <sup>nd</sup> quarter (Apr–Jun)	438	25.83	120	111	97	105	28.64	26.56	23.21	25.12		
3 <sup>rd</sup> quarter (Jul–Sep)	408	24.06	99	94	105	102	23.63	22.49	25.12	24.40		
4 <sup>th</sup> quarter (Oct–Dec)	401	23.64	98	94	98	103	23.39	22.49	23.44	24.64		
Race/ethnicity												
White	1,221	71.99	299	302	305	305	71.36	72.25	72.97	72.97		
Black	90	5.31	26	15	24	24	6.21	3.59	5.74	5.74		
Asian	180	10.61	45	44	40	46	10.74	10.53	9.57	11.00		
Hispanic	160	9.43	37	41	38	38	8.83	9.81	9.09	9.09		
Other	45	2.65	12	16	11	5	2.86	3.83	2.63	1.20		
Education												
High school or less	240	14.15	61	55	64	55	14.56	13.16	15.13	13.16		
Some college	603	35.55	149	147	153	146	35.56	35.17	36.60	34.93		
College graduate	455	26.83	108	101	114	123	25.78	24.16	27.27	29.43		
Post-graduate	398	23.47	101	115	87	94	24.11	27.51	20.81	22.49		
Partner Status												
Married/Living as married	1,066	62.85	268	271	248	266	63.96	64.83	59.33	63.64		
Widowed	190	11.20	39	43	54	49	9.31	10.29	12.92	11.72		
Separated/Divorced	301	17.75	69	78	75	76	16.47	18.66	17.94	18.18		
Single	137	8.08	43	25	41	26	10.26	5.98	9.81	6.22		

	Total <sup>a</sup>		Change in Total Non-Sedentary Activity (MET-hours/week) <sup>b, c</sup>							
			Quartile 1 (-207.38 to -22.70)		Quartile 2 (-22.70 to -7.03)		Quartile 3 (-7.03 to 5.47)		Quartile 4 (5.47 to 224.76)	
	n	%	n	%	n	%	n	%	n	%
Currently Employed	731	43.10	177	42.24	175	41.87	183	43.78	188	44.98
Smoking History										
Never	949	55.96	246	58.71	235	56.22	216	51.67	235	56.22
Former	689	40.63	160	38.19	171	40.91	186	44.50	166	39.71
Current	58	3.42	13	3.10	12	2.87	16	3.83	17	4.07
Menopausal Status at Baseline										
Postmenopausal	1,272	75.00	306	73.03	322	77.03	313	74.88	310	74.16
BMI at Baseline (kg/m <sup>2</sup> )										
<25 (normal)	634	37.38	165	39.38	167	39.95	138	33.01	154	36.84
25-29 (overweight)	529	31.19	144	34.37	114	27.27	120	28.71	143	34.21
≥30 (obese)	524	30.90	109	26.01	135	32.30	156	37.32	120	28.71
<b>Clinical Characteristics</b>										
AJCC Stage (6 <sup>th</sup> Edition)										
Stage I	918	54.13	196	46.78	218	52.15	231	55.26	260	62.20
Stage II	581	34.26	165	39.38	147	35.17	145	34.69	117	27.99
Stage III	176	10.38	54	12.89	47	11.24	39	9.33	33	7.89
Stage IV	21	1.24	4	0.95	6	1.44	3	0.72	8	1.91
Hormone Receptor Status										
ER+/PR+	1,082	63.80	238	56.80	263	62.92	283	67.70	282	67.46
ER+/PR-	328	19.34	90	21.48	85	20.33	69	16.51	82	19.62
ER-/PR+	2	0.12	0	0.00	1	0.24	1	0.24	0	0.00
ER-/PR-	270	15.92	87	20.76	67	16.03	60	14.35	51	12.20
Her2 Status										
Positive	197	11.62	59	14.08	57	13.64	44	10.53	31	7.42
Breast Surgery										
None	10	0.59	2	0.48	3	0.72	3	0.72	2	0.48
Conserving	1,064	62.74	244	58.23	260	62.20	274	65.55	274	65.55

