Prospective, Longitudinal Study of Leisure-Time Exercise in Women with Early-Stage Breast Cancer

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Abstract

Physical activity can have a beneficial effect on both physical and mental health in cancer survivors. However, evidence from cross-sectional and/or retrospective research suggests that cancer treatment can be associated with both short- and long-term reductions in physical activity. A prospective, longitudinal research design was used to examine the trajectory of leisure-time exercise in early-stage breast cancer patients from two treatment centers (*n* = 231). Participation in mild, moderate, and strenuous leisure-time exercise was assessed before, during, and following completion of adjuvant radiotherapy (*n* = 136) or chemotherapy + radiation (*n* = 95). Results indicated significant decreases, relative to pre-diagnosis baseline, in total estimated weekly metabolic equivalents and minutes of leisure-time exercise during adjuvant therapy for both the radiotherapy and chemotherapy + radiation groups. However, activity levels seemed to quickly recover and did not differ from pre-diagnosis baseline at assessments 2 and 6 months following completion of adjuvant radiotherapy or chemotherapy + radiation. Although suggesting little effect of breast cancer diagnosis and treatment on participation in leisure-time exercise at 6-month follow-up, these group analyses obscure the fact that a large number of individuals (35.5%) exhibited clinically significant change, both decreases or increases, in total weekly metabolic equivalents between pre-diagnosis baseline and 6-month follow-up. Fostering appropriate participation in physical activity in cancer patients and survivors is likely to be enhanced by better understanding of the beliefs and motivations that underlie spontaneous changes in participation in leisure-time exercise. (Cancer Epidemiol Biomarkers Prev 2007;16(3):430–8)

Introduction

Cancer diagnosis and treatment can be associated with distress and treatment-related side effects. The collective burden of these adverse sequelae can result in a reduction of physical activity. Indeed, research suggests that a decline in physical activity during receipt of adjuvant cancer therapy is common (1-3). Declines in physical activity during adjuvant therapy can be a significant concern due to the potential effect on quality of life. This is particularly true if adjuvant therapy is administered over a prolonged period of time. Equally, if not more, worrisome is the possibility that a decline in physical activity manifest during receipt of adjuvant chemotherapy or radiation might extend well beyond the conclusion of adjuvant treatment. In healthy individuals, an extended period of physical inactivity can lead to reduced cardiorespiratory fitness, bone loss, muscle atrophy, and declines in glucose metabolism, insulin sensitivity, and digestive and immune function (4). In the long term, a sedentary lifestyle is associated with increased risk for several potentially life-limiting, chronic illnesses including diabetes and cardiovascular disease. Conversely, physical activity has been linked to successful management of several chronic disease conditions (5, 6), enhanced mental health and quality of life (7), and reduced all-cause mortality (8). Given increasing numbers of cancer survivors living for increasing time after diagnosis, it is clear that a cancer diagnosis does not obviate the importance of maintaining an active lifestyle. In the context of a good prognosis, the physical and mental health benefits associated with physical activity are also relevant to cancer survivors. Indeed, both correlational and interventional research has shown that physical activity and exercise are associated with better quality of life and physical functioning, improved cardiorespiratory fitness, and less distress and fatigue in cancer patients and survivors (9-12).

Physical activity might also confer unique benefits on cancer survivors. Epidemiologic data suggest a positive link between physical activity and reduced risk of recurrence and/or longer survival for some cancers (13) as well as a positive association between body weight at diagnosis and cancer death rates (14), increased risk of breast cancer recurrence (15), and reduced survival time in women with breast cancer (15-17). Research has also found a positive association between weight gain after breast cancer diagnosis and disease relapse and mortality (18). Although body weight and weight gain are multifactorially determined, physical activity is certainly one element in the equation. Although data linking physical activity to clinical outcomes in cancer survivors are suggestive rather than definitive (19), it is believed physical activity is critical to achievement of optimal physical and mental health in cancer survivors. Current guidelines for physical activity for cancer survivors suggest that in the absence of any physical contraindications, any physical movement or activity is beneficial, and any steps to move from a sedentary to a more physically active lifestyle should be encouraged (20).

Several studies employing diverse methods have addressed the important question of whether declines in physical activity evident during adjuvant therapy persist beyond treatment completion. Courneya and Friedenrich solicited retrospective reports from cancer survivors regarding how physical activity changed after cancer diagnosis and treatment (1, 2). Breast and colorectal cancer survivors reported decreases in exercise during treatment followed by an increase in exercise after treatment completion. Exercise activity, however, did not return to pre-diagnosis levels. Blanchard et al. found that 30% of breast and prostate cancer survivors reported decreased

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exercise activity, whereas 15% reported increased activity since diagnosis (21). Patterson et al. surveyed breast, prostate, and colorectal cancer survivors within 2 years of diagnosis and found that 21% acknowledged an *increase* in physical activity since diagnosis (22). Decreases in physical activity were not assessed. Finally, Irwin et al. compared current physical activity assessed 4 to 12 months after breast cancer diagnosis with retrospective reports of pre-diagnosis activity (23). Physical activity declined by about 2 h/wk with the greatest decreases in sports-related physical activity in women treated with surgery + radiation and chemotherapy. Collectively, these studies suggest that physical activity after treatment completion may remain depressed relative to pre-diagnosis levels. However, these studies are limited by reliance upon cross-sectional designs, retrospective reports of physical activity and activity change after diagnosis, and/or heterogeneity in time since diagnosis and treatment completion.

Coups and Ostroff compared current physical activity in cancer survivors with healthy controls (24). The prevalence of physical inactivity was higher among cancer survivors (75%) relative to controls (69%), but only among respondents 40 to 64 years old. Although the case-control design eliminates reliance on retrospective reports of physical activity change, differences between survivors and controls on variables potentially related to physical activity (e.g., age, sex, geographic residence, or time of year when physical activity is assessed) could have obscured true differences in physical activity between the groups.

