Physical Activity and Health Outcomes Three Months After Completing a Physical Activity Behavior Change Intervention: Persistent and Delayed Effects

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Abstract

Purpose: **We previously reported the effectiveness of a 12-week physical activity behavior change intervention for breast cancer survivors postintervention with this report, aiming to determine delayed and/or persistent effects 3 months after intervention completion.**
Methods: **Forty-one sedentary women with stage I, II, or IIIA breast cancer currently receiving hormonal therapy were randomly assigned to receive the 12-week Better Exercise Adherence after Treatment for Cancer intervention or usual care. Assessments occurred at baseline, postintervention, and 3 months postintervention.**
Results: **Weekly minutes of greater than or equal to moderate intensity physical activity measured by accelerometer showed a significant group by time interaction (F = 3.51; P = 0.035; between group difference in the mean change from baseline to 3 months postintervention, 100.1 minute, P = 0.012). Significant group by time interactions also showed sustained improvements from baseline to 3 months postintervention in strength (F = 3.82; P = 0.027; between group difference, 11.2 kg; P = 0.026), waist-to-hip ratio (F = 3.36; P = 0.041; between group difference, −0.04; P = 0.094), and social well-being (F = 4.22; P = 0.023; between group difference, 3.9; P = 0.039). A delayed reduction in lower extremity dysfunction 3 months postintervention was noted (F = 3.24; P = 0.045; between group difference in the mean change from postintervention to 3 months follow-up; P = −7.6; P = 0.015). No group by time effect was noted for fitness, body mass index, percent fat, bone density, total quality of life (Functional Assessment of Cancer Therapy-General), fatigue, endocrine symptoms, cognitive function, or sleep.**
Conclusions: **The intervention resulted in sustained improvements in physical activity, strength, central adiposity, and social well-being with lower extremity function benefits appearing 3 months after intervention completion. Testing translation in a multisite study is warranted.** (Cancer Epidemiol Biomarkers Prev 2009;18(5):1410–8)

Introduction

Although physical activity after breast cancer diagnosis improves quality of life, reduces fatigue, and may prevent cancer recurrence and mortality, most breast cancer survivors remain insufficiently active (1-5). Behavior change interventions are needed to reduce physical inactivity and, fortunately, a cancer diagnosis may be a ''teachable moment'' when patients are more motivated and open to participation in such interventions (6). Multiple randomized trials of physical activity behavior change studies in cancer survivors have been reported with eight focusing on breast cancer, one focusing on prostate cancer, one focusing on endometrial cancer, and four focusing on mixed cancer types (7-20). It is encouraging that 10 of these studies have shown significant improvements in physical activity, and 2 of the 4 without activity increases reported improvements in exercise stage of change.

In spite of the initial success, several important questions related to optimal enhancement of exercise adherence after a breast cancer diagnosis warrant further investigation. For example, can interventions improve objectively measured physical activity as well as self-reported activity? Few studies have attempted to confirm activity increases with objective rather than self-report measures (11, 17-19), which is of paramount importance because self-reported activity can increase without a concomitant increase in objective activity after a physical activity behavior change intervention (11, 18). Furthermore, does the physical activity increase noted immediately postintervention persist after the intervention is completed? Although long-term adherence after intervention completion is of substantial importance, few behavior change studies in cancer survivors of any type have reported long-term adherence results (8, 9, 12,

Received 11/12/08; revised 1/12/09; accepted 3/2/09; published OnlineFirst 4/21/09.
Grant support: Southern Illinois University School of Medicine Excellence in Academic Medicine Award (#E200634), Brooks Medical Research Fund, Memorial Medical Center Foundation and Regional Cancer Center.
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doi:10.1158/1055-9965.EPI-08-1045

15, 21) with only two demonstrating a statistically significant improvement months after intervention completion (8, 9). It is also noteworthy that no prior randomized trial of a behavior change intervention in cancer survivors has used an objective measure of physical activity to assess long-term adherence. In addition to improving activity behavior, confirming that the activity increases after intervention completion is sufficient to induce persistent improvements in health outcomes remains uncertain. Of the four prior studies reporting longer term health outcomes [i.e., quality of life, depression, anxiety, pain, and body mass index (BMI)], only one has confirmed sustained improvements (i.e., fatigue; refs. 8, 12, 15, 21).

We have previously reported a significant improvement in objectively measured physical activity immediately after completion of a 3-month physical activity behavior change intervention [i.e., Better Exercise Adherence after Treatment for Cancer (BEAT Cancer intervention); ref. 11]. This improvement was concomitant with improved muscle strength, waist-to-hip ratio, and social well-being (11). In contrast, a significant increase in joint stiffness was reported by participants in our intervention study group immediately postintervention. Although our reporting of changes postintervention focused on determining effect sizes for future study design, we now report the BEAT Cancer physical activity behavior change intervention effects on longer term objectively measured physical activity and selected health outcomes in an effort to address the above mentioned knowledge gap. Therefore, the study aim of this report was to determine the effects of our physical activity behavior change intervention on objectively measured physical activity, motivational readiness for physical activity, fitness, muscle strength, body composition, quality of life, fatigue, endocrine symptoms, cognitive function, sleep quality, and joint symptoms 3 months after intervention completion.

