Research Article

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Exploring the Feasibility of a Broad-Reach Physical Activity Behavior Change Intervention for Women Receiving Chemotherapy for Breast Cancer: A Randomized Trial

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Abstract

Background: Facilitating healthy levels of physical activity (PA) during chemotherapy is important for the psychosocial and physical health of breast cancer survivors. The primary objective of this feasibility study was to examine the effects of a broad-reach PA behavior change intervention among women with breast cancer receiving adjuvant chemotherapy.

Methods: Breast cancer patients receiving adjuvant chemotherapy ($N = 95$) were randomly assigned to receive a PA resource kit consisting of tailored print materials and a step pedometer (intervention) or a standard public health PA recommendation (standard recommendation). The primary outcome was daily pedometer steps. Secondary outcomes were self-reported light, moderate, and vigorous intensity PA, total moderate-to-vigorous PA, and sedentary time. Assessments were conducted before and after adjuvant chemotherapy.

Results: Attrition was 19% (17 of 95). Intervention patients wore their step pedometer for 85 days (range, 35–144 days; SD = 26.4) for a 95% adherence rate. Analyses of covariance suggested that the intervention was not statistically superior to standard recommendation for daily average pedometer steps (−771; 95% CI = −2024 to 482; $P = 0.22$), total MVPA minutes (−4; 95% CI = −62 to 570; $P = 0.90$), or sedentary time (+160; 95% CI = −186 to 506; $P = 0.42$).

Conclusion: This broach-reach and low intensive intervention was not more effective for promoting PA in breast cancer patients receiving chemotherapy than providing the standard public health guidelines for PA.

Impact: Achieving physical activity behavior change during adjuvant breast cancer chemotherapy may require some level of supervised physical activity or more intensive (e.g., face-to-face, supervised) interventions. *Cancer Epidemiol Biomarkers Prev; 25(2); 391–8. ©2015 AACR.*

Introduction

It is well established that the vast majority of breast cancer patients do not achieve public health recommendations for physical activity (PA; ref. 1). Breast cancer patients who engage in regular PA during chemotherapy have clinically significant improvements in health-related quality of life (HRQoL), physical functioning, fatigue, and cardiorespiratory fitness (2–5) and may even achieve improved disease-free survival (6). One study suggested women who were previously inactive and increased their PA after breast cancer diagnosis had a 45% lower risk of death compared with women who remained inactive after diagnosis (7). Moreover, engaging in PA during adjuvant chemotherapy may aid in facilitating the adoption of PA after treatment (8).

The majority of previous studies that have demonstrated these benefits in breast cancer patients during chemotherapy have delivered fully supervised exercise interventions (9). These interventions are not likely scalable to the majority of breast cancer survivors because they are expensive, require substantial expertise and equipment, and are usually only available in large metropolitan areas. Broad-reaching and low intensive interventions designed to increase PA in breast cancer patients undergoing chemotherapy are warranted. This contention is substantiated by the evidence suggesting that breast cancer survivors indicate that they are interested in pursuing PA and receiving PA counseling and information during their treatments (10, 11). Moreover, researchers have contended that the initial treatment period may function as a "teachable moment" in which breast cancer survivors' motivation for lifestyle change may be especially high (10, 12, 13). Given that breast cancer patients may face several barriers to engaging in PA programs during chemotherapy (14), researchers have advocated for the need to develop and assess the efficacy of interventions that use distance medicine-based approaches (e.g., home-based approaches; refs.12, 13, 15).

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We previously reported results from two key studies that demonstrated (i) supervised exercise is safe, feasible, and effective for breast cancer patients receiving chemotherapy (2) and (ii) a broad-reach intervention consisting of tailored PA print resources and a step pedometer were effective in improving self-reported PA levels and HRQoL in breast cancer survivors who had completed treatments (16). Whether a similar broad-reach intervention could improve PA in breast cancer patients receiving chemotherapy is unknown.

To examine the feasibility and utility of a broad-reach PA intervention during adjuvant chemotherapy for breast cancer, we conducted the Promoting Physical Activity during Chemotherapy (PROACTIVE) trial (http://clinicaltrials.gov, NCT01053468). The primary objective of the PROACTIVE trial was to examine the effects of a broad-reach PA behavior change intervention consisting of theoretically framed PA resources, step pedometers, and step tracking in a sample of women with breast cancer receiving adjuvant chemotherapy. The intervention was compared with a standard PA recommendation consisting of a generic (and widely available) public health PA resource. The primary aim was to compare the intervention and standard recommendation on objectively assessed walking behavior assessed via pedometer. The secondary aims were to compare intervention and standard recommendation on self-reported PA minutes per week (i.e., light, moderate, and vigorous minutes) and sedentary time. We hypothesized that patients in the intervention group would report greater increases in objectively assessed walking and self-reported PA compared with patients receiving the standard recommendation.

Materials and Methods

This trial was a multicentre, prospective, two-armed, feasibility study conducted in Alberta, Canada. Breast cancer patients were recruited from seven cancer centers (two comprehensive, four associate, and one community cancer center) across the province. Patients were eligible for the trial if they (i) were diagnosed with stage I to IIIA breast cancer, (ii) were scheduled to receive neoadjuvant or adjuvant chemotherapy, (iii) did not receive transabdominal rectus abdominus muscle (TRAM) reconstructive surgery, (iv) were $\geq$18 years of age, (v) received approval from their treating oncologist to participate, and (vi) did not have uncontrolled hypertension, cardiac illness, or psychiatric conditions.