The optimal strategy for examining the trajectory of exercise activity following cancer diagnosis and treatment would involve prospective, longitudinal assessment of exercise activity. Pinto et al. assessed current physical activity multiple times during the year after completion of adjuvant therapy for breast cancer (25). Participation in moderate and vigorous intensity activity was stable during the year after completion of adjuvant therapy (26). Unfortunately, the failure to assess pre-diagnosis or pretreatment physical activity precludes interpretation of the stable levels of physical activity observed after cancer treatment. Did physical activity decrease, increase, or stay the same relative to pre-diagnosis or pretreatment levels? Satia et al. assessed physical activity in colon cancer survivors at two points in time (27). Retrospective reports of pre-diagnosis physical activity were obtained several months after diagnosis and compared with reports of current physical activity obtained ~2 years after diagnosis. Current physical activity data was collected from healthy controls at two comparable time points. Nonoccupational physical activity *increased* in both groups between the two assessments. Unfortunately, cancer survivors in this study were all participants in an intervention trial promoting fruit and vegetable consumption and physical activity. Consequently, the generalizability of these results is quite limited.

The present study uses a prospective, longitudinal design to examine change in leisure-time exercise activity during and after adjuvant therapy for early-stage breast cancer. We hypothesize the following: (*a*) leisure-time exercise activity will decrease during adjuvant therapy; (*b*) activity levels will rebound and approach pre-diagnosis levels 6 months after completion of adjuvant therapy; and (*c*) decreases in exercise activity will be greater in women receiving treatment regimens including chemotherapy. This latter hypothesis was based on research linking breast cancer chemotherapy with greater physical toxicity and dysfunction, in general (28), and greater fatigue (29), in particular.

Materials and Methods

Patients. Participants were women scheduled to receive adjuvant therapy after diagnosis of breast cancer. Participants were recruited from two sites: the Moffitt Cancer Center at the University of South Florida and the Markey Cancer Center at the University of Kentucky. Inclusion criteria were (*a*) >18 years old, (*b*) stage 0 to II breast cancer, (*c*) scheduled to receive adjuvant therapy consisting of radiotherapy or chemotherapy + radiotherapy, and (*d*) no prior cancer diagnosis other than basal cell skin carcinoma. Consistent with standard clinical practice at each study site, study participants were not routinely provided with any specific exercise recommendations.

Procedure. The data reported here were collected as part of a broader study of physical and psychological effects of adjuvant therapy for early-stage breast cancer. Previous publications reported data related to fatigue, cognitive functioning, and quality of life (29-31). After institutional review board approval, potential participants were identified from clinical rosters followed by review of medical records and consultation with clinical staff to confirm study eligibility. Participants were recruited during a clinical visit after breast surgery but before beginning adjuvant therapy. At recruitment, study staff furnished information about the study and obtained written consent for study participation. Women were told the study was to examine the broad effect of adjuvant therapy upon a range of end points. Exercise activity was not specifically mentioned as a focus of interest. A baseline assessment was then conducted. Upon completion of their initial course of adjuvant therapy (radiotherapy or chemotherapy), all women completed a post-treatment 1 assessment. Women receiving adjuvant therapy consisting of a course of chemotherapy followed by a course of radiotherapy also completed a post-treatment 2 assessment at completion of radiotherapy. Finally, all women completed separate follow-up assessments 2 and 6 months following completion of all adjuvant chemotherapy or radiotherapy (2- and 6-month follow-ups).

At each of the five potential study assessments, respondents completed a set of measures that included the Leisure-Time Exercise Questionnaire (LTEQ). At the baseline and 6-month follow-up assessments, all study measures were administered by written questionnaire. Because of variability in patient scheduling across and within study sites, study measures at the post-treatment 1, post-treatment 2, and 2-month follow-up assessments were completed either by written questionnaire (in clinic or at home with mail back to the researchers) or by a telephone interview. (Although exact records were not maintained, only a small minority of respondents at each of these three assessments completed study measures via telephone interview.) Information regarding stage of disease, surgery, adjuvant therapy, and height and weight at baseline was obtained from medical records. Recruitment of participants occurred continuously between November 1999 and November 2004. Less than 5% of study-eligible women declined participation.

Questionnaires

Godin LTEQ. Leisure-time exercise was assessed using a modified version of the Godin LTEQ (32). The original LTEQ assesses the frequency of periods of strenuous, moderate, and mild exercise >15 min in duration during the preceding 7 days. The LTEQ was modified by asking respondents to indicate the frequency and average duration (in minutes) of periods of strenuous, moderate, and mild exercise. This enabled calculation of the total minutes spent engaged in strenuous, moderate, and mild exercise. At the post-treatment 1 and 2 and 2- and 6-month follow-up assessments, the LTEQ assessed leisure-time exercise activity during the preceding 7 days. At the post-treatment 1 and 2 assessments, this 7-day period represented the week preceding a final chemotherapy or radiotherapy treatment. At the baseline assessment, the LTEQ assessed ''typical'' weekly exercise activity during the 6 months before cancer diagnosis. Hence, LTEQ responses at the baseline assessment were a measure of pre-diagnosis leisure-time exercise levels.

Medical Outcomes Study Short-Form 36-Item Health Survey. Current mental and physical health was assessed at the baseline assessment using the Medical Outcomes Study Short Form 36-Item Health Survey or SF-36 (33).

Sociodemographic Information. Information regarding age, race, partner and employment status, education, and whether a woman had children living in her home was obtained at the baseline assessment.

Statistical Analysis. The criterion for statistical significance was set at $P < 0.05$. Standard procedures were used to compute baseline SF-36 Mental and SF-36 Physical component scores (34). Baseline height and weight were used to compute body mass index using standard procedures. Responses to the LTEQ at each of the study assessments were converted to estimated weekly metabolic equivalent (METS). Responses on the LTEQ were converted into estimated weekly METS using a slightly modified version of the formula used by the developers of the LTEQ (32): [(total METS = minutes of strenuous exercise / 15) × 9] + [(total minutes of moderate exercise / 15) × 5] + [(total minutes of light exercise / 15) × 3]. Responses on the LTEQ identified sedentary women and women meeting recommended exercise guidelines at each study assessment. Sedentary was defined as complete absence of any leisure-time activity at a particular assessment (i.e., stated zero frequency of mild, moderate, and strenuous exercise). Women reporting >150 min of moderate or strenuous exercise (i.e., 5 days/wk of 30-min activity daily) were categorized as meeting current physical activity guidelines for both healthy adults (26) and cancer survivors (20) at that assessment. Responses on the LTEQ were also used to identify the proportion of women reporting *any* exercise at all as well as *any* mild, moderate, or strenuous intensity exercise at each assessment.