	Total <sup>a</sup>		Change in Total Non-Sedentary Activity (MET-hours/week) <sup>b, c</sup>							
	n	%	Quartile 1 (-207.38 to -22.70)	Quartile 2 (-7.03 to 5.47)	Quartile 3 (5.47 to 224.76)	Quartile 4 (5.47 to 224.76)	n	%	n	%
Mastectomy	622	36.67	173	41.29	155	37.08	141	33.73	142	33.97
Treatment										
None	378	22.29	68	16.23	102	24.40	88	21.05	112	26.79
Chemotherapy only	560	33.02	199	47.49	133	31.82	130	31.10	93	22.25
Radiation therapy only	556	32.78	102	24.34	131	31.34	150	35.89	165	39.47
Both	189	11.14	48	11.46	50	11.96	48	11.48	41	9.81
Hormonal Therapy										
Yes	1,219	71.88	286	68.26	296	70.81	311	74.40	311	74.40
Family History of Breast Cancer										
Yes	364	21.46	98	23.39	92	22.01	90	21.53	81	19.38
Oral Contraceptive Use										
Yes	1,248	73.58	329	78.52	300	71.77	302	72.25	307	73.44
HRT (Postmenopausal)										
Yes	850	66.82	201	65.69	222	68.94	202	64.54	215	69.35
Lymphedema Self-Report at Follow-up										
Yes	118	6.96	26	6.21	31	7.42	24	5.74	34	8.13

Abbreviations: MET, metabolic equivalent; SD, standard deviation; ref, reference; BMI, body mass index; ER, estrogen receptor; PR, progesterone receptor; her2, human epidermal growth factor receptor 2.

<sup>a</sup>Missings n (%): Partner Status n=2 (0.12); Currently Employed n=5 (0.29); BMI at Baseline n=9 (0.53); Hormone Receptor Status n=14 (0.83); Her2neu Status n=43 (2.54); Chemotherapy n=13 (0.77); Hormonal Therapy n=15 (0.88); Oral Contraceptive Use n=10 (0.59); Hormone Replacement Therapy n=3 (0.24); Lymphedema Self-Report at Follow-up n=108 (6.37)

<sup>b</sup>For the ranges defining the quartiles of change, positive (+) or negative (-) sign indicates an increase or decrease in measure, respectively, compared to reference measure at baseline.

<sup>c</sup>n=23 women were missing complete physical activity data; n=5 and n=11 women had 0 MET-hours/week of total non-sedentary activity at baseline and 6-month follow-up, respectively.

**Table 2**

Physical activity measures at baseline and 6-month follow-up, and associated change, Pathways Study (n=1,696), 2006–2010