Recruitment

Recruitment took place at the initial treatment consultation with the medical oncologist (i.e., new patient breast clinic, which was approximately 2 weeks prior to the initiation of chemotherapy). Interested patients received a study information envelope that contained detailed information pertaining to the study and related requirements and were asked to notify the research team of their intent to participate. They were then sent a study information package containing an informed consent form, a baseline questionnaire, a step pedometer, a 3-day step-assessment log sheet, and a self-addressed stamped envelope. When the study team received all baseline documents, patients were randomized to the intervention or standard recommendation groups, and the designated materials were distributed to the patient. All efforts were made to receive the above assessments prior to the second scheduled chemotherapy cycle. Patients were not eligible to start the trial if they had received their second scheduled chemotherapy cycle.

Randomization

Patients were stratified by study site and type of chemotherapy (taxane vs. nontaxane chemotherapy) and randomly assigned to either intervention or standard recommendation in a 1:1 ratio using a computer-generated allocation sequence (StatMate, Version 1.01, 1998). A random blocks permutation procedure was used to generate the allocation sequence within each stratum. The allocation sequence and group assignments were generated centrally and enclosed in sequentially numbered and sealed envelopes. A trained research assistant conducted all randomization-related procedures.

Intervention materials

Patients in the intervention group received the PROACTIVE PA resource kit that included PA print materials, a step pedometer, and a step logbook (see Fig. 1). Patients received a StepsCount SC-01 step pedometer (StepsCount Inc.) and were asked to wear their pedometer daily for the duration of their chemotherapy treatments (i.e., 4–6 months). Pedometers provide a low-tech option for objective and accurate monitoring of PA (i.e., steps taken) and have been shown to increase PA in cancer survivors (16).

Patients in the intervention group received the resource "Physical activity for health: Your proactive resource for being active after a breast cancer diagnosis." The primary recommendation was for participants to increase their PA by at least 150 minutes of moderate intensity PA per week over and above the activity they normally do. "Physical activity for health" contained information and advocated for a wide range of physical activities (walking, hiking, cycling, golfing, and dancing). Brisk walking was recommended as the easiest and safest form of PA and contained information reflective of the chemotherapy process (e.g., engaging in PA during chemotherapy). Included were eight interactive activities the participant was prompted to complete (e.g., barrier identification, goal setting, planning/scheduling). "Physical activity for health" was modified from our previously developed PA and breast cancer resource, which was tested for suitability and has demonstrated evidence of effectiveness in a large sample of breast cancer survivors (16, 17).

To supplement the pedometer, patients also received a copy of "Step into survivorship: Your proactive resource for walking after a breast cancer diagnosis." This newly developed resource informed the patient specifically about walking and step counting and how to monitor and log steps, and provided strategies and tips for increasing stepping activity. Both resources were developed using the Theory of Planned Behavior framework (18), and content was designed to enhance attitudes, subjective norms, perceived behavioral control, and intentions. Patients were asked to record their step totals and moderate and vigorous PA minutes at the end of each day in the "Physical Activity Journal." Patients recorded these values each day for the duration of time they were receiving chemotherapy treatment. A team including a graphic designer, health literacy expert, health education expert, breast cancer survivors (i.e., end users), and study investigators collaborated to produce the resources.

Patients in the standard recommendation group received a generic two-page public health PA resource. Patients younger than 65 years received a copy of *Canada's Physical Activity Guide to Healthy Active Living for Healthy Adults*. This resource recommended that adults should be active for at least 30 minutes on 4 days a week. Patients who were 65 years of age or older received a copy of *Canada's Physical Activity Guide for Older Adults*. This