Patients and Methods

Here, we report the results of a 2-armed, randomized controlled trial of a physical activity behavior change intervention, 3 mo after completion of the intervention. A detailed description of the study setting, participants, design, procedures, and intervention was provided with the report of the effect size changes in physical activity and health outcomes immediately postintervention (11). Study details are summarized in the following paragraphs.

Setting, Participants, and Design. Institutional review board approval was obtained, and all participants provided informed consent before initiation of study procedures. Community-wide and clinic-based recruitment identified eligible participants based on the following criteria: (*a*) female, age 18 to 70 y with history of stage I, II, or IIIA breast cancer; (*b*) English speaking; (*c*) currently taking an aromatase inhibitor or estrogen receptor modulator; and (*d*) medical clearance provided by physician. Although surgery within the past 8 wk was not an exclusion criteria, enrollment was postponed until the patient was at least 8 wk postsurgery. Individuals were not included if one or more of the following were reported as follows: dementia, inability to fully participate in all intervention activities (e.g., inability to ambulate, plans to relocate outside the study area during the study period, etc.), contraindication to regular physical activity participation, breast cancer recurrence or metastasis, or engaging in ≥150 min of moderate plus vigorous activity or ≥60 min of vigorous physical activity per week for the prior month.

The study pilot tested the changes in physical activity and health outcomes 3 mo after participants completed a physical activity behavior change intervention. These assessments were the final (or 3-mo follow-up) measures obtained for the previously reported 2-armed, randomized controlled trial comparing intervention versus usual care group (11). A structured interview format was used to screen potentially eligible participants (primarily by telephone) with follow-up appointments scheduled for consenting and detailed instructions for completion of study measures. Randomization was based on computer-generated numbers, stored in sealed, opaque envelopes, and done in the order in which participants completed baseline assessments.

Intervention and Usual Care Summary. The physical activity behavior change intervention has been previously described (11). In brief, this 12-wk program was based on exercise programming preferences and social cognitive theory correlates (e.g., self-efficacy, emotional coping, perceived barriers, outcome expectations, behavioral capability, environment, observational learning, and self-control) among breast cancer survivors (22-25). Participants completed 6 discussion group sessions with a clinical psychologist during the first 8 wk, 12 individual exercise sessions with an exercise specialist during the first 6 wk, and 3 individual counseling sessions with an exercise specialist during the final 6 wk of the intervention. The group sessions provided social support, speakers who were regularly active breast cancer survivors, and a personal behavioral modification plan to facilitate regular exercise participation. Group counseling related to overcoming exercise barriers (including barriers self-efficacy and time management), emotional coping (including stress management), exercise benefits and importance of such benefits, and physical activity enjoyment was also included. The 12 supervised exercise sessions focused on improving task self-efficacy by gradual advancement of the exercise prescription, self-monitoring with daily activity log, and overcoming exercise barriers experienced by the participant. The final three individual counseling sessions reinforced self-monitoring, use of the behavioral modification plan, and exercise benefits while assisting with overcoming barriers, providing positive reinforcement for those reaching their exercise goal, and updating the exercise prescription if indicated. The program objective was to gradually transition the participant to a home-based program with the goal of engaging in 150 min of moderate intensity activity (primarily walking) by the final weeks of the intervention. At the completion of the intervention, participants were told to continue the exercise prescription they had been following during the final weeks of the intervention.

At the time of randomization, the usual care group received written materials about physical activity available through the American Cancer Society. Usual care participants were not given any other specific instructions related to physical activity behavior at the time of randomization or at the immediate postintervention assessment. Neither the intervention nor the usual care group received staff or intervention contact during the 3 mo between the immediate postintervention testing and the 3-mo follow-up assessments reported here.

Assessment of Physical Activity and Health Outcomes. Physical activity was objectively measured with the GT1M accelerometer (Actigraph) worn for 7 consecutive days. Four valid days were required for the assessment to be considered adequate for use (26). For this report, the primary physical activity outcomes were total daily activity counts (i.e., based on both the frequency and intensity of activity) and weekly minutes of moderate plus vigorous physical activity. Activity counts were used to ascertain intensity levels (i.e., light, <1,952 counts/min; moderate, 1,952-5,724 counts/min; and vigorous, >5,724 counts/min; ref. 27). Activity minutes were analyzed per week for consistency with the intervention objective of 150 min per week, but activity counts were analyzed per day because of the magnitude of this number.

Although the intervention was based on the social cognitive theory, the stage of motivational readiness for physical activity (an aspect of the transtheoretical model) was assessed because behavior change interventions may improve stage of readiness without a significant improvement in physical activity levels (7, 12, 28, 29). Responses to a previously validated 5-item scale were classified into precontemplation, contemplation, preparation, action, or maintenance stage of readiness and coded as 1 through 5, respectively (30).