	Baseline	6-month Follow-up	Change from Baseline (ref) to 6-month Follow-up <sup>a</sup> Mean Difference (SD)	P value <sup>c</sup>
<b>Total Non-Sedentary Activity (MET-hours/week)</b>				
Median (I-Q Range) <sup>b</sup>	46.33 (28.88–68.57)	36.98 (21.45–56.70)	–9.40 (27.94)	<0.0001
Quartile 1: Median (I-Q Range) <sup>b</sup>	19.80 (14.58–24.34)	14.49 (9.94–18.03)	---	---
Quartile 2: Median (I-Q Range)	37.67 (33.60–42.05)	29.16 (25.71–33.22)	---	---
Quartile 3: Median (I-Q Range)	56.46 (51.11–61.60)	46.00 (40.84–50.70)	---	---
Quartile 4: Median (I-Q Range)	87.25 (76.92–105.02)	75.60 (63.98–93.75)	---	---
<b>Moderate-Vigorous Physical Activity (hours/week)</b>				
Overall: Median (I-Q Range) <sup>b</sup>	4.69 (1.88–8.56)	3.38 (1.19–6.75)	–1.28 (4.48)	<0.0001
Quartile 1: Median (I-Q Range) <sup>b</sup>	1.13 (0.69–1.69)	0.75 (0.44–1.13)	---	---
Quartile 2: Median (I-Q Range)	3.50 (2.88–4.19)	2.56 (2.13–3.19)	---	---
Quartile 3: Median (I-Q Range)	6.63 (5.63–7.56)	5.06 (4.31–5.94)	---	---
Quartile 4: Median (I-Q Range)	12.00 (10.06–15.00)	10.13 (8.38–12.75)	---	---
Household Activity: Median (I-Q Range)	0.94 (0.19–3.00)	0.63 (0–2.25)	–0.44 (2.69)	<0.0001
Recreational Activity: Median (I-Q Range)	1.88 (0.19–4.50)	1.13 (0–3.25)	–0.74 (3.09)	<0.0001
Transportation Activity: Median (I-Q Range)	0.50 (0–0.75)	0.19 (0–0.75)	–0.08 (1.38)	0.018
<b>Sedentary Behavior (hours/week)</b>				
Overall: Median (I-Q Range) <sup>b</sup>	17.63 (12.56–22.63)	16.75 (12.13–21.75)	–0.83 (6.95)	<0.0001
Quartile 1: Median (I-Q Range) <sup>b</sup>	9.44 (7.69–11.13)	9.56 (7.63–10.88)	---	---
Quartile 2: Median (I-Q Range)	15.38 (14.13–16.50)	14.81 (13.50–15.75)	---	---
Quartile 3: Median (I-Q Range)	20.06 (18.94–21.31)	19.06 (18.00–20.34)	---	---
Quartile 4: Median (I-Q Range)	27.00 (24.75–30.00)	25.50 (23.44–28.63)	---	---
Doing crafts: Median (I-Q Range)	0 (0–0.63)	0 (0–0.63)	–0.15 (1.56)	0.0001
Reading: Median (I-Q Range)	4.50 (2.25–7.50)	4.50 (1.88–7.50)	–0.16 (2.53)	0.0092
Socializing: Median (I-Q Range)	2.25 (1.13–4.50)	2.25 (0.75–4.50)	–0.28 (2.52)	<0.0001
Attending group events: Median (I-Q Range)	0.63 (0–1.88)	0.63 (0–1.88)	–0.081 (1.57)	0.038
Watching television: Median (I-Q Range)	5.00 (3.00–7.50)	5.00 (3.00–7.50)	0.32 (2.55)	<0.0001
Playing games: Median (I-Q Range)	0 (0–0.38)	0 (0–0.38)	–0.05 (1.25)	0.10

Abbreviations: ref, reference; MET, metabolic equivalent; I-Q, interquartile.

<sup>a</sup> Positive (+) or negative (–) sign indicates an increase or decrease in measure, respectively, compared to reference measure at baseline.

<sup>b</sup> No activity level was calculated for n=5 (0.29%) at baseline and n=11 (0.66%) at follow-up for total non-sedentary activity; n=64 (3.77%) at baseline and n=114 (6.81%) at follow-up for moderate-vigorous physical activity; n=2 (0.12%) at baseline and n=3 (0.18%) at follow-up for sedentary behavior.

<sup>c</sup> From one-sample paired t-test comparing baseline and 6-month follow-up measures.

**Table 3**

Fully-adjusted multivariable linear regression of sociodemographic and clinical characteristics and change in moderate-vigorous physical activity and sedentary behavior from baseline to six month follow-up, Pathways Study (n=1,696), 2006–2010