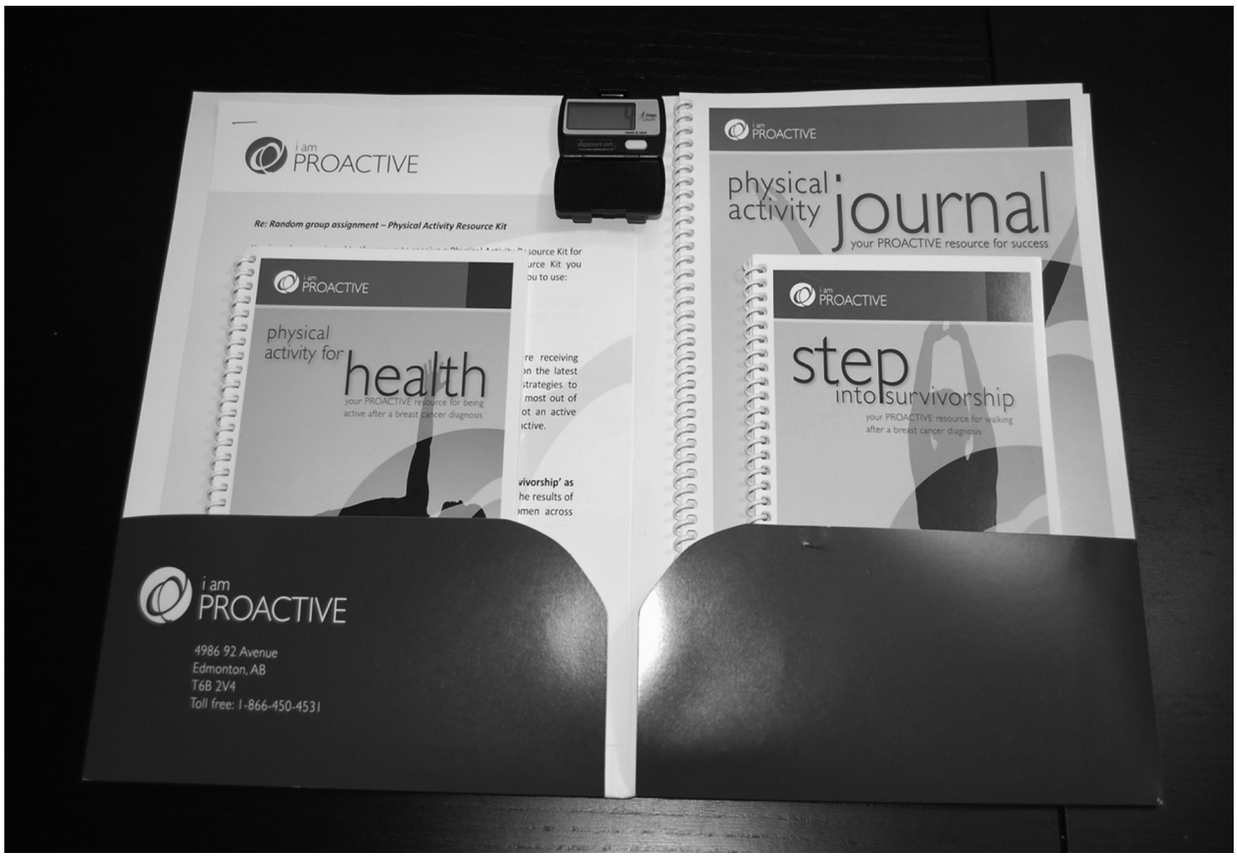

Figure 1.
PROACTIVE physical activity resource kit (intervention).

resource recommended that older adults accumulate 30 to 60 minutes of moderate PA on most days of the week. Both resources were developed by the Public Health Agency of Canada (PHAC). Patients randomized to the standard recommendation group were asked to refrain from using their baseline assessment pedometer during the study period.

Intervention uptake/adherence

Patients randomized to the intervention group were asked (i) how many times they read the resources, (ii) how long they spent reading the resources, and (iii) how many resource activities they completed (e.g., goal-setting, barrier identification). Adherence to the pedometer was assessed by monitoring how many days the participant wore their pedometer during the primary study period (i.e., baseline to post-chemotherapy). At the end of the primary study period (i.e., post-chemotherapy), participants submitted their PA journal that contained their daily step counts from the study period.

Measures

Pedometer steps were the primary outcome and self-reported physical activity and sitting time were secondary outcomes. Measures were administered at baseline (prior to second chemotherapy administration) and at post intervention (between 3 and 4 weeks after the last chemotherapy administration). Demographic information was assessed via self-report and included age, marital status, education, income, employment status, and ethnicity. Health information was assessed via self-report and included HRQoL (assessed via Functional Assessment of Cancer Therapy–Breast; ref. 19), height and weight, smoking, and comorbidities. Medical information was assessed via self-report and included disease stage, type of surgery, chemotherapy protocol, and menopausal status.

Objective walking behavior was assessed via a 3-day step test using the StepsCount SC-01 pedometer. During the 3-day monitoring period, participants in both groups recorded their daily step counts at the end of each day and then reset the pedometer to zero each morning. Research indicates that a 3-day step monitoring period correlates highly (i.e., $r > 0.90$) with an individual's weekly step count (20).

Self-reported physical activity was assessed by the leisure score index (LSI) of the Godin Leisure-Time Exercise Questionnaire (GLTEQ; refs. 21, 22). The LSI contains three questions that assess the average frequency and duration of mild, moderate, and strenuous exercise during free time in a typical week in the past month and has demonstrated evidence of reliability and validity (23).

Total and domain-specific sitting was assessed using the total and domain-specific measure of sitting developed and evaluated by Marshall and colleagues (24) that included five items assessing time spent sitting (hours and minutes) each day in the following domains: (i) while traveling to and from places, (ii) while at work, (iii) while watching television, (iv) while using a computer at

home, and (v) at leisure not including watching television, on a weekday and a weekend day. This measure is an acceptable measure of domain-specific sitting time (25).

Sample-size calculation and data analysis

We conducted a sample size calculation based on comparing the mean of two groups. To detect a difference of 2,500 steps per day with a power of 0.90 and a two-tailed alpha less than 0.05 (SD = 4,000), we needed 54 patients per group. To account for 20% related to attrition and missing covariate data, we planned to randomize 130 patients.