As the total number of study assessments scheduled for a woman varied as a function of type of adjuvant therapy received, separate one-way repeated-measures ANOVA were conducted for the chemotherapy + radiotherapy and radiotherapy–only groups. Dependent variables included total weekly METS, minutes of exercise, and minutes of mild, moderate, and strenuous intensity exercise. Post hoc planned simple comparisons, using pre-diagnosis exercise activity, assessed at the baseline assessment, as the reference value were conducted to identify posttreatment and follow-up assessments that differed from the baseline assessment. Differences across assessments in the proportion of sedentary women, women meeting exercise guidelines, and women reporting any mild, moderate, and strenuous intensity exercise as well as any exercise activity at all were examined using Cochran's Q test (35). (Cochran's Q test is appropriate for longitudinal research as it examines whether or not three or more "matched" sets of proportions differ significantly from each other; ref. 35). Again, separate Cochran's Q test analyses were conducted for the radiotherapy and chemotherapy + radiation groups. Planned, post hoc comparisons using the McNemar test and pre-diagnosis exercise levels (at the baseline assessment) as the reference value were conducted to identify posttreatment and follow-up assessments that differed from baseline.

Results

Two hundred fifty-seven women completed both baseline and 6-month follow-up assessments (see Fig. 1). Study participants were drawn from the University of Kentucky (n = 109, 42.4%) and University of South Florida (n = 148, 57.6%) sites, were a mean age of 55.2 years (SD, 9.8; range, 29-82), had a mean body mass index of 27.1 (SD, 5.9; range, 13-63), were predominantly White (n = 237, 92.2%), and married or partnered (n = 191, 79%). A minority of women were working full time outside the home (n = 83, 32.3%) and had children living in their home (n = 77, 30.0%). Education level was less than high school (n = 73, 28.4%), some college (n = 78, 30.4%), and more than a college baccalaureate degree (n = 106, 41.2%). Adjuvant therapy consisted of chemotherapy + radiation (n = 114, 44.4%) or radiotherapy only (n = 143, 55.6%), whereas surgical treatment consisted of lumpectomy (n = 240, 93.4%), mastectomy (n = 11, 4.3%), and double mastectomy or a combination of both lumpectomy and mastectomy (n = 6, 2.3%). Comparison of the University of Kentucky and University of South Florida sites revealed no differences for age, education, race, partner status, presence of children in the home, employment status, body mass, type of adjuvant therapy, or disease stage. Participants from the University of South Florida site were more likely to have undergone a surgery involving mastectomy (mastectomy alone, bilateral mastectomy, and mastectomy and lumpectomy; 11.5% versus 0.0% for University of Kentucky participants; $P < 0.01$). Data for the two study sites were combined for all analyses.

Table 1 shows baseline demographic and clinical characteristics for the radiotherapy and chemotherapy + radiotherapy groups. As expected, the groups differed with regard to age, surgical treatment, and disease stage (all $P < 0.001$). The radiotherapy group was older, more likely to have undergone

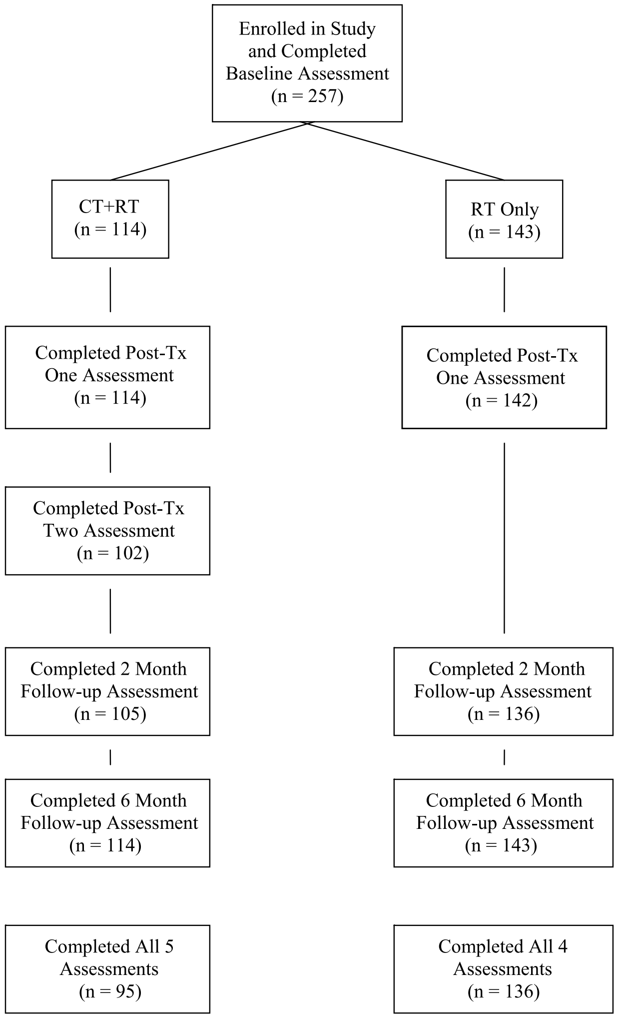

Figure 1. Flow chart showing study enrollment and completion of study assessments. RT, radiotherapy; CT, chemotherapy; Tx, treatment.

lumpectomy, and less likely to have stage II disease. The radiotherapy group was also less likely to have children living in their home and reported better SF-36 Physical component scores at baseline ($P < 0.05$). No differences were noted for race, partner or employment status, education, baseline body mass index, or baseline SF-36 Mental component scores. In addition, using data obtained at the baseline assessment, no differences were found for pre-diagnosis weekly METS, sedentary status, or whether they met exercise guidelines before diagnosis. Finally, as expected, the number of days between the baseline and 6-month follow-up assessments was less for the radiotherapy group (mean, 257 days; SD, 53) than the chemotherapy + radiation group (mean, 381 days; SD, 69; $P < 0.01$).