Fitness was assessed with a submaximal treadmill test using the Naughton protocol to estimate oxygen consumption at 85% of predicated maximal heart rate (31). Hand grip (Lafeyette model #78010) and back/leg extensor (Takei Back-A model #Tkk5002) dynamometers were used to assessed muscle strength (i.e., best of three attempts). Body composition was assessed three ways. BMI was derived from a scale and stadiometer [weight (kg)/height (m^2)]. A nonstretching tape measure was used to measure the waist and hip circumferences over undergarments with three measurements averaged before calculating the waist-to-hip ratio. Finally, percent body fat and bone mineral density were assessed by dual energy X-ray absorptiometry. Although the intervention was not a weight loss intervention, daily caloric intake was obtained to determine if any changes in body composition noted were related to changes in diet that may have occurred as a ''halo'' effect of the intervention. Diet intake was assessed with 3-d diet record (i.e., 1 weekend and 2 weekdays) and analyzed with Diet Analysis Plus software, version 7.0.1 (Thomson Corporation).

Quality of life was assessed with the 37-item Functional Assessment of Cancer Therapy (FACT)-Breast (32), which uses the sum of 5-point Likert scales to determine physical well-being, social well-being, emotional well-being, functional well-being, and additional concerns. All subscales except for additional concerns are summed for the FACT-General (FACT-G) with additional concerns added to FACT-G for the total FACT-Breast score. A higher FACT score (or subscale) reflects better quality of life. Symptom-specific FACT instruments were used for fatigue [i.e., 13-item FACT-fatigue (33)], endocrine symptoms [19-item FACT-endocrine symptoms (34)], and cognitive function [42-item FACT-cognitive (35)] with higher scores indicating more frequent symptoms.

Self-reported sleep dysfunction (i.e., higher score indicates higher dysfunction or poorer sleep quality) was assessed using the Pittsburgh Sleep Quality Index (36). The following sleep quality domains were assessed individually and with a summative score: habitual sleep efficiency, sleep latency, sleep duration, subjective sleep quality, use of sleeping medication, and daytime dysfunction. Because of the association between adjuvant endocrine therapy and arthralgias (37) and the intervention focus on increasing weight bearing exercise (i.e., walking), the 24-item Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC; ref. 38) was used to assess lower extremity joint pain, stiffness, and dysfunction (i.e., higher score indicates more frequent joint symptoms and dysfunction).

Demographic and Medical Characteristics, Intervention Adherence, and Adverse Events. The following demographic and medical variables were self-reported: age, race, education, income, cancer stage, treatment type, and months since treatment. Intervention adherence was monitored by the study staff as previously reported, and adverse events after intervention completion were self-reported at the time of the follow-up survey (11).

Statistical Analysis. To determine the differences between the intervention and usual care groups over the 6-mo study period (i.e., baseline, immediately postintervention, and 3 mo postintervention follow-up), mixed model ANOVA was done for each physical activity and health outcome of interest. Contrast coding analyses to assess differences that persisted or changed during the 3-mo follow-up period postintervention are reported for outcomes with a significant group by time interaction on mixed model ANOVA (i.e., $P < 0.05$). The contrast coding analysis focused on the differences from baseline to 3 mo postintervention and from immediately postintervention to 3 mo postintervention. An intent-to-treat analysis was done with all statistical procedures done using SAS Version 9.1 (SAS, Inc.).

No baseline data were missing. At the immediate postintervention follow-up, endocrine symptoms subscale, cognitive function interference subscale, and the cognitive function total score were missing on one participant due to incomplete survey responses. Also, one participant provided a dual energy X-ray absorptiometry but withdrew from the study before finishing the remainder of the measures. At the 3-mo postintervention follow-up, 1 dual energy X-ray absorptiometry was missing because the participant was not able to schedule a convenient time to have this done due to her work schedule.

Results

Patient Flow and Follow-up. Recruitment ran for 13 months beginning in April 2006. A figure outlining participant flow from baseline through immediate postintervention follow-up has been previously reported (11).

Table 1. The delayed effects of the BEAT Cancer physical activity behavior change intervention on physical activity, muscle strength, body composition, and daily caloric intake in breast cancer survivors on hormonal therapy