Baseline comparisons were performed using univariate analysis of variance (ANOVA) for continuous variables and χ^2 analyses for categorical variables. The primary analysis of our study was to compare intervention to standard recommendation on objective walking (i.e., pedometer steps) while the secondary analyses compared intervention with standard recommendation on self-reported PA variables (light, moderate, vigorous intensity PA, and moderate-to-vigorous PA), and sedentary time. Using the intention-to-treat (ITT) approach on all patients with follow-up data regardless of their adherence to the intervention (26), ANCOVA models were used to assess differences in group change scores from pre- to post-intervention. Potential moderators were explored and included meeting PA guidelines (at least 150 minutes per week of moderate-to-vigorous PA), body mass index (BMI), age, and breast cancer stage. Covariates included breast cancer stage, chemotherapy (taxane vs. non-taxane), chronic disease, baseline age, BMI, marital status, education, HRQoL, and the relevant dependent variable.

Results

Between November 2010 and June 2012, we randomized 95 eligible participants (46 standard recommendation; 49 intervention; Fig. 2). Accrual was stopped early because of slower-than-expected accrual and the completion of the funding period. Overall, 78 of 95 participants completed the trial

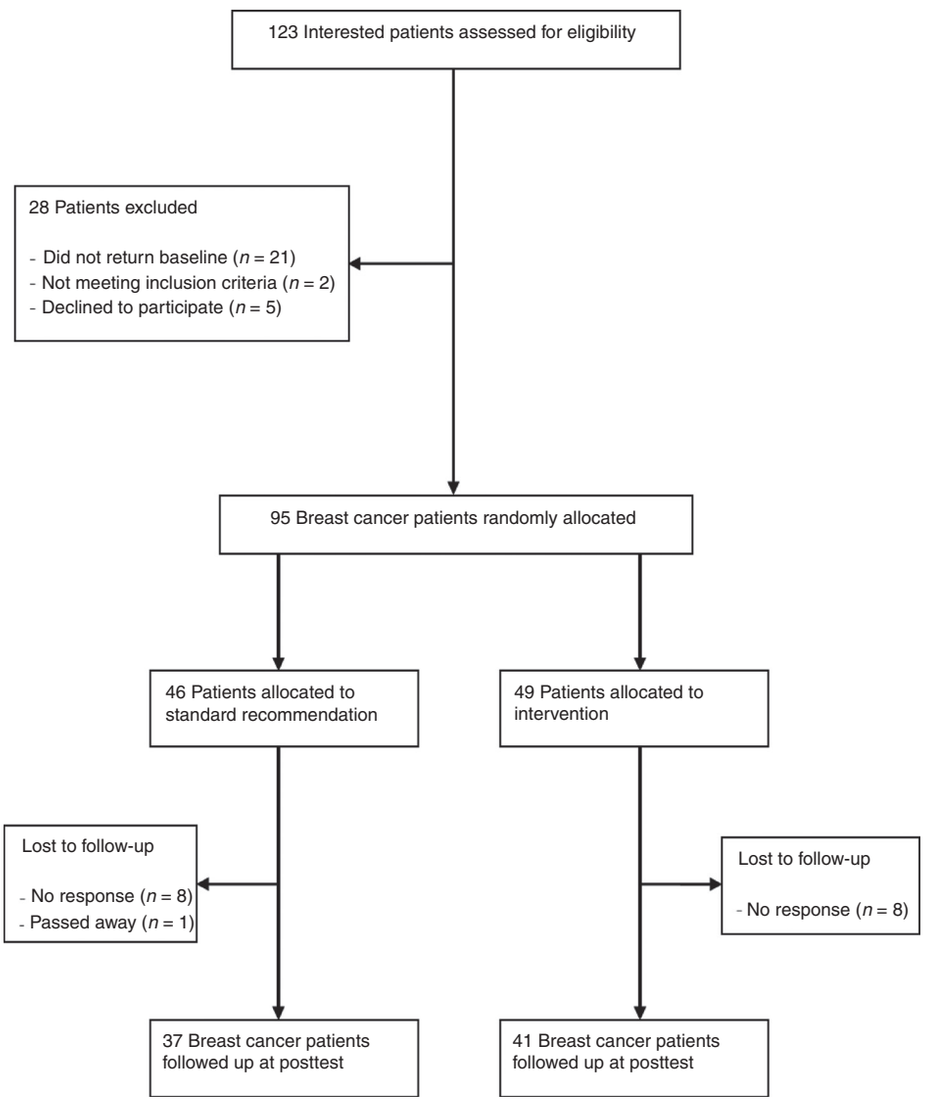

Figure 2.
PROACTIVE trial study flow chart.