Table 2 presents information regarding leisure-time exercise across study assessments for the entire sample at each point of assessment. Before diagnosis, nearly a quarter of the sample (n = 64, 24.9%) reported they were sedentary (i.e., *no* leisure-time exercise during a typical week before cancer diagnosis). Similarly, before diagnosis, only about one fourth of participants (n = 70, 27.2%) met guidelines for >150 min weekly of at least moderate-intensity exercise.

Of the 257 women in the study sample, 26 women (10%) missed one or more study assessments after the baseline assessment (see Fig. 1). Comparison of the 231 women who completed all study assessments with these 26 women on demographic (age, education, and race) and clinical variables (stage, surgery type, type of adjuvant therapy, baseline METS, body mass index, and SF-36 Physical and SF-36 Mental component scores) revealed a significant difference only with respect to adjuvant therapy: women in the radiotherapy group were more likely to complete all study assessments (n = 136, 95.1%) than women in the chemotherapy + radiation group (n = 95, 83.3%). (This is not surprising given the radiotherapy group had fewer scheduled assessments than the chemotherapy + radiation group.) Consequently, analyses used the 231 women who completed all study assessments and were conducted separately for the radiotherapy (n = 136) and chemotherapy + radiation (n = 95) groups.

One-way, repeated-measures ANOVA examined change over time in METS and minutes of mild, moderate, strenuous, and total minutes of exercise. For the radiotherapy group, main effects were obtained for total weekly METS [$F(3,133) = 6.31$; $P < 0.001$] and weekly minutes of moderate [$F(3,133) = 4.02$; $P < 0.01$] and total exercise [$F(3,133) = 5.29$; $P < 0.01$; see Table 3]. Figure 2 portrays the significant results for total weekly METS and total minutes of weekly exercise for the radiotherapy group. Post hoc planned comparisons indicated differences between the post-treatment 1 and baseline assessments for METS and minutes of strenuous and total exercise ($P < 0.01$). A difference was also found between baseline and 6-month follow-up for minutes of strenuous exercise ($P < 0.05$). No other differences were obtained between baseline and the 2- and 6-month follow-up assessments for any of the five dependent variables. In general, women in the radiotherapy group reported declines in exercise at the post-treatment 1 assessment with mild and moderate intensity exercise returning to pre-diagnosis levels at 2- and 6-month follow-ups.

For the chemotherapy + radiation group, main effects were obtained for weekly METS [$F(4,91) = 7.35$; $P < 0.001$] and weekly minutes of mild [$F(4,91) = 2.65$; $P < 0.05$], moderate [$F(4,91) = 5.11$; $P < 0.001$], and total exercise [$F(4,91) = 7.75$; $P < 0.001$; see Table 3]. Figure 2 also portrays the significant results for total weekly METS and total minutes of weekly exercise for the chemotherapy + radiation group. Post hoc planned comparisons indicated differences between baseline and post-treatment 1 assessments for METS and minutes of mild, moderate, strenuous, and total exercise ($P < 0.05$). In addition, a difference was found between baseline and post-treatment 2 assessments for minutes of strenuous exercise ($P < 0.05$). No differences were found between baseline and the 2- and 6-month follow-up assessments for any of the five dependent variables. In general, women in the chemotherapy + radiation group reported declines in exercise at the post-treatment 1 assessment with only strenuous activity remaining depressed at the post-treatment 2 assessment. Exercise activity returned to pre-diagnosis levels at 2- and 6-month follow-up.

Table 4 shows the proportions of sedentary women, women meeting exercise guidelines, and women reporting any exercise or any mild, moderate, or strenuous exercise at each assessment. Cochran Q test was used to examine differences across assessments in these six dichotomous measures of exercise. For the radiotherapy group, differences over time were found for the proportion of women meeting exercise guidelines [Cochran's $Q(3) = 10.24$; $P < 0.02$], engaging in any strenuous exercise [Cochran's $Q(3) = 10.89$; $P < 0.02$], and engaging in any moderate intensity exercise [Cochran's $Q(3) = 9.61$; $P < 0.05$]. No longitudinal effect was found for the proportion of sedentary women or the proportion of women

Table 1. Comparison of radiotherapy + chemotherapy and radiotherapy groups with regard to demographic and clinical characteristics at the baseline assessment

	CT + RT (n = 114), n (%)	RT only (n = 143), n (%)
White	101 (89)	136 (95)
Married/partnered	86 (75)	105 (73)
Children in home	42 (37)	35 (25)*
Employed full time	38 (32)	48 (33)
Education less than or equivalent to high school	32 (28)	41 (29)
Lumpectomy only†	99 (87)	141 (99)‡
Stage II disease at diagnosis	82 (72)	8 (6)‡
Sedentary (baseline)§	24 (21)	40 (28)
Met exercise guidelines (baseline)§	30 (26)	40 (28)
Mean age (SD)	51.2 (8.7)	58.4 (9.4)‡
Mean body mass index (SD)	26.8 (5.5)	27.3 (6.2)
Mean METS (baseline)§	52.9 (69.7)	49.8 (70.7)
SF-36 physical (baseline)	44.7 (9.2)	49.2 (8.6)∥
SF-36 mental (baseline)	50.4 (10.2)	51.8 (8.9)

Abbreviations: RT, radiotherapy; CT, chemotherapy.
*$P < 0.05$.
†Information on surgical treatment was not available for eight women.
‡$P < 0.001$.
§Refers to pre-diagnosis exercise activity.
∥$P < 0.01$.

Table 2. Participation in mild, moderate, and strenuous leisure-time exercise activity at each study assessment

	Frequency (%)*	Mean frequency (SD)†	Mean duration (SD)‡	Mean total (SD)§
Baseline (n = 257)‖				
Mild	134 (52.1)	1.93 (2.9)	39.4 (48.6)	65.0 (125.9)
Moderate	120 (46.7)	1.75 (2.3)	34.9 (20.0)	60.6 (90.9)
Strenuous	59 (23.0)	0.84 (2.0)	37.7 (24.7)	31.2 (80.5)
All exercise				156.9 (200.6)
Sedentary¶	64 (24.9)			
Meets guidelines**	70 (27.2)			
Post-treatment 1 (n = 256)				
Mild	118 (46.1)	1.62 (2.4)	33.2 (55.2)	49.5 (117.4)
Moderate	76 (29.7)	1.18 (2.2)	34.4 (19.1)	39.7 (83.7)
Strenuous	32 (12.5)	0.41 (1.2)	39.3 (23.2)	16.1 (55.8)
All exercise				105.3 (174.8)
Sedentary	100 (39.1)			
Meets guidelines	39 (15.2)			
Post-treatment 2 (n = 102)				
Mild	55 (53.9)	2.25 (2.8)	42.8 (60.9)	93.9 (244.8)
Moderate	36 (35.3)	1.28 (2.1)	31.8 (15.5)	40.3 (76.3)
Strenuous	13 (12.7)	0.49 (1.5)	21.9 (9.0)	9.7 (29.6)
All exercise				143.9 (284.0)
Sedentary	32 (31.4)			
Meets guidelines	15 (14.7)			
2-mo follow-up (n = 241)				
Mild	133 (55.2)	1.97 (2.4)	38.3 (40.3)	72.4 (142.3)
Moderate	116 (48.1)	1.92 (2.7)	40.1 (39.9)	72.2 (120.7)
Strenuous	45 (18.7)	0.59 (1.5)	33.0 (17.9)	21.0 (70.9)
All exercise				165.6 (239.0)
Sedentary	60 (24.9)			
Meets guidelines	59 (24.5)			
6-mo follow-up (n = 257)				
Mild	152 (59.4)	2.28 (2.8)	33.4 (31.5)	72.7 (132.3)
Moderate	120 (46.9)	1.76 (2.5)	39.2 (23.9)	69.5 (114.1)
Strenuous	47 (18.4)	0.59 (1.7)	37.0 (29.1)	20.1 (57.1)
All exercise				162.4 (220.5)
Sedentary	64 (25.0)			
Meets guidelines	63 (24.6)			

NOTE: Values for mean frequency, duration, and total minutes of leisure-time exercise activity are calculated based only on women reporting some exercise activity in that category.

*% Sample reporting any activity in that category.

†Number of times exercised per week.

‡In minutes per week, based on women reporting physical activity in that intensity category only.

§In minutes per week, based on mean frequency times mean duration.

‖Data collected at the baseline assessment represent pre-diagnosis exercise activity.

¶Defined as absence of any physical activity of any intensity.

**Defined as ≥150 min of moderate or strenuous activity per week.

engaging in any exercise or engaging in mild intensity exercise. Post hoc planned comparisons using the McNemar test identified the locus of differences for dependent variables for which a significant Cochran's Q was obtained. A difference was found only between baseline and post-treatment 1 in the proportion of women meeting exercise guidelines [$X^2(1)$ = 7.03; P < 0.01] and reporting strenuous (P < 0.01, binomial exact test) and moderate intensity exercise [$X^2(1)$ = 6.88; P < 0.01]. For each, the proportion of women meeting exercise guidelines (28% versus 16%) and reporting moderate (48% versus 35%) or strenuous (24% versus 13%) intensity exercise at the post-treatment 1 assessment was less than before diagnosis.

For the chemotherapy + radiation group, differences over time were found for the proportion of sedentary women [Cochran's $Q(4)$ = 30.99; P < 0.001], women meeting exercise guidelines [Cochran's $Q(4)$ = 9.40, P < 0.05], and women reporting moderate-intensity [Cochran's $Q(4)$ = 33.48, P < 0.001], mild-intensity [Cochran's $Q(4)$ = 14.37, P < 0.01], or any exercise [Cochran's $Q(4)$ = 30.99; P < 0.001]. No longitudinal effect was found for the proportion of women reporting strenuous exercise. Post hoc planned comparisons using the McNemar test identified the locus of differences for dependent variables for which a significant Cochran's Q was obtained. A difference was found only between the baseline and post-treatment 1 assessments in the proportion of sedentary women [$X^2(1)$ = 12.90; P < 0.001] and women reporting moderate-intensity exercise [$X^2(1)$ = 9.82; P < 0.01] or any exercise [$X^2(1)$ = 12.90; P < 0.001]. The proportion of sedentary women at the post-treatment 1 assessment was greater than before diagnosis (45% versus 23%). Conversely, the proportion of women at the post-treatment 1 assessment reporting moderate-intensity exercise (43% versus 23%) or any exercise (77% versus 55%) was less than before diagnosis.

To assess individual change in leisure-time exercise, each woman's pre-diagnosis weekly METS (obtained at baseline assessment) and whether or not they were sedentary and met exercise guidelines pre-diagnosis were compared with their 6-month follow-up data (Table 5). About 75% of the sample exhibited no change in whether they were sedentary or met exercise guidelines between pre-diagnosis and 6-month follow-up. For both indices, there are similar proportions of participants that improved (i.e., moved from sedentary to nonsedentary status or from not meeting exercise guidelines to meeting guidelines) between the two assessments as participants that declined (i.e., moved from nonsedentary status to sedentary status or from meeting exercise guidelines to not meeting guidelines). For both indices, the proportion of improvers and decliners was in the 10% to 15% range. Improvements or declines in weekly METS were classified by whether a woman exhibited an increase or decrease in METS ≥ 0.5 SD (i.e., ±35 METS) between pre-diagnosis and