	Baseline	3 mo*	6 mo†	Group by time interaction‡	Baseline to 6 mo§		Baseline to 6 mo§		3-6 mo‖		3-6 mo‖	
	Mean	Mean	Mean	*P*	Mean change	*P*	Group difference	*P*	Mean change	*P*	Group difference	*P*
Physical activity counts (daily)												
Usual care	224,944	206,799	209,375		−15,569	0.50			2,576	0.89		
Intervention	194,968	248,628	241,050	0.01	46,082	0.04	61,651	0.06	−7,578	0.68	−10,154	0.70
≥Moderate minutes (weekly)												
Usual care	113.4	116.5	92.0		−21.4	0.45			−24.5	0.31		
Intervention	96.2	165.8	174.9	0.04	78.7	0.01	100.1	0.01	9.1	0.69	33.6	0.31
Stage of change												
Usual care	2.6	3.1	2.6		0.0	0.91			−0.5	0.12		
Intervention	2.4	3.9	4.2	<0.001	1.8	<0.001	1.8	<0.001	0.3	0.27	0.8	0.06
Fitness												
Usual care	25.4	27.5	26.3		0.9	0.49			−1.2	0.34		
Intervention	24.5	29.4	28.1	0.18	3.6	<0.01	2.7	0.12	−1.3	0.27	−0.1	0.94
Hand strength												
Usual care	25	23.1	24.7		−0.3	0.61			1.6	0.01		
Intervention	26.4	26.5	27.9	0.03	1.5	0.01	1.8	0.03	1.4	0.02	−0.2	0.84
Back/leg strength												
Usual care	68.5	64.5	69.2		0.7	0.85			4.7	0.19		
Intervention	72.9	80.9	84.8	0.03	11.9	<0.001	11.2	0.03	3.9	0.25	−0.8	0.87
Waist-to-hip ratio												
Usual care	0.81	0.83	0.83		0.02	0.36			0	0.89		
Intervention	0.85	0.82	0.83	0.04	−0.02	0.14	−0.04	0.09	0.01	0.52	0.01	0.73
Daily kilocalorie intake												
Usual care	1,891	1,667	1,593		−298	0.01			−74	0.50		
Intervention	1,870	1,586	1,638	0.70	−232	0.03	66	0.66	52	0.61	126	0.40

*Immediately postintervention.
†Three months postintervention.
‡Mixed model ANOVA.
§Baseline to 3 mo postintervention.
‖Immediately postintervention to 3 mo postintervention.

In brief, 41 participants (i.e., 34% of the 119 participants screened for eligibility) were enrolled and randomized with 93% (i.e., 38) completing the immediate post-intervention follow-up and 88% (i.e., 36) completing the full 6 months of the study. Among the 5 participants who withdrew, 3 were in the usual care group and withdrew due to unrelated illness (n = 1), distance (n = 1), and ill spouse (n = 1). Two withdrew from the intervention group due to unrelated medical problems (n = 1) and lost to follow-up (n = 1).

Baseline Characteristics. For each baseline characteristic, the percentage or mean ± SD is provided. Participant mean age was 53 ± 9 y with 93% being White. The mean years of education was 15 ± 2 y with 59% reporting annual household income of ≥$50,000, 19% reporting $35,000 to $50,000, 15% reporting $20,000 to $35,000, and 7% reporting <$20,000. A third (29%) had stage I disease, with 50% having stage II and 20% having stage III. All participants reported prior surgery related to their breast cancer diagnosis with mean months since surgery being 34 ± 34 months. For the 34 (83%) reporting a history of chemotherapy, the mean months since treatment was 33 ± 35 months. Similarly, 34 (83%) reported prior radiation therapy for breast cancer with a mean months since treatment of 33 ± 36 months. For hormonal therapy, 11 (27%) were on an estrogen receptor modulator and 30 (73%) were on an aromatase inhibitor with mean months on hormonal therapy of 18 ± 17 months. The majority (83%) were postmenopausal. The two study groups were balanced (i.e., no statistical difference between the two groups at baseline with regard to demographic, medical, physical activity, or health outcome variables including no difference at baseline with regard to percentage of participants on aromatase inhibitors versus estrogen receptor modulators; ref. 11). Comparison of the participants who withdrew with those completing the study could not be done due to the small number of withdrawals (n = 5).

Change in Physical Activity–Related Outcomes and Body Composition. For daily physical activity counts, a significant group by time interaction (F = 4.28; P = 0.013) was noted. Similarly, weekly minutes of moderate plus vigorous activity and stage of motivational readiness showed significant group by time interactions (F = 3.51; P = 0.035; and F = 7.85; P < 0.001, respectively). The analysis for fitness showed a lack of main effect for group (F = 0.29; P = 0.59) with a significant time effect (F = 8.63; P < 0.001) and a nonsignicant group by time interaction (F = 1.76; P = 0.18). For muscle strength, both left-hand grip and back/leg extensor strength showed a significant group by time interaction (F = 3.68; P = 0.030; and F = 3.82; P = 0.027).

For body composition, a significant group by time interaction was noted for waist-to-hip ratio (F = 3.36; P = 0.041) with no significant effects for group, time, or group by time interaction noted for BMI or percent fat.

Daily caloric intake showed a significant time effect (i.e., mean for baseline, 1,880.4; postintervention, 1,624.7; and 3 months postintervention, 1,624.6; F = 8.34; $P < 0.001$) with no significant effects of group (F = 0.03; $P = 0.87$) or group by time interaction (F = 0.35; $P = 0.70$). With regard to bone density, mean femoral neck bone density showed a significant time effect (i.e., mean for baseline, 0.934; postintervention, 0.926; and 3 months postintervention, 0.927; F = 5.42; $P = 0.007$) with no significant group effect (F = 0.32; $P = 0.57$) or group by time interaction (F = 0.54; $P = 0.59$). Although not significant, a similar pattern was noted for bone density of the lumbar spine (i.e., L2-L4; i.e., F = 2.94 and $P = 0.059$ for time, F = 0.678 and $P = 0.42$ for group, and F = 0.06 and $P = 0.94$ for group by time interaction).

The contrast coding analysis results for the significant physical activity, muscle strength, and body composition outcomes are provided in Table 1. Although the group by time interaction was not significant for fitness, contrast results are included because it objectively assessed whether activity increases were sufficient for improving cardiorespiratory fitness, which has been shown to mediate the benefits of activity in cancer survivors (39). Similarly, the group by time interaction was not significant for daily caloric intake, but contrasts are provided because of its relevance to the body composition changes. Graphical presentations of minutes of moderate plus vigorous activity, muscle strength, and waist-to-hip ratio are provided in Figs. 1, 2 and 3 to enhance interpretation of the pattern of change.

For quality of life, a significant group by time interaction was noted for social well-being (F = 4.22; $P = 0.023$). No significant group by time interactions were noted for overall quality of life (i.e., FACT-Breast and FACT-G) nor the remaining subscales. Physical well-being showed a significant time effect (F = 3.90; $P = 0.029$), and FACT-G showed a significant between group difference for mean change from baseline to 3 months postintervention (i.e., +3.6 for intervention versus −4 for usual care; $P = 0.045$). No significant group, time, or group by time interaction was noted for fatigue, endocrine symptoms, or cognitive function (total or subscales). No significant group, time, or group by time interaction was noted for sleep (total or subscales) with the exception of a significant group effect for sleep latency (F = 4.17; $P = 0.048$).

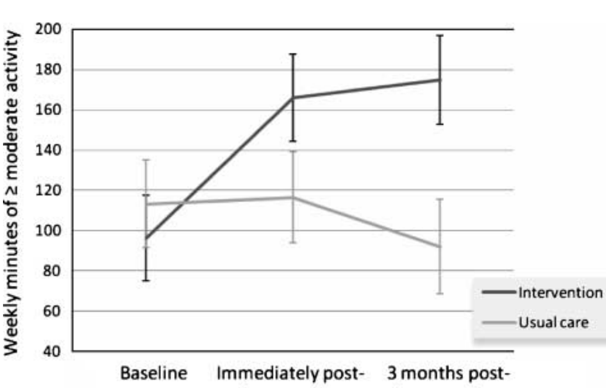

Figure 1. The effects of the BEAT Cancer physical activity behavior change intervention on weekly minutes of moderate plus vigorous physical activity immediately postintervention and 3 mo postintervention (least square means ± SE). Physical activity assessed with accelerometer.

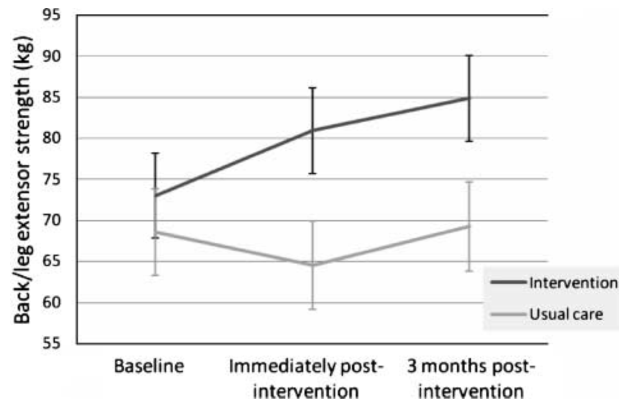

Figure 2. The effects of the BEAT Cancer physical activity behavior change intervention on back/leg extensor muscle strength immediately postintervention and 3 months postintervention (least square means ± SE).

With regard to lower extremity symptoms, a significant group by time interaction was noted for lower extremity joint dysfunction (F = 3.24; $P = 0.045$) but not for joint pain (F = 1.82; $P = 0.17$), stiffness (F = 2.48; $P = 0.091$), or overall WOMAC score (F = 3.06; $P = 0.053$). A significant time effect was seen for joint pain (F = 3.46; $P = 0.037$).

The contrast coding analysis results for the quality of life and joint symptom outcomes are provided in Tables 2 and 3. Although the group by time interaction was only significant for one of the FACT quality of life subscales (i.e., social well-being), contrasts for total and subscales scores are provided for completeness. A similar approach was used for presentation of the WOMAC results. A graphical presentation of the lower extremity joint dysfunction is provided in Fig. 4 to enhance interpretation of the pattern of change.

Discussion

The BEAT Cancer physical activity behavior change intervention showed persistent improvements in physical activity behavior, muscle strength, and waist-to-hip ratio 3 months after intervention completion. In contrast, the intervention did not affect bone mineral density, percent body fat, or BMI. With regard to quality of life, the intervention showed a persistent benefit for social well-being, primarily by slowing a decline noted in the control group 3 months after intervention completion. Although not statistically significant, a similar pattern was noted for other aspects of quality of life with overall quality of life demonstrating a significant between group difference for the mean change from baseline to 3 months postintervention. Importantly, the intervention significantly improved lower extremity joint dysfunction when compared with the control group 3 months postintervention.