Table 1. Demographic and medical details of study participants ($N = 95$)

	Overall	Intervention ($N = 49$)	Standard recommendation ($N = 46$)	*P*
Age	52.8 ± 9.8	52.8 ± 9.6	52.9 ± 10.1	0.92
BMI	24.6 ± 3.8	25.1 ± 4.1	24.1 ± 3.4	0.22
Weight (kg)	66.2 (10.0)	66.8 (10.0)	65.6 (10.0)	0.55
Marital status				
Not married	16 (17)	8 (8)	8 (8)	0.55
Married	79 (83)	41 (84)	38 (83)	
Education				
<College/university	22 (22)	11 (22)	11 (24)	0.53
≥College/university degree	73 (77)	38 (78)	35 (76)	
Employment status				
Not working	52 (55)	28 (57)	24 (52)	0.39
Working part or full time	43 (45)	21 (43)	22 (48)	
Racial background				
% Caucasian	90 (95)	46 (94)	44 (96)	0.29
Comorbidities				
Stroke	2 (2)	1 (2)	1 (2)	0.73
Diabetes	1 (1)	1 (2)	0 (0)	0.51
High blood pressure	18 (19)	10 (20)	8 (17)	0.45
High blood cholesterol	12 (13)	7 (14)	5 (11)	0.42
Smoke				
Never smoked	69 (73)	38 (78)	31 (67)	0.27
Ex smoker	25 (26)	10 (20)	15 (33)	
Current smoker	1 (1)	1 (2)	0 (0)	
Menopause				
Normal menses	33 (35)	18 (37)	15 (33)	0.65
Irregular menses	19 (20)	8 (16)	11 (24)	
No menses	43 (45)	23 (47)	20 (44)	
Health-related quality of life	107.6 (16.8)	110 (14)	105 (19)	0.18
Cancer variables				
Stage I	15 (16)	10 (20)	5 (11)	0.06
Stage II	55 (58)	31 (63)	24 (52)	
Stage III	25 (26)	8 (16)	17 (37)	
Chemotherapy				
Taxane	82 (86)	42 (86)	40 (87)	086
Non-taxane	13 (14)	7 (14)	6 (13)	

NOTE: Numbers may not equal 95 due to missing data. Data are presented as the mean (SD) for continuous variables (i.e., age, weight, BMI, and physical activity variables) and frequency (%) for categorical variables. Demographic and clinical characteristics of participants were compared using analysis of variance and χ^2 tests where appropriate.

(37 standard recommendation; 41 intervention) for an overall completion rate of 82%. Baseline characteristics of the sample are presented in Table 1. To summarize, 74% were married, 27% were working full time, and 53% had completed university/college. The mean BMI was 24.6 (SD = 3.8). No significant differences were observed across any demographic and medical variables between intervention and control participants at baseline.

Evaluation and adherence to physical activity resources

On average, intervention patients wore their step pedometer for 85.2 days (range, 35–144 days; SD = 26.4) during the intervention over a possible 90.1 days (average; SD = 29.2) for an overall 95% adherence rate. Intervention patients reported reading the "Physical activity for health" resource 1.5 times (SD = 0.51), and referring to the resource 1.6 times (SD = 1.6), for a total reading time of 67 minutes (SD = 44). These patients reported reading the "Step into survivorship" resource 1.4 times (SD = 0.50), and referring to the resource 1.3 times (SD = 1.3), for a total reading time of 54 minutes (SD = 17). Intervention patients reported reading approximately 97% and 95% of the "Physical activity for health" resource and "Step into survivorship" resources, respectively. Out of the seven written activities in the "Physical activity for health" resource, participants completed on average 2.3 activities (SD = 2.7). Patients indicated setting on average 1.2 goals.

Physical activity and sedentary time outcomes

Overall, the intervention was not statistically superior to a standard recommendation for daily average pedometer steps (−771; 95% CI, −2024 to 482; $P = 0.22$), light intensity PA minutes (−15; 95% CI, −90 to 61; $P = 0.70$), moderate intensity PA minutes (+6; 95% CI, −53 to 64; $P = 0.90$), vigorous intensity PA minutes (−1; 95% CI, −29 to 27; $P = 0.93$), total MVPA minutes (−4; 95% CI, −62 to 570; $P = 0.90$), and sedentary time (+160; 95% CI, −186 to 506; $P = 0.42$; Table 2). Meeting PA guidelines, BMI, age, or breast cancer stage did not moderate any associations between group assignment and the dependent variables. No adverse events were reported.

Discussion

Contrary to our hypotheses, we found that a theoretically framed PA resource kit including targeted print materials and a step pedometer (with step logging activity) did not facilitate PA behavior compared with standard public health print materials among women with breast cancer receiving adjuvant chemotherapy. No significant differences in objective walking behavior, or

Table 2. Effects of PA intervention and standard recommendation on physical activity behavior in breast cancer patients receiving chemotherapy

Variable	Baseline ($N = 95$) Mean (SD)	Postintervention ($N = 78$) Mean (SD)	Between-groups comparison[a,b] (95% CI)	*P*
Daily steps				
Intervention	6,890 (3,793)	5,923 (3,109)	−771 (−2024 to 482)	0.22
Standard recommendation	6,889 (3,496)	6,885 (3,576)		
Light PA				
Intervention	158 (135)	108 (126)	−15 (−90 to 61)	0.70
Standard recommendation	192 (270)	141 (164)		
Moderate PA				
Intervention	134 (127)	123 (126)	+6 (−53 to 64)	0.90
Standard recommendation	141 (158)	116 (130)		
Vigorous PA				
Intervention	34 (73)	19 (43)	−1 (−29 to 27)	0.93
Standard recommendation	15 (33)	30 (72)		
MVPA				
Intervention	168 (149)	143 (132)		
Standard recommendation	156 (162)	146 (155)	−4 (−62 to 570)	0.90
Sedentary time				
Intervention	1,001 (354)	1,023 (729)		
Standard recommendation	992 (326)	1,134 (683)	+160 (−186 to 506)	0.42

[a]Given adjustment for baseline covariates, the between groups comparison score does not reflect the difference between groups' postintervention minus baseline scores.