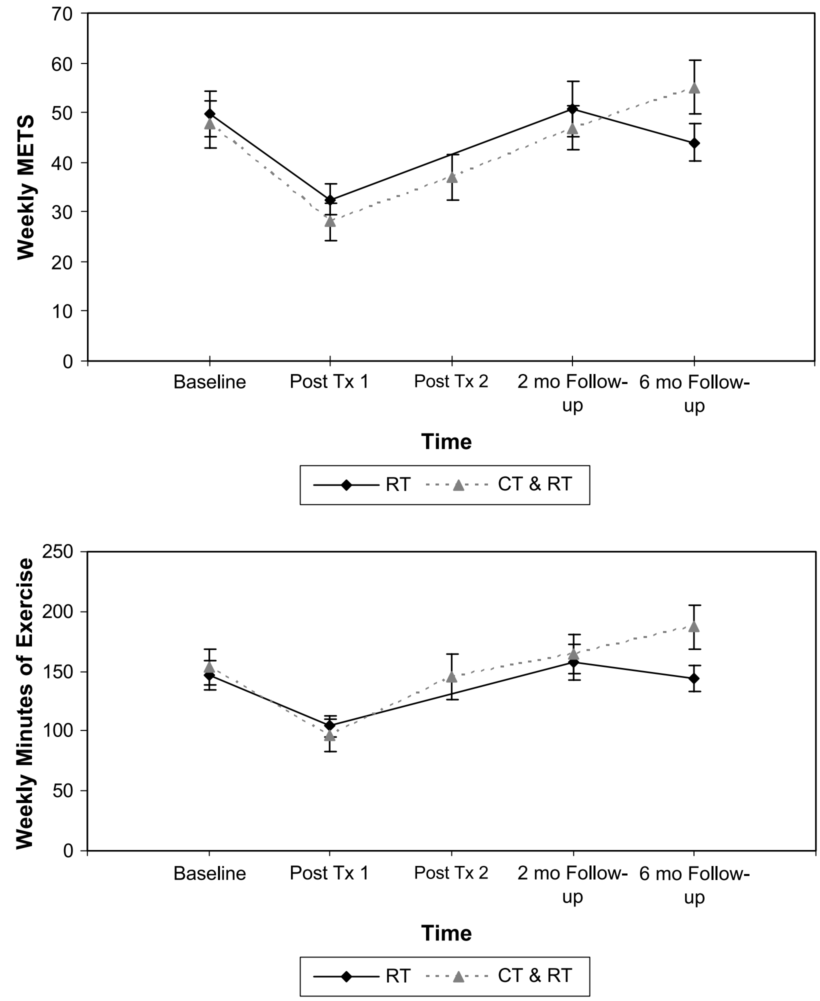

Figure 2. Weekly METS and minutes of exercise across time in the radiotherapy and chemotherapy + radiotherapy groups.

6-month follow-up. One-half SD was chosen as the criterion as this magnitude of change is often viewed as clinically significant or important (36, 37). Using this criterion, most women (64.5%) exhibited no clinically significant change in METS over time, whereas similar proportions of women increased weekly METS (16%) as decreased METS (19.5%) between pre-diagnosis and 6-month follow-up.

X^2 analysis was used to identify clinical and demographic variables differentiating women who increased, decreased, or showed no clinically significant change in weekly METS (i.e., ≥35 METS) between pre-diagnosis and 6-month follow-up. Dependent variables included age (<50 versus ≥50 years), partner status, race, education (less than high school degree versus more than high school degree), disease stage, surgery (lumpectomy versus mastectomy), adjuvant therapy (radiotherapy versus chemotherapy + radiotherapy), and study site. Only adjuvant therapy was associated with change in weekly METS [$X^2(2) = 6.29$; $P < 0.05$]. Women receiving chemotherapy + radiation were more likely to exhibit an increase *or* decrease ≥35 METS (43% versus 30% for the radiotherapy group). Of the 48 women in the chemotherapy + radiation group reporting a change in METS, about equal numbers of women increased ($n = 25$) as decreased ($n = 23$) weekly METS between pre-diagnosis and 6-month follow-up.

Discussion

As hypothesized, leisure-time exercise activity decreased during adjuvant therapy and rebounded after completion of adjuvant therapy. This pattern of results was clearly evident in both the radiotherapy and chemotherapy + radiation groups for both total METS and minutes of exercise per week (Fig. 2) and the proportion of women meeting weekly exercise guidelines (Table 4). Our prospective and longitudinal data thus suggest that the diagnosis and treatment of early-stage breast cancer does not result in a significant reduction in leisure-time exercise activity, at least through the first 6 months following conclusion of adjuvant therapy.

Amidst this general pattern of findings, several things were noteworthy. First, declines in leisure-time exercise during adjuvant therapy were not overly large. Declines in METS and total minutes of exercise evident at the post-treatment 1 assessment were on the order of 0.20 to 0.30 SD, a small-to-medium effect size. This represents a decline of 15 to 20 METS or 40 to 60 total minutes of exercise per week. Second, leisure-time exercise recovered rather quickly. For both the radiotherapy and chemotherapy + radiation groups, no differences were found between pre-diagnosis exercise reports and 2- and 6-month follow-up for total weekly METS or minutes of exercise or the proportion of sedentary women or women meeting exercise guidelines. In general, recovery of leisure-time exercise activity was complete by the 2-month follow-up. Third, recovery of leisure-time exercise seemed to begin even before completion of adjuvant therapy in the chemotherapy + radiation group. In this group, whereas weekly total METS and minutes of exercise were below pre-diagnosis levels at the conclusion of chemotherapy (i.e., post-treatment 1), these differences had disappeared by the time radiotherapy was completed (i.e., post-treatment 2). Fourth, the magnitude of decline in leisure-time exercise was similar

Table 3. Weekly leisure time exercise activity over time in the radiotherapy and chemotherapy + radiotherapy groups

	Baseline*	Posttreatment assessments		Follow-up assessments	
		Post-treatment 1	Post-treatment 2	2 mo	6 mo
RT group (n = 136)					
Total METS	49.7 (69.9)	32.5 (47.2)†		50.7 (82.1)	43.9 (55.9)‡
Mild exercise	55.1 (104.0)	42.9 (79.5)		61.7 (121.9)	58.6 (79.9)
Moderate exercise	58.3 (86.5)	45.1 (81.1)		69.4 (117.9)	68.3 (11.4)§
Strenuous exercise	33.4 (84.2)	16.0 (57.8)†		26.5 (89.3)	17.0 (53.7)†
Total exercise	146.8 (182.1)	104.0 (131.3)†		157.6 (224.4)	143.8 (166.7)§
CT + RT group (n = 95)					
Total METS	47.6 (69.9)	28.0 (58.5)†	36.9 (68.6)	46.8 (67.0)	55.1 (84.3)‡
Mild exercise	74.7 (150.9)	53.6 (144.4)†	98.0 (252.4)	81.7 (166.5)	96.1 (189.0)‖
Moderate exercise	51.9 (85.7)	30.8 (78.4)†	37.8 (75.0)	69.1 (108.1)	67.7 (11.6)‡
Strenuous exercise	26.9 (77.9)	12.6 (42.6)†	9.4 (29.5)†	13.9 (33.0)	23.3 (58.3)
Total exercise	153.5 (220.3)	96.7 (212.2)†	145.2 (291.4)	164.7 (243.9)	187.0 (282.9)‡

NOTE: Values for moderate, mild, strenuous, and total exercise are minutes per week. Values for total METS are METS per week.
Abbreviations: RT, radiotherapy; CT, chemotherapy.
*Represents pre-diagnosis exercise activity.
†Significantly different from baseline by the McNemar test ($P < 0.05$).
‡$P < 0.001$.
§$P < 0.01$.
‖$P < 0.05$.

for the radiotherapy and chemotherapy + radiation groups (Fig. 1). Contrary to hypothesis, chemotherapy was not associated with a greater decline in exercise activity, either in the short term (post-treatment 1) or longer term (2- and 6-month follow-ups). In part, this hypothesis was based on our own research linking chemotherapy to greater fatigue in women being treated for breast cancer (29). Although one might assume that greater fatigue would be associated with a propensity to exercise less, women might exercise as a means of combating fatigue. Indeed, both correlational and interventional research has shown that physical activity is associated with less fatigue in cancer patients and survivors (9-12). In addition, despite experiencing fatigue, women might exercise in hope of influencing recurrence and survival outcomes. Although a link between exercise and clinical outcome has not been established, such a belief would likely limit the observed correspondence between fatigue and exercise activity.

The decline in total weekly METS and minutes of exercise during adjuvant therapy was driven by both a decline in the intensity of exercise as well as the amount of time devoted to exercise. For both radiotherapy and chemotherapy + radiation groups, the proportion of women engaging in *any* moderate intensity exercise significantly declined after initiation of adjuvant therapy (Table 4). Similarly, for both radiotherapy and chemotherapy + radiation groups, weekly minutes devoted to strenuous exercise at the post-treatment 1 assessment was significantly less (>50% decrease relative to pre-diagnosis levels) than the number of minutes before diagnosis.

Although group analyses suggest adjuvant therapy had little effect on leisure-time exercise participation at the 6-month follow-up, some women did evidence significant change in their exercise activity at the 6-month follow-up, relative to pre-diagnosis levels. Very importantly, whereas some women reported decreases in leisure-time exercise after diagnosis, other women reported increases in exercise. Specifically, about 20% of the sample evidenced a decrease ≥35 weekly METS at the 6-month follow-up, relative to pre-diagnosis METS, whereas 16% exhibited an increase of ≥35 METS. As 35 METS represented 0.5 SD, over a third of the sample evidenced a clinically meaningful or important change in leisure-time exercise over the course of the study (36, 37). Women in the chemotherapy + radiation group were especially volatile, as

Table 4. Leisure time exercise activity over time in the radiotherapy and chemotherapy + radiotherapy groups

	Baseline*, n (%)	Posttreatment assessments, n (%)		Follow-up assessments, n (%)	
		Post-treatment 1	Post-treatment 2	2 mo	6 mo
RT group (n = 136)					
Sedentary	37 (27.2)	48 (35.3)		39 (28.7)	37 (27.2)
Meets guidelines	38 (27.9)	22 (16.2)†		36 (26.5)	33 (24.3)‡
Mild exercise	68 (50.0)	64 (47.1)		68 (50.0)	77 (56.7)
Moderate exercise	65 (47.8)	47 (34.6)†		60 (44.1)	62 (45.6)‡
Strenuous exercise	32 (23.5)	17 (12.5)†		25 (18.4)	22 (16.2)‡
Any exercise	99 (72.8)	88 (64.7)		97 (71.3)	99 (72.8)
CT + RT group (n = 95)					
Sedentary	22 (23.1)	43 (45.3)†	30 (31.6)	19 (20.0)	20 (21.1)§
Meets guidelines	20 (21.1)	13 (13.7)	12 (12.6)	19 (20.0)	23 (24.2)‡
Mild exercise	53 (55.8)	41 (43.2)	53 (55.8)	58 (61.1)	61 (64.2)‖
Moderate exercise	41 (43.2)	22 (23.2)†	31 (32.6)	52 (54.7)	47 (49.5)§
Strenuous exercise	18 (19.0)	11 (11.6)	12 (12.6)	19 (20.0)	20 (21.1)
Any exercise	73 (76.8)	52 (54.7)†	65 (68.4)	76 (80.0)	75 (79.0)§

Abbreviations: RT, radiotherapy; CT, chemotherapy.
*Represents pre-diagnosis exercise activity.
†Significantly different from pre-diagnosis levels ($P < 0.05$).
‡$P < 0.05$.
§$P < 0.001$.
‖$P < 0.01$.

Table 5. Individual change between baseline (before diagnosis) and 6-mo follow-up on measures of leisure-time exercise activity

	No. women	% Entire sample
Sedentary status		
Improved*	32	12.5
No change	192	75.0
Declined	32	12.5
Met exercise guidelines		
Improved†	30	11.7
No change	190	74.2
Declined	36	14.1
METS		
Improved‡	41	16.0
No change	165	64.5
Declined§	50	19.5

NOTE: Measures of pre-diagnosis exercise levels are obtained at baseline assessment.
*Sedentary pre-diagnosis and non-sedentary at 6 Mo Follow-up.
†Did not meet exercise guidelines before diagnosis and met exercise guidelines at 6-mo follow-up.
‡Increase ≥ 0.5 SD (i.e., 35 METS) between pre-diagnosis and 6-mo follow-up.
§Decrease ≥ 0.5 SD (i.e., 35 METS) between pre-diagnosis and 6-mo follow-up assessments.

50% of this group exhibited either a clinically significant increase or decrease in weekly METS. What might cause such changes? Obviously, a decline in exercise activity could stem from the adverse physical and psychological sequelae associated with breast cancer. Less obviously, we could speculate that a decline could stem from a belief that standard health behavior recommendations are less relevant to breast cancer survivors. On the other hand, increased leisure-time exercise, even in the face of increased fatigue, could be motivated by the belief that exercise reduces risk of recurrence and prolongs survival. Finally, a cancer diagnosis can be a critical life transition or ''teachable moment'' that can promote positive change in various behaviors, attitudes, and beliefs (38-40). Indeed, research has shown that cancer patients and survivors show interest in positive lifestyle changes (41). Increased leisure-time exercise could be one manifestation of this interest.

Limitations of our study should be noted. First, whereas our sample was recruited from two sites, thus increasing the generalizability of our findings, our combined sample included very few minority women. As leisure-time exercise might have different cultural meanings and value, research examining the effect of cancer diagnosis and treatment on leisure-time exercise in different racial and ethnic groups is warranted. Similarly, our study only included women with breast cancer and then only women with early-stage (0-II) disease. Future research is necessary to extend our findings to males, individuals with other cancer diagnoses, and women with breast cancer with later-stage disease who also receive chemotherapy and radiotherapy. Second, we focused on participation in leisure-time exercise and not physical activity, in general. Physical activity can be roughly categorized into activity associated with routine activities of daily living, including job-related physical activity, and elective physical activity associated with leisure-time activities, including intentional exercise and physical activity associated with leisure pursuits (e.g., gardening, hiking, and tennis). Thus, our measure of leisure-time exercise is only one facet of the physical activity picture. We focused on leisure-time exercise due to its elective nature; thus, we assumed that it would be maximally sensitive to the effect of cancer diagnosis and treatment. Future research, however, could track both elective and nonelective forms of physical activity. Third, we only followed participants out to 6 months after completion of adjuvant therapy. Although leisure-time activity levels seemed to return to pre-diagnosis baseline by this time, concluding that leisure-time exercise activity is not affected in the long-term by diagnosis and treatment for early-stage breast cancer may not be warranted. Exercise activity might still be in flux 6 months following conclusion of adjuvant therapy as women continue to resume responsibilities and roles they might have set aside temporarily during their recovery from breast cancer. As they continue to resume these responsibilities, less time might be available for leisure-time exercise. Additionally, the notion of cancer diagnosis and treatment as a ''teachable moment'' suggests that motivation to exercise might be high early in the course of recovery from breast cancer and might diminish over time. Thus, our 6-month follow-up might capitalize on an enhanced motivation to exercise. Both scenarios suggest our 6-month follow-up could mask an ultimate long-term decline in exercise in breast cancer survivors. Interestingly, Fig. 2 suggests a decline in exercise participation in the radiotherapy–only group at the 6-month assessment, perhaps due to a quicker recovery of routine home and work responsibilities or less motivation to exercise in this group. Clearly, additional follow-up is necessary to determine the long-term effect of cancer diagnosis and treatment on leisure-time exercise participation.

Finally, a couple of limitations were present in the methods used to assess leisure-time exercise. First, leisure-time exercise was measured retrospectively. Exercise during the past week was assessed at all but the baseline assessment, whereas at baseline, women reported their ''typical'' weekly exercise activity during the 6 months before diagnosis. Such retrospective assessments are thought to be less reliable than current assessments of exercise obtained through paper or electronic diaries. Second, exercise activity was assessed exclusively via self-report. Objective indices of exercise activity could enhance future research. Third, the LTEQ assesses exercise during the past week. For the post-treatment 1 and 2 assessments, the week preceding the final chemotherapy or radiotherapy treatment might not be representative of exercise participation during the entire course of chemotherapy or radiotherapy. Finally, whereas most respondents completed the LTEQ as a written questionnaire, a small minority of women completed the LTEQ in the course of a telephone interview at some assessments. Some evidence suggests that written questionnaires might yield underestimates of physical activity when compared with interview assessments of physical activity (42), perhaps due to enhanced social desirability biases when interview methods are used (43). Although use of both self-report and interview versions of the LTEQ at some assessments is not ideal, of course, its effect on current study findings might be minimal. As all women completed the LTEQ as a written questionnaire at the baseline and 6-month follow-up assessments, direct comparisons of LTEQ responses for these two assessments were not affected. Additionally, any bias introduced by our occasional use of telephone interviews to assess activity level at the remaining three study assessments would likely be in the direction of *underestimating* decline in exercise activity during adjuvant therapy.

In conclusion, this study examines the important question of whether cancer diagnosis and treatment significantly affects leisure-time exercise in cancer survivors. In general, our data suggest the diagnosis and treatment of early-stage breast cancer produces a decline in exercise participation during adjuvant therapy followed by recovery to pre-diagnosis levels 6 months after conclusion of adjuvant therapy. Although comforting, this conclusion overlooks the fact that participation in leisure-time exercise activity 6 months after conclusion of adjuvant therapy was still suboptimal, a finding reported by others (24, 25). Only 20% to 40% of our sample met current guidelines for exercise activity either before or after cancer treatment. As exercise is not contraindicated for most breast cancer survivors, there are clearly physical and mental health benefits to be gained from encouraging exercise in this group. Furthermore, our conclusion of ''no overall change'' in exercise also overlooks that about one third of our sample did report clinically important change in leisure- time exercise up to 6 months after treatment completion. Some women reported clinically important decreases in leisure-time exercise, whereas about equal numbers of women reported increases. The importance of physical activity for both the physical and mental health of cancer survivors is well documented, and there is additional speculation that physical activity may positively affect prognosis. Consequently, identification of factors that facilitate or impede spontaneous participation in leisure-time exercise in cancer survivors is important. Some of these factors could be unique to cancer survivors. In particular, identification of the beliefs and motivations of cancer patients and survivors regarding participation in exercise activity is needed to support clinical efforts to increase the number of survivors evidencing appropriate levels of physical activity.

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