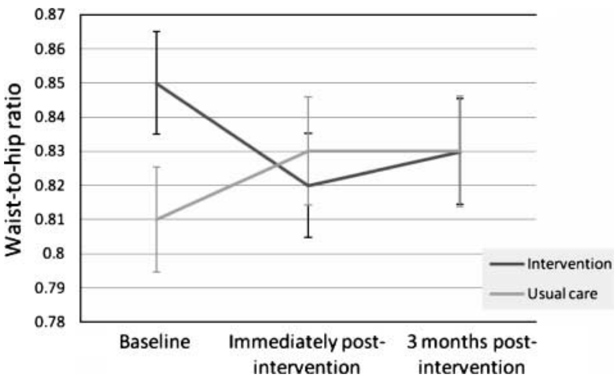

Figure 3. The effects of the BEAT Cancer physical activity behavior change intervention on waist-to-hip ratio immediately postintervention and 3 mo postintervention (least square means ± SE).

It is noteworthy that our study showed a persistent, statistically significant improvement in objective physical activity. Few randomized trials in cancer survivors have shown statistically significant improvements in activity months after completing a behavior change intervention (8, 9), and no prior study has shown sustained benefit based on objective monitoring. Although the primary advantage of objectively measuring physical activity is the minimization of overreporting activity levels, we acknowledge that accelerometers do not record activities such as bicycling or swimming and do not differentiate between occupational and leisure activity. Nevertheless, we have previously reported that participants rarely engaged in exercise types other than walking and self-reported leisure activity immediately postintervention increased, suggesting that improvements in objective activity may have been due, at least in part, to increases in leisure activity (11). With regard to the magnitude of our intervention effect months after completion, direct comparison to other studies is difficult because only two studies report longer term adherence as the change in minutes of activity (8, 21). Specifically, mean change for the intervention versus control group in self-report weekly minutes has been noted to be 60 to 94 minutes (8, 21). Because participants may over report their physical activity change when compared with accelerometer data by nearly 75% (i.e., a change score of 16.6 minutes per day by self-report versus 9.6 by accelerometer; ref. 11), our between group difference of 100.1 minutes per week by objective assessment is particularly noteworthy.

We theorize that the magnitude and objective confirmation of physical activity maintenance 3 months after intervention participation is due to a theory-based intervention based on careful attention to prior needs assessments (i.e., correlates and preferences) in the target population. Although programs consistent with participant preferences may be more successful (40), our use of multiple approaches (group and individual) with tapering format is theorized to have contributed to our success. As mentioned, no prior study has shown

Table 2. The delayed effects of the BEAT Cancer physical activity behavior change intervention on quality of life in breast cancer survivors on hormonal therapy

	Baseline	3 mo*	6 mo†	Group by time interaction‡	Baseline to 6 mo§		Baseline to 6 mo§		3-6 mo‖		3-6 mo‖	
	Mean	Mean	Mean	*P*	Mean change	*P*	Group difference	*P*	Mean change	*P*	Group difference	*P*
Physical well-being												
Usual care	22.6	25.3	23.5		0.9	0.44			−1.8	0.08		
Intervention	21.1	23.3	23.2	0.46	2.1	0.07	1.2	0.48	−0.1	0.87	1.7	0.24
Social well-being												
Usual care	23.3	22.1	19.3		−4	<0.01			−2.8	0.04		
Intervention	21.6	22.5	21.5	0.02	−0.1	0.92	3.9	0.04	−1	0.42	1.8	0.32
Emotional well-being												
Usual care	21	21	20.6		−0.4	0.51			−0.4	0.53		
Intervention	19.3	20.1	19.7	0.48	0.4	0.43	0.8	0.30	−0.4	0.51	0	0.99
Functional well-being												
Usual care	22.8	24.1	22.5		−0.3	0.73			−1.6	0.08		
Intervention	20.7	21.2	21.8	0.19	1.1	0.17	1.4	0.23	0.6	0.43	2.2	0.07
Additional concerns												
Usual care	25.8	26.2	25.1		−0.7	0.58			−1.1	0.34		
Intervention	26.2	27.1	26.9	0.68	0.7	0.51	1.4	0.39	−0.2	0.84	0.9	0.58
FACT-General¶												
Usual care	89.8	92.4	85.8		−4	0.14			−6.6	0.02		
Intervention	82.6	87.2	86.2	0.12	3.6	0.16	7.6	0.05	−1	0.70	5.6	0.14
FACT-Breast¶												
Usual care	115.5	118.7	111.3		−4.2	0.18			−7.4	0.05		
Intervention	108.8	114.3	113.1	0.15	4.3	0.15	8.5	0.05	−1.2	0.74	6.2	0.22

*Immediately postintervention.
†Three months postintervention.
‡Mixed model ANOVA.
§Baseline to 3 mo postintervention.
‖Immediately postintervention to 3 mo postintervention.
¶FACT, Functional Assessment of Cancer Therapy.