[b]Models adjusted for breast cancer stage, chemotherapy (taxane vs. non-taxane), at least one chronic disease, and baseline age, BMI, marital status, education, HRQoL, and the dependent variable.

self-reported light, moderate, and vigorous intensity PA emerged between the two groups. The intervention group reported almost 3 hours less of daily sedentary time, although this finding did not reach statistical significance.

It has been suggested a cancer diagnosis functions as a "teachable moment" where cancer patients may be particularly motivated to engage in health behavior change efforts (12). Indeed, several well-designed randomized controlled trials have demonstrated distance-based approaches to facilitating PA behavior among breast cancer survivors are effective (16, 27–29). One recent review of telephone, print, and web-based interventions for PA concluded that broad-reach intervention delivery modalities are effective for improving health behaviors, including PA (30). However, most studies only included survivors who had completed active treatment (with most being $\geq$1 year post diagnosis). The breast cancer treatment trajectory (e.g., surgery, chemotherapy, and radiation) presents a unique set of challenges that significantly impacts an individual's ability and willingness to adopt PA. The side effects of chemotherapy for breast cancer and their influence on PA behavior are well known and often include cancer-related fatigue and physical discomfort (31). While survivors who have completed treatment also report fatigue and discomfort, there are other common symptoms unique to chemotherapy treatment and often include gastrointestinal side effects, cytopenias, neutropenia, arthralgia, cardiovascular toxicity, alopecia, pain, peripheral neuropathy, and neurocognitive dysfunction (32). These side effects may indeed inhibit an individual from initiating and/or maintaining PA during adjuvant chemotherapy. One study of supervised exercise training during chemotherapy reported that 53% of missed exercise sessions were due to disease/treatment-related barriers (33). Despite the consistent evidence demonstrating declines in PA behaviors during adjuvant treatment for breast cancer (34, 35), relatively few studies have examined the influence of distance-based health promotion strategies designed to facilitate PA behavior during adjuvant chemotherapy. Further, studies published to date are also considered feasibility/pilot studies, thus limiting the inferences and conclusions drawn from the studies.

Our study found no significant differences in objective walking behavior and self-reported PA behaviors between the intervention and standard recommendation groups. We have previously reported PA print materials and step pedometers were effective broad-reach strategies in improving self-reported PA among breast cancer survivors who were on average 3 years post treatment. Our study is consistent with one randomized controlled trial that examined the impact of a distance-based diet and PA intervention in 90 premenopausal women with breast cancer on adjuvant chemotherapy (the STRENGTH study; ref. (36). The STRENGTH intervention consisted of telephone counseling for 6 months with dietary and exercise workbooks. While dietary outcomes improved (e.g., calcium, fruit, and vegetable intake), no measures of self-report PA changed significantly over time or differed among study arms. The study did not include any objective measures of PA. However, some studies have found broad-reach approaches to PA promotion during adjuvant chemotherapy to be effective (37, 38). For example, in a single group study design, Ligibel and colleagues provided 41 sedentary women (80% receiving chemotherapy) with a 12-week telephone-delivered PA intervention (38). A significant increase in weekly PA minutes was observed; however, weekly activity did not meet the target activity goal of 150 minutes/week and no comparison group was available.

Our results and the aforementioned literature suggest that more research is needed examining optimal strategies that can facilitate PA during the treatment time period. It appears changing PA behavior through broad-reach strategies tailored toward women receiving chemotherapy for breast cancer may not be as effective as broad-reach interventions conducted with non-chronic disease and otherwise healthy populations. A recent review of exercise promotion interventions after a cancer diagnosis concluded that there was a lack of convincing evidence that behavioral strategies can promote exercise behavior, and that significant research gaps

and challenges persist (39). An accompanying editorial concluded that one-size-fits-all strategies are not the most appropriate strategies to facilitating PA behavior after a cancer diagnosis (40). Optimal PA behavior change strategies during cancer treatment are still unknown, but may include an important role for the oncologist (29), smartphone/App technology, or various forms of social media. Given the physical, social, and emotional challenges experienced by patients during this time period, it is entirely plausible that more intensive interventions that include face-to-face, supervised, and individualized components may be necessary to support PA during breast cancer chemotherapy.

Our study has limitations that must be considered when interpreting the data. First, this was a feasibility study with a small sample size. Second, we were unable to achieve our planned sample size target and thus had reduced power; however, the between-group differences were small and not likely meaningful. Third, we were unable to determine how many patients were approached to participate in the study given the broad provincial recruitment strategy. Therefore, we cannot determine the recruitment rate for this study. We relied on self-reported assessments of light, moderate, and vigorous intensity PA that may have led to bias estimates of PA. Finally, the length of the intervention varied across participants (e.g., due to different chemotherapy regimens and treatment delays); therefore, the lack of a significant intervention effect may have been a result of failing to standardize the length of the intervention. Strengths of this study include the randomized controlled trial design, the objective measurement of walking, and the inclusion of a homogeneous sample of women receiving adjuvant chemotherapy for breast cancer. The results of this study only generalize to women undergoing adjuvant chemotherapy for breast cancer.