	Change in Moderate-Vigorous Physical Activity (hours/week) <sup>a, b</sup>		Change in Sedentary Behavior (hours/week) <sup>a, b</sup>	
	LS Mean Change (SE)	P value	LS Mean Change (SE)	P value
<b>Sociodemographic Factors</b>				
Age at Diagnosis (years)		0.12		0.10
<50 = Ref	-0.92 (0.96)		-1.93 (1.54)	
50–59	-1.45 (0.93)		-1.62 (1.50)	
60–69	-1.02 (0.94)		-0.84 (1.53)	
≥70	-1.55 (0.96)		-1.92 (1.54)	
Season of Diagnosis		0.39		0.20
1 <sup>st</sup> quarter (Jan–Mar) = Ref	-1.14 (0.93)		-1.60 (1.49)	
2 <sup>nd</sup> quarter (Apr–Jun)	-1.53 (0.92)		-1.87 (1.49)	
3 <sup>rd</sup> quarter (Jul–Sep)	-1.17 (0.94)		-1.00 (1.52)	
4 <sup>th</sup> quarter (Oct–Dec)	-1.11 (0.93)		-1.85 (1.50)	
Race/ethnicity		0.22		0.014
White = Ref	-0.84 (0.92)		-0.77 (1.48)	
Black	-0.95 (1.00)		-1.81 (1.62)	
Asian	-1.11 (0.98)		-2.12 (1.58)	
Hispanic	-0.98 (0.94)		-2.43 (1.52)	
Other	-2.30 (1.09)		-0.76 (1.75)	
Education		0.60		0.0068
High school or less = Ref	-1.37 (0.96)		-2.48 (1.55)	
Some college	-1.37 (0.92)		-1.93 (1.49)	
College graduate	-1.05 (0.93)		-1.07 (1.51)	
Post-graduate	-1.15 (0.92)		-0.83 (1.49)	
Partner Status		0.14		0.77
Married/Living as married = Ref	-0.89 (0.92)		-1.77 (1.49)	
Widowed	-1.21 (0.97)		-1.21 (1.57)	
Separated/Divorced	-1.10 (0.94)		-1.80 (1.51)	
Single	-1.74 (0.95)		-1.53 (1.54)	
Currently Employed		0.15		0.031
No = Ref	-1.40 (0.92)		-1.19 (1.49)	
Yes	-1.07 (0.92)		-1.97 (1.49)	
Smoking History		0.37		0.53
Never = Ref	-1.43 (0.90)		-1.96 (1.45)	
Former	-1.52 (0.91)		-1.77 (1.47)	
Current	-0.75 (1.05)		-1.00 (1.69)	
Menopausal Status at Baseline		0.43		0.019



	Change in Moderate-Vigorous Physical Activity (hours/week) <sup>a, b</sup>		Change in Sedentary Behavior (hours/week) <sup>a, b</sup>	
	LS Mean Change (SE)	P value	LS Mean Change (SE)	P value
Premenopausal = Ref	-1.09 (0.95)		-0.89 (1.53)	
Postmenopausal	-1.38 (0.92)		-2.26 (1.48)	
BMI at Baseline (kg/m <sup>2</sup> )		0.0079		0.063
<25 (normal) = Ref	-0.84 (0.93)		-2.11 (1.50)	
25–29 (overweight)	-1.58 (0.92)		-1.27 (1.49)	
≥30 (obese)	-1.29 (0.93)		-1.36 (1.50)	
<b>Clinical Characteristics</b>				
AJCC Stage		0.88		0.13
Stage I = Ref	-1.20 (0.98)		-2.48 (1.58)	
Stage II	-1.07 (0.98)		-2.61 (1.59)	
Stage III	-1.33 (1.02)		-2.89 (1.65)	
Stage IV	-1.34 (1.23)		1.67 (1.98)	
Hormone Receptor Status		0.81		0.25
ER+/PR+ = Ref	-1.02 (0.64)		-2.82 (1.04)	
ER+/PR-	-1.17 (0.66)		-2.05 (1.06)	
ER-/PR+	-1.38 (2.78)		1.10 (4.48)	
ER-/PR-	-1.37 (0.69)		-2.54 (1.11)	
Her2 Status		0.70		0.88
Negative = Ref	-1.09 (0.91)		-1.56 (1.47)	
Positive	-1.23 (0.96)		-1.40 (1.55)	
Not Done	-1.39 (0.96)		-1.78 (1.54)	
Breast Surgery		0.40		0.019
Conserving = Ref	-1.45 (0.81)		1.09 (1.31)	
None	-0.49 (1.86)		-6.25 (3.00)	
Mastectomy	-1.76 (0.81)		0.43 (1.31)	
Treatment		<0.0001		0.46
None = Ref	-0.60 (0.95)		-1.32 (1.53)	
Chemotherapy only	-2.12 (0.92)		-1.23 (1.48)	
Radiation therapy only	-0.62 (0.95)		-1.95 (1.54)	
Both	-1.60 (0.94)		-1.81 (1.52)	
Hormonal therapy		0.27		0.77
No = Ref	-1.07 (0.93)		-1.51 (1.50)	
Yes	-1.40 (0.93)		-1.65 (1.50)	
Family History of Breast Cancer		0.80		0.28
No = Ref	-1.21 (0.91)		-1.37 (1.47)	
Yes	-1.27 (0.93)		-1.79 (1.51)	
Oral Contraceptive Use		0.39		0.80
No = Ref	-1.13 (0.92)		-1.63 (1.49)	
Yes	-1.34 (0.92)		-1.53 (1.49)	
Lymphedema Self-Report at Follow-up		0.42		0.24