Table 3. The delayed effects of the BEAT Cancer physical activity behavior change intervention on lower extremity joint pain, stiffness, and dysfunction in breast cancer survivors on hormonal therapy

	Baseline	3 mo*	6 mo†	Group by time interaction‡	Baseline to 6 mo§		Baseline to 6 mo§		3-6 mo‖		3-6 mo‖	
	Mean	Mean	Mean	*P*	Mean change	*P*	Group difference	*P*	Mean change	*P*	Group difference	*P*
Joint pain												
Usual care	2.3	2.4	4.1		1.8	0.02			1.7	0.02		
Intervention	2.1	3.0	2.9	0.17	0.8	0.25	−1.0	0.32	−0.1	0.81	−1.8	0.06
Joint stiffness												
Usual care	2.4	1.7	2.2		−0.2	0.55			0.5	0.22		
Intervention	2.0	2.4	2.2	0.09	0.2	0.56	0.4	0.40	−0.2	0.55	−0.7	0.19
Joint physical dysfunction												
Usual care	7.5	6.4	13.1		5.6	0.01			6.7	<0.01		
Intervention	6.3	7.6	6.7	0.05	0.4	0.85	−5.2	0.09	−0.9	0.67	−7.6	0.02
Total WOMAC¶												
Usual care	12.3	10.6	19.4		7.1	0.02			8.8	<0.01		
Intervention	10.4	13.1	11.8	0.05	1.4	0.61	−5.7	0.16	−1.3	0.65	−10.0	0.02

*Immediately postintervention.
† Three months postintervention.
‡ Mixed model ANOVA.
§ Baseline to 3 mo postintervention.
‖ Immediately postintervention to 3 mo postintervention.
¶Higher score reflects greater lower extremity symptoms.

maintenance of physical activity by objective monitoring in cancer survivors but the studies demonstrating self-reported activity maintenance have used group counseling (9) or print materials with pedometer and log sheet administered by a single individual counseling session followed by telephone counseling (8). No prior exercise behavior change study in cancer survivors has examined an intervention that incorporates a tapering format from supervised exercise sessions to home-based with both group and individual counseling. We hypothesize that our diverse approach provided one or more formats that were consistent with each participant's preference. Also, our tapering approach provided an environment of support and accountability that was more intense during the beginning of the program when participants may need assistance in overcoming ''behavior change inertia'' with continued but less intense support as their self-efficacy and personal experience of exercise benefits increased. Nevertheless, future study is needed to determine the social cognitive theory factors that mediate physical activity adoption and maintenance in response to our intervention, the intervention components most strongly influencing these factors, and the potential moderating effect of preference on intervention effects.

The significant improvement in muscle strength without a significant group by time effect for fitness is worthy of discussion. The pattern of fitness change is consistent with intervention benefit and fitness significantly increased among the intervention participants from baseline to 3 months postintervention ($P < 0.01$; i.e., see Table 1). Moreover, power calculations indicate that a sample size of 54 and 61 would be required to achieve statistical significance for the observed effect size change from baseline to immediately postintervention and from baseline to 3 months postintervention (i.e., .55 and .51, respectively). Therefore, inadequate sample size is a likely explanation for the lack of significant group by time interaction for fitness. With regard to muscle strength, the intervention did not include a resistance training component, but the improvement in back/leg muscle strength is consistent with increased lower body strength that may occur with a walking program. The improvement in hand grip strength is more difficult to explain because a ''learning effect'' causing improvement with practice in performing the assessment would be expected to be similar for both study groups. It is possible that as individuals became more active, they also became more functional resulting in performance of more tasks, including those using the hands. Although not significant, the direction of the between group differences for physical and functional well-being support this possibility.

The lack of intervention effect on BMI or percent body fat is similar to that noted in other physical activity behavior change studies with only one prior study in cancer survivors demonstrating a significant decline in BMI (14) and only one demonstrating improvements

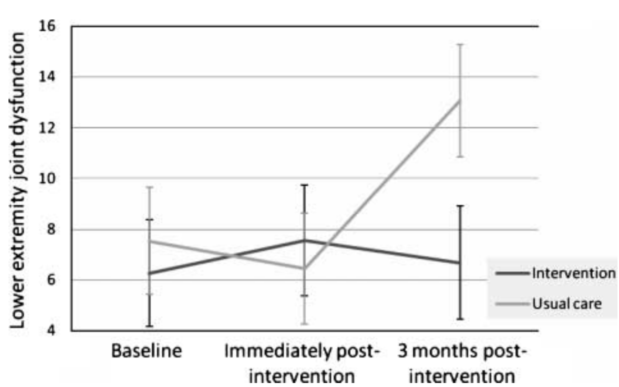

Figure 4. The effects of the BEAT Cancer physical activity behavior change intervention on lower extremity joint dysfunction immediately postintervention and 3 mo postintervention (least square means ± SE).

in percent body fat (13). Our lack of intervention effect on BMI is possibly because our intervention did not focus on weight loss contributing to a similar decline in caloric intake in both study groups. The reduction in waist-to-hip ratio is consistent with the reduction in waist circumference previously reported by Demark-Wahnefried et al. (13) and is an extremely important finding because of the association between waist-to-hip ratio and breast cancer mortality (41). Moreover, the fact that waist-to-hip ratio decreased without a concomitant change in body composition is consistent with the reduced central adiposity associated with exercise (42). This effect may occur through hormonal and inflammatory pathways. For example, exercise may reduce cortisol levels that are higher among women with greater abdominal body fat distribution (43, 44). In addition, reductions in inflammatory markers such as C-reactive protein may play a role (42). Although the pattern of change in waist-to-hip ratio is consistent with regression to the mean, the beneficial changes in other outcomes (e.g., physical activity) suggest that the improvement in waist-hip-ratio is likely related to intervention participation and warrants confirmation in future studies. Also related to body composition, our intervention resulted in substantial improvements in activity 3 months postintervention, but future interventions aimed to increase (or prevent the decline of) bone density may require higher impact exercise with the addition of resistance training and longer follow-up (45, 46).

The lack of significant group by time interaction for quality of life with the exception of social well-being may be related to inadequate study power. Of note, those aspects expected to improve with exercise (i.e., physical well-being, functional well-being, and overall quality of life) were noted to have between group differences in the correct direction with overall quality of life (FACT-G), demonstrating a significant between group difference between baseline and 3 months postintervention. Lack of adequate sample size as an explanation is further supported by the fact that the between group differences for the FACT-Breast (i.e., 8.5) and FACT-G (i.e., 7.6) exceed the minimally important differences of 7 to 8 and 5 to 6, respectively (47). Moreover, the pattern of change indicates that a physical activity behavior change intervention may prove useful in preventing decline months after intervention completion. This suggests the need for additional studies assessing the long-term effect of such interventions on quality of life, using a control group to assess the amount of decline that is prevented.

Uniquely, our study is the first, to date, to report the effect of a physical activity behavior change intervention on joint symptoms in breast cancer survivors who are at increased risk for arthralgias related to hormonal therapy (37). Because this risk is higher among patients receiving aromatase inhibitors compared with estrogen receptor modulators (37), it is noteworthy that our study groups did not differ with regard to percent receiving aromatase inhibitors (11). Also, no participant reported a change in hormonal therapy from immediately postintervention to 3 months postintervention with little change in the numbers of participants receiving each type of therapy immediately postintervention (i.e., the control group had 1 less participant on an aromatase inhibitor and 1 additional participant on estrogen receptor modulator with the intervention group having 1 additional participant on an aromatase inhibitor and 2 fewer participants on estrogen receptor modulators). The improvement in joint function 3 months after intervention completion is particularly encouraging because of the transient increase in joint stiffness noted in our original report of the baseline to immediate postintervention changes (11). Fortunately, this stiffness did not persist and was replaced with evidence that the intervention can prevent a decrease in lower extremity joint dysfunction and possibly prevent an increase in joint pain. The initial worsening may have been related to the stiffness that often occurs when an individual begins an exercise program but then resolves as tolerance increases.

The improvement in joint symptoms is of clinical importance because of the current lack of effective therapies for arthralgias related to hormonal therapy (37). There are several theorized reasons for our results. First, exercise is a proven nonpharmacologic therapy for osteoarthritis, which may have been more prevalent in our sample due to age and postmenopausal status. Also, arthralgias related to hormonal therapy may be partially due to bone loss and/or increased sensitivity to pain due to changes in nociceptive input mediated by inflammatory changes occurring with estrogen depletion (37, 48). Exercise may reduce inflammatory mediators counteracting the proinflammatory state that occurs with estrogen depletion. We acknowledge that a ''gold standard'' for assessment of hormonal therapy–related arthralgias does not exist (37, 49) and that our measure (i.e., WOMAC) may have been more sensitive for changes in osteoarthritis symptoms rather than arthralgias related to treatment. Nevertheless, additional research is needed to confirm our findings and identify underlying mechanisms. If better assessment tools can be identified, such measures should be used.

Our randomized controlled study design with examination of long-term effects of an effective behavior change intervention with an objective physical activity measure and multiple important health outcomes enhances the strength of our report. However, our sample size restricted study power for detecting differences in quality of life and fitness outcomes and the racial/ethnic uniformity of our participants may limit the applicability of our results to other racial/ethnic groups. Nevertheless, we have shown that a physical activity behavior change intervention in breast cancer survivors can result in persistent improvements in physical activity sufficient for improved waist-to-hip ratio, quality of life, and lower extremity joint function 3 months after intervention completion. Research is needed to test translation into other settings, further enhance intervention effectiveness, and confirm benefits with larger sample sizes and longer follow-up.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Acknowledgments

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