In conclusion, our data suggest that realizing actual gains in PA behavior during the adjuvant chemotherapy time period remains a challenge. Broad-reaching, low intensity PA interventions that require patient self-motivation to participate may not be suitable for women receiving chemotherapy. Several well-designed studies have emerged demonstrating the feasibility and effectiveness of supervised exercise interventions for women with breast cancer receiving chemotherapy (e.g., enhanced HRQoL and fitness, reduced fatigue, and possibly breast cancer outcomes; refs. 2, 6, 41). These studies provide a good base of evidence on which to promote and advocate for supervised PA during this time period. Further, given the mounting evidence suggesting a strong association between PA during treatment and reduced risk of cancer recurrence and mortality, researchers should continue to develop and evaluate strategies to improve PA behaviors and reduce sedentary time during adjuvant chemotherapy.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The study sponsors had no role in the design of the study; the collection, analysis, and interpretation of the data; the writing of the manuscript; and the decision to submit the manuscript for publication. All authors had no financial relationship with the organization that sponsored the research.

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References

1. Vallance JK, Courneya KS. Social cognitive approaches to understanding exercise motivation and behavior in cancer survivors. In: Treasure D, Roberts G, editors. Advances and applications in motivation in sport and exercise (3rd edition). Champaign, IL: Human Kinetics; 2012. p. 299–326.
2. Courneya KS, Segal RJ, Mackey JR, Gelmon K, Reid RD, Friedenreich CM, et al. Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: a multicenter randomized controlled trial. J Clin Onc 2007;25:4396–404.
3. Markes M, Brockow T, Resch KL: Exercise for women receiving adjuvant therapy for breast cancer. Cochrane Database Syst Rev 2006:CD005001.
4. McNeely ML, Campbell KL, Rowe BH, Klassen TP, Mackey JR, Courneya KS. Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. CMAJ 2006;175:34–41.
5. Schmitz KH, Holtzman J, Courneya KS, Masse LC, Duval S, Kane R. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. Cancer Epidemiol Biomarkers Prev 2005;14:1588–95.
6. Courneya KS, Segal RJ, McKenzie DC, Dong H, Gelmon K, Friedenreich CM, et al. Effects of exercise during adjuvant chemotherapy on breast cancer outcomes. Med Sci Sports Exerc 2014;46:1744–51.
7. Irwin ML, Smith AW, McTiernan A, Ballard-Barbash R, Cronin K, Gilliland FD, et al. Influence of pre- and postdiagnosis physical activity on mortality in breast cancer survivors: the health, eating, activity, and lifestyle study. J Clin Onc 2008;26:3958–64.
8. Courneya KS, Segal RJ, Gelmon K, Reid RD, Mackey JR, Friedenreich CM, et al. Six-month follow-up of patient-rated outcomes in a randomized controlled trial of exercise training during breast cancer chemotherapy. Cancer Epidemiol Biomarkers Prev 2007;16:2572–8.
9. Mishra SI, Scherer RW, Snyder C, Geigle PM, Berlanstein DR, Topaloglu O. Exercise interventions on health-related quality of life for people with cancer during active treatment. Cochrane Database Syst Rev 2012;8: CD008465.
10. Demark-Wahnefried W, Peterson B, McBride C, Lipkus I, Clipp E. Current health behaviors and readiness to pursue life-style changes among men

and women diagnosed with early stage prostate and breast carcinomas. Cancer 2000;88:674–84.
11. Jones LW, Courneya KS. Exercise counseling and programming preferences of cancer survivors. Cancer Pract 2002;10:208–15.
12. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. J Clin Onc 2005;23:5814–30.
13. Demark-Wahnefried W, Morey MC, Clipp EC, Pieper CF, Snyder DC, Sloane R, et al. Leading the Way in Exercise and Diet (Project LEAD): intervening to improve function among older breast and prostate cancer survivors. Control Clin Trials 2003;24:206–23.
14. Brawley LR, Culos-Reed SN, Angove J, Hoffman-Goetz L. Understanding the barriers to physical activity for cancer patients: review and recommendations. J Psychosoc Oncol 2002;20:1–21.
15. Demark-Wahnefried W, Clipp EC, McBride C, Lobach DF, Lipkus I, Peterson B, et al. Design of FRESH START: A randomized trial of exercise and diet among cancer survivors. Med Sci Sport Exerc 2003;35:415–24.
16. Vallance JK, Courneya KS, Plotnikoff RC, Yasui Y, Mackey JR. Randomized controlled trial of the effects of print materials and step pedometers on physical activity and quality of life in breast cancer survivors. J Clin Onc 2007;25:2352–9.
17. Vallance JK, Courneya KS, Taylor LM, Plotnikoff RC, Mackey JR. Development and evaluation of a theory-based physical activity guidebook for breast cancer survivors. Health Educ Behav 2008;35:174–89.
18. Ajzen I. The theory of planned behavior. Organ Behav Hum Dec 1991; 50:179–211.
19. Brady MJ, Cella DF, Mo F, Bonomi AE, Tulsky DS, Lloyd SR, et al. Reliability and validity of the functional assessment of cancer therapy-breast quality-of-life instrument. J Clin Onc 1997;15:974–86.
20. Tudor-Locke C, Burkett L, Reis JP, Ainsworth BE, Macera CA, Wilson DK. How many days of pedometer monitoring predict weekly physical activity in adults? Prev Med 2005;40:293–8.
21. Godin G, Jobin J, Bouillon J. Assessment of leisure time exercise behavior by self-report: a concurrent validity study. Can J Public Health 1986; 77:359–62.
22. Godin G, Shephard RJ: A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985, 10:141–6.
23. Jacobs DR, Jr, Ainsworth BE, Hartman TJ, Leon AS: A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sport Exerc 1993;25:81–91.
24. Marshall AL, Miller YD, Burton NW, Brown WJ. Measuring total and domain-specific sitting: a study of reliability and validity. Med Sci Sports Exerc 2010, 42:1094–102.
25. Vallance JK, Eurich D, Marshall AL, Lavallee CM, Johnson ST. Associations between sitting time and health-related quality of life among adult males. Mental Health Phys Act 2013;6:49–54.
26. Newell DJ. Intention-to-treat analysis: implications for quantitative and qualitative research. Int J Epidemiol 1992;21:837–41.
27. Demark-Wahnefried W, Clipp EC, Lipkus IM, Lobach D, Snyder DC, Sloane R, et al. Main outcomes of the FRESH START trial: a sequentially tailored, diet and exercise mailed print intervention among breast and prostate cancer survivors. J Clin Onc 2007;25:2709–18.
28. Hawkes AL, Chambers SK, Pakenham KI, Patrao TA, Baade PD, Lynch BM, et al. Effects of a telephone-delivered multiple health behavior change intervention (CanChange) on health and behavioral outcomes in survivors of colorectal cancer: a randomized controlled trial. J Clin Onc 2013;31: 2313–21.
29. Jones LW, Courneya KS, Fairey AS, Mackey JR. Effects of an oncologist's recommendation to exercise on self-reported exercise behavior in newly diagnosed breast cancer survivors: a single-blind, randomized controlled trial. Ann Behav Med 2004;28:105–13.
30. Goode AD, Lawler SP, Brakenridge CL, Reeves MM, Eakin EG. Telephone, print, and web-based interventions for physical activity, diet, and weight control among cancer survivors: A systematic review. J Cancer Surviv 2015;9:660–82.
31. Midtgaard J, Baadsgaard MT, Moller T, Rasmussen B, Quist M, Andersen C, et al. Self-reported physical activity behaviour; exercise motivation and information among Danish adult cancer patients undergoing chemotherapy. Eur J Onc Nur 2009;13:116–21.
32. Tao JJ, Visvanathan K, Wolff AC. Long term side effects of adjuvant chemotherapy in patients with early breast cancer. Breast 2015;24: S149–S153.
33. Courneya KS, McKenzie DC, Reid RD, Mackey JR, Gelmon K, Friedenreich CM, et al. Barriers to supervised exercise training in a randomized controlled trial of breast cancer patients receiving chemotherapy. Ann Behav Med 2008;35:116–22.
34. Irwin ML, Crumley D, McTiernan A, Bernstein L, Baumgartner R, Gilliland FD, et al. Physical activity levels before and after a diagnosis of breast carcinoma: the health, eating, activity, and lifestyle (HEAL) study. Cancer 2003;97:1746–57.
35. Vallance JK, Lavallee CM, Culos-Reed NS, Trudeau MG. Physical activity is associated with clinically important differences in health-related quality of life among rural and small-town breast cancer survivors. Supp Care Cancer 2012;20:1079–87.
36. Demark-Wahnefried W, Case LD, Blackwell K, Marcom PK, Kraus W, Aziz N, et al. Results of a diet/exercise feasibility trial to prevent adverse body composition change in breast cancer patients on adjuvant chemotherapy. Clin Breast Cancer 2008;8:70–9.
37. Djuric Z, Ellsworth JS, Weldon AL, Ren J, Richardson CR, Resnicow K, et al. A diet and exercise intervention during chemotherapy for breast cancer. Open Obese J 2011;3:87–97.
38. Ligibel JA, Partridge A, Giobbie-Hurder A, Campbell N, Shockro L, Salinardi T, et al. Physical and psychological outcomes among women in a telephone-based exercise intervention during adjuvant therapy for early stage breast cancer. J Women's Health 2010;19:1553–9.
39. Bourke L, Homer KE, Thaha MA, Steed L, Rosario DJ, Robb KA, et al. Interventions to improve exercise behaviour in sedentary people living with and beyond cancer: A systematic review. Br J Cancer 2014;10:831–41.
40. Hudis CA, Jones L. Promoting exercise after a cancer diagnosis: Easier said than done. Br J Cancer 2014;110:829–30.
41. Courneya KS, McKenzie DC, Mackey JR, Gelmon K, Friedenreich CM, Yasui Y, et al.: Effects of exercise dose and type during breast cancer chemotherapy: Multicenter randomized trial. J Natl Cancer Inst 2013; 105:1821–32.