	Change in Moderate-Vigorous Physical Activity (hours/week) <sup>a, b</sup>		Change in Sedentary Behavior (hours/week) <sup>a, b</sup>	
	LS Mean Change (SE)	P value	LS Mean Change (SE)	P value
No = Ref	-1.39 (0.90)		-1.21 (1.45)	
Yes	-1.08 (0.97)		-1.94 (1.57)	

Abbreviations: LS, least squares; SE, standard error; ref, reference; BMI, body mass index; ER, estrogen receptor; PR, progesterone receptor; her2, human epidermal growth factor receptor 2.

<sup>a</sup>Positive (+) or negative (-) sign indicates an increase or decrease in measure, respectively, compared to reference measure at baseline.

<sup>b</sup>Adjusting for all covariates listed in table as well as relevant baseline physical activity measure.

Fully-adjusted multivariable linear regression of change in physical activity measures from baseline to 6-month follow-up by treatment status, Pathways Study (n=1,696), 2006–2010

Table 4

	Change in Physical Activity from Baseline (ref) to 6-month Follow-up				P value <sup>b</sup>
	None=Ref (n=378)	Chemotherapy only (n=560)	Radiation Therapy only (n=556)	Chemotherapy and Radiation Therapy (n=189)	
<b>Moderate-Vigorous Physical Activity (hours/week)</b>					
Overall	-0.60 (0.95)	-2.12 (0.92)	-0.62 (0.95)	-1.60 (0.94)	<0.0001
Household Activity	-0.06 (0.61)	-0.51 (0.59)	-0.15 (0.61)	-0.55 (0.60)	0.12
Recreational Activity	-0.68 (0.66)	-1.62 (0.64)	-0.71 (0.67)	-1.26 (0.66)	0.0001
Transportation Activity	-0.12 (0.32)	-0.36 (0.31)	-0.19 (0.32)	-0.17 (0.32)	0.11
<b>Sedentary Behavior (hours/week)</b>					
Overall	-1.32 (1.53)	-1.23 (1.48)	-1.95 (1.54)	-1.81 (1.52)	0.46
Doing crafts	0.08 (0.38)	0.03 (0.37)	0.16 (0.38)	0.07 (0.38)	0.82
Reading	-0.10 (0.58)	0.08 (0.56)	-0.30 (0.58)	-0.27 (0.57)	0.20
Socializing	-0.89 (0.54)	-0.86 (0.52)	-1.17 (0.54)	-0.99 (0.53)	0.29
Attending group events	-0.14 (0.38)	-0.28 (0.37)	-0.02 (0.38)	-0.19 (0.38)	0.24
Watching television	0.54 (0.58)	0.68 (0.56)	0.39 (0.58)	0.31 (0.57)	0.27
Playing games	-0.26 (0.29)	-0.44 (0.28)	-0.46 (0.30)	-0.52 (0.29)	0.14

Abbreviations: LS, least squares; SE, standard error; ref, reference.

<sup>a</sup> Positive (+) or negative (-) sign indicates an increase or decrease in measure, respectively, compared to reference measure at baseline.

<sup>b</sup> Adjusting for all covariates listed in Table 3 as well as relevant baseline physical activity measure.