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Reduced Barriers Mediated Physical Activity Maintenance Among Breast Cancer Survivors

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Abstract

To better understand mechanisms of physical activity (PA) behavior change in breast cancer survivors, we examined mediation of a successful PA behavior change intervention by social cognitive theory (SCT) constructs. Our exploratory study randomized 41 breast cancer survivors to receive the 3-month intervention (INT) or usual care (UC). We used the Freedman and Schatzkin approach to examine mediation of intervention effect on PA 3 months postintervention by changes in SCT constructs from baseline to immediately postintervention. Compared with UC, the INT group reported lower barriers interference (mean difference = -7.8 , 95% CI [-15.1 , -0.4], $d = -0.67$, $p = .04$) and greater PA enjoyment (mean difference = 0.7 , 95% CI [0 , 1.5], $d = 0.61$, $p = .06$). Barriers interference mediated 39% ($p = .004$) of the intervention effect on PA 3 months postintervention. PA enjoyment was not a significant mediator. Reducing barriers to PA partially explained our intervention effect.

Keywords

oncology; exercise; social cognitive theory; predictor; breast cancer; survivorship

Enhancing physical activity among breast cancer survivors may improve quality of life and reduce breast cancer recurrence and mortality (Holmes, Chen, Feskanich, Kroenke, & Colditz, 2005; McNeely et al., 2006). Although a cancer diagnosis may prompt healthier lifestyles (Demark-Wahnefried, Aziz, Rowland, & Pinto, 2005), most breast cancer survivors remain insufficiently physically active (Pinto, Trunzo, Reiss, & Shiu, 2002). Several physical activity behavior change interventions for breast cancer survivors have demonstrated promising results but few have reported sustained, objective increases in physical activity (Pinto et al., 2008; Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009; von Gruenigen et al., 2008). Determining mechanisms of sustained physical activity behavior change will assist in designing more effective theory-based interventions after a breast cancer diagnosis.

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The social cognitive theory (SCT) (Bandura, 1977) is a frequently used framework for physical activity interventions and its constructs warrant examination as potential mediators of such interventions (Conn, Minor, Burks, Rantz, & Pomeroy, 2003; Pinto & Floyd, 2008). With regard to cancer populations specifically, cross-sectional studies support SCT constructs as predictors of physical activity behavior (Pinto, Maruyama, et al., 2002; Rogers, McAuley, Courneya, & Verhulst, 2008; Rogers et al., 2005). However, identifying these constructs as “active ingredients” in interventions has not been reported (Pinto & Floyd, 2008) because physical activity interventions improving SCT constructs (e.g., self-efficacy and social support) did not achieve statistical significance with regard to improvements in physical activity (Carmack Taylor et al., 2006; Demark-Wahnefried et al., 2006). The lack of significance may have been due to failure to reach accrual goal limiting study power (Demark-Wahnefried et al., 2006) or the nature of the interventions tested. Specifically, cognitive-behavioral skills training (Carmack Taylor et al., 2006) or telephone counseling with print materials (Demark-Wahnefried, et al., 2006) were used, with neither intervention including supervised exercise sessions. In addition, the intervention significantly increasing social support (or “helping relationships”) did not significantly improve self-efficacy, suggesting that an increase in social support alone may not be sufficient for increasing physical activity (Carmack Taylor et al., 2006). Moreover, interventions that include supervised exercise sessions, which facilitate greater attention to sources of self-efficacy such as mastery experiences and appropriately interpreting physiologic response as nonthreatening (Bandura, 1986), may be required for increases in self-efficacy sufficient to mediate behavior change. Also relevant, several important SCT constructs (e.g., perceived barriers) have not been tested in any randomized trial in cancer survivors. The only two randomized trials in cancer survivors with adequate change in both mediators and physical activity behavior tested mediation by constructs of the theory of planned behavior (TPB) (Ajzen, 1991) rather than the SCT (Jones, Courneya, Fairey, & Mackey, 2005; Vallance, Courneya, Plotnikoff, & Mackey, 2008). Therefore, further study is warranted to determine the usefulness of the SCT in cancer survivors given that adequate randomized trials testing the potential predictors consistently identified in cross-sectional studies has not occurred.

Although overlap exists among the main sociocognitive determinants of the SCT and the TPB (Bandura, 2004), the SCT is based on a dynamic and reciprocal interaction of behavior, personal factors, and environmental influences (Glanz, Lewis, & Rimer, 1997; McKenzie & Smeltzer, 1997) which is in contrast to the unidirectional nature of the TPB (McKenzie & Smeltzer, 1997). In addition, SCT constructs have been reported to be better predictors of physical activity than that of the TPB (Dzewaltowski, 1989; Dzewaltowski, Noble, & Shaw, 1990). In addition to behavior prediction, pragmatic application of theoretical constructs is needed to improve effectiveness of interventions (Glanz et al., 1997). Therefore, it is noteworthy that Bandura (2004) has stated that theories other than the SCT are more concerned with behavior prediction than with providing principles that can be used to assist individuals in making healthy behavior change. Therefore, examination of the role of SCT constructs in physical activity behavior change in cancer survivors is warranted. A focus on breast cancer survivors specifically is necessary given the differences in predictors and mechanisms of physical activity behavior for cancer versus noncancer populations (Blanchard, Courneya, Rodgers, & Murnaghan, 2002; Courneya & Friedenreich, 1999; Leddy, 1997; Rhodes & Courneya, 2003) and among different cancer types (Blanchard, Courneya, et al., 2002; Courneya, Blanchard, & Laing, 2001; Courneya & Friedenreich, 1997, 1999; Rogers, Courneya, Robbins, et al., 2008). Importantly, we have reported significant, sustained improvements in accelerometer measured exercise behavior among breast cancer survivors participating in our BEAT Cancer physical activity behavior change intervention (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009), allowing mediation testing.

With regard to potential mediators of behavior change, the SCT was the foundation for our BEAT Cancer intervention and multiple constructs within this theory were assessed based on needs assessments examining physical activity correlates and program preferences among breast cancer survivors (Rogers, Courneya, Shah, Dunnington, & Hopkins-Price, 2007; Rogers, Courneya, Verhulst, Markwell, & McAuley, 2008; Rogers, Markwell, Courneya, McAuley, & Verhulst, 2009; Rogers et al., 2004, 2005; Rogers, McAuley, et al., 2008). Specifically, self-efficacy is an individual's confidence in their ability to perform a specified behavior (Bandura, 1977) with barriers self-efficacy reflecting an individual's confidence in overcoming exercise barriers and task self-efficacy reflecting confidence in ability to perform the constituent components of the task (Bandura, 1977; Maddux, 1995). For example, an individual may not feel confident that they can be physically active due to lack of time (i.e., barriers self-efficacy) or a physical condition such as arthritis (i.e., task self-efficacy). We assessed both barriers and task self-efficacy because task self-efficacy may be a stronger predictor of physical activity in cancer and chronic disease populations (Blanchard, Rodgers, Courneya, Daub, & Black, 2002; Rogers, Courneya, Robbins, et al., 2008; Rogers, McAuley, Courneya, Humphries, & Gutin, 2007; Rogers et al., 2005). Because self-efficacy is not the only construct in the SCT model (Glanz, et al., 1997), the following SCT constructs were also included based on cross-sectional studies in breast cancer survivors suggesting these constructs may be predictive of physical activity behavior: (a) perceived magnitude of interference with regular exercise by barriers (i.e., perceived barriers interference), (b) social support for exercise, (c) role models, (d) exercise partner, (e) outcome expectations (i.e., the expected benefits or harms resulting from exercise) and values (i.e., the importance of achieving the expected benefits or avoiding the harms resulting from exercise), (f) physical activity enjoyment, and (g) fear of physical activity (Rogers, McAuley, et al., 2008; Rogers et al., 2005). Focusing on multiple constructs is a useful approach when designing health behavior interventions (Glanz et al., 1997).

A temporal relationship between mediator change and physical activity behavior occurring in longitudinal rather than cross-sectional studies more accurately identifies mediators of behavior change (Weinstein, 2007). Moreover, identifying mediators of physical activity maintenance is important for designing the much-needed interventions that successfully help cancer survivors adopt sustainable lifestyle change. Therefore, the primary aim for our pilot, exploratory study was to determine the effect of the 3-month BEAT Cancer intervention on the following SCT constructs immediately postintervention (i.e., 3 months): (a) self-efficacy, (b) perceived interference by barriers, (c) social support, (d) enjoyment, (e) fear, (f) outcome expectations, (g) outcome values, and (h) role models. We hypothesized that all constructs would improve with intervention participation. Our secondary aim was to determine if the change in SCT constructs during the intervention mediated the effect of our intervention on physical activity 3 months after intervention completion (i.e., 6 months after baseline). Due to limited data examining SCT mediators of physical activity behavior in cancer survivors, our hypotheses were based on the constructs addressed by our intervention and the importance of self-efficacy in the SCT (Bandura, 1977). Although all constructs had mediation potential, we hypothesized that the strongest mediators would include (a) barrier interference because of its emphasis in the intervention and (b) self-efficacy because of its key role in the SCT.

Methods

Design and Procedures

Study methods have been described in detail in separate publications (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009; Rogers, Hopkins-Price, Vicari, Pamentier, et al., 2009). In brief, a two-armed randomized controlled trial enrolled breast cancer survivors identified by newspaper advertisements, physician referrals, and flyers placed in physician offices and

beauty salons. Participants were required to be English-speaking females between the ages of 18 and 70 with history of Stage I, II, or IIIA breast cancer currently being treated with an aromatase inhibitor or estrogen receptor modulator. Physician medical clearance for exercise participation was required. Enrollment was postponed until the patient was at least 8 weeks postsurgery. Breast cancer survivors with (a) dementia, (b) inability to fully participate in all intervention activities (an inability to ambulate, plans to relocate outside the study area during the study period, etc.), (c) contraindication to regular physical activity participation, (d) breast cancer recurrence or metastasis, or (e) engaging in ≥ 150 min of moderate plus vigorous activity or ≥ 60 min of vigorous physical activity per week for the prior month were excluded.

The study took place in a small urban Midwest setting in the United States, was approved by the local institutional review board, and was performed in accordance with the 1964 Declaration of Helsinki ethical standards. All participants signed an informed consent before completing any study procedures. After completing baseline assessments, participants were randomized to receive the 3-month intervention ($n = 21$) or usual care ($n = 20$). In addition to baseline, assessments were done immediately postintervention (i.e., 3 months from baseline) and 3 months postintervention (i.e., 6 months from baseline). Randomization occurred in blocks of four using computer-generated numbers provided by the project statistician. Allocation sequence was kept in numbered, sealed, opaque envelopes that were opened by the study coordinator in the order in which participants completed baseline testing. Due to the nature of the exercise intervention, blinding of study staff to group allocation was not possible.

Physical Activity Behavior Change Intervention (BEAT Cancer Intervention)

The physical activity behavior change intervention was based on the SCT and prior needs assessments (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009; Rogers, Hopkins-Price, Vicari, Pamenter, et al., 2009). Intervention content and relationship to the SCT have been described in detail in separate publications (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009; Rogers, Hopkins-Price, Vicari, Pamenter, et al., 2009; Rogers, Vicari, & Courneya, 2010). In brief, the intervention included 12 individual supervised exercise sessions, 6 discussion group sessions, and 3 individual face-to-face counseling sessions administered over a 3-month period. The majority of the contact time occurred in the first weeks of the intervention with gradual tapering to a home-based program. The intervention aimed to gradually increase participants to 150 min of moderate intensity exercise (primarily walking) by the final 4 weeks of the intervention. Activities during the individual exercise sessions included walking on a treadmill and stretching exercises. Walking time and intensity was based on an exercise prescription derived from the baseline fitness test and regularly reviewed and updated by the study exercise physiologist.

Barriers self-efficacy and barriers interference were emphasized in both the group and individual sessions by assisting participants in planning for and dealing with exercise barriers. Social support, outcomes expectations and values, enjoyment, role models, and exercise partners were primarily addressed in the group sessions. For example, group participants provided social support with the group curriculum also encouraging participants to find friend and family support for exercise outside of the group membership. The benefits of a partner for continuing to exercise during the home-based portion of the intervention were discussed in the group with members having the choice to exercise alone, with someone within the group, or with someone outside the group membership. Discussing physical activity benefits and assisting participants in identifying the benefits most important to them dealt with outcome expectations. To enhance enjoyment, participants were (a) encouraged to choose an activity they enjoyed once they completed the supervised portion of the intervention and (b) taught to use cognitive reframing (e.g., thinking positive,

beneficial thoughts rather than negative, unhelpful thoughts). A breast cancer survivor who exercised regularly acted as a role model speaker at one of the group sessions. The individual exercise sessions with the exercise specialists were used to improve the participants confidence in their physical ability (i.e., task self-efficacy) to increase their physical activity to the recommended amount without injury (i.e., fear of exercise).

Usual Care Group

Participants randomized to the usual care group were given American Cancer Society printed pamphlets and downloaded Web site information (cancer.org) related to physical activity after a cancer diagnosis. The study staff did not provide the participants with any specific recommendations related to physical activity. However, the usual care group was offered free participation in the intervention at the end of the study as an incentive for physician referral and patient participation.

Measures

As described previously (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009; Rogers, Hopkins-Price, Vicari, Pamerter, et al., 2009), physical activity was objectively assessed using 7-day accelerometer monitoring (GT1M Actigraph) at baseline, immediately postintervention, and at 3 months postintervention with daily minutes of activity greater than or equal to moderate intensity. Participants were asked to wear the accelerometer at the waist during waking hours. The accelerometer was removed during sleep. A minimum of four valid days of monitoring were required. The cutpoints were 1,952–5,724 counts/minute for moderate activity and > 5,724 counts/minutes for vigorous activity (Freedson, Melanson, & Sirard, 1998).

A 9-item scale specifically designed for breast cancer survivors assessed barriers self-efficacy (Cronbach's $\alpha = .96$, test-retest reliability = .89) (Rogers et al., 2006). The scale utilizes frequently reported barriers among breast cancer patients (e.g., "How confident are you that you can exercise when you are tired?"). A 4-item scale assessed task self-efficacy (Cronbach's $\alpha = .89$, test-retest reliability = .83) (Rogers et al., 2006). The scale asks participants to rate their confidence in ability to (a) walk 20 min without stopping, (b) run for 10 min without stopping, (c) climb three flights of stairs without stopping, and (d) exercise for 20 min at a level hard enough to cause a large increase in heart rate and breathing. Confidence (i.e., self-efficacy) for both scales was rated on a Likert scale from 0% to 100% (0% = not at all confident to 100% = extremely confident) with the mean score used for the analyses.

For barrier interference, participants rated on a 5-point Likert scale (1 = *never* to 5 = *very often*) how often 21 different barriers interfered with exercise with responses summed for a barrier interference score (Cronbach's $\alpha = .92$) (Rogers, McAuley, et al., 2008). Frequently reported barriers among breast cancer survivors were included (Leddy, 1997; Rogers, Courneya, et al., 2007; Rogers et al., 2004). For social support, participants reported the frequency with which friends (2 items) or family (2 items) offered to exercise with the participant or encouraged the participant to exercise (Sallis, Grossman, Pinski, Patterson, & Nader, 1987; Sallis et al., 1989). Items were summed for friends, family, and total social support scores with higher scores indicating greater social support. Internal consistencies (i.e., Cronbach's α s) were .58 for family, .74 for friend, and .73 for total social support.

For outcome expectations, participants indicated agreement using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*) with the statement that exercise would result in 14 positive outcomes (e.g., feel less depressed) and 3 negative outcomes (e.g., increased joint pain). A higher score indicated a greater expectation that exercise would result in positive

outcomes (i.e., positive outcome expectations) or negative outcomes (i.e., negative outcome expectations). For the outcome value, participants used a 5-point Likert scale (1 = *not important at all* to 5 = *extremely important*) to report the importance of achieving the specific benefit or avoiding the risk. A higher score indicated that the participant felt it was more important to achieve the expected exercise benefits (i.e., positive outcome values) or more important to avoid the expected exercise risks (i.e., negative outcome values). Responses were summed for the positive outcome expectations (Cronbach's alpha = .75), positive outcome values (Cronbach's alpha = .87), negative outcome expectations (Cronbach's alpha = .40), and negative outcome values (Cronbach's alpha = .81). The multiplicative functions for each expectation and its value have been reported in prior studies to be inferior to examining associations for expectations/values separately (Rogers et al., 2005).

Fear of exercise was assessed with a single question asking participants to indicate their agreement (5-point Likert scale of 1 = *strongly disagree* to 5 = *strongly agree*) with the statement "I am afraid to exercise". Similarly, a single item with 5-point Likert scale assessed physical activity enjoyment by asking agreement with the statement "I enjoy engaging in regular physical activity" (1 = *strongly disagree* to 5 = *strongly agree*). Both fear and enjoyment items have demonstrated significant associations with physical activity during preliminary studies (Rogers, et al., 2005). Exercise role models were assessed with three yes/no questions (i.e., yes = 1, no = 0) asking about breast cancer exercise role models with the responses summed for a role model score (higher score indicated greater exposure to a role model). Exercise partner was assessed with a single, multiple choice item asking if the participant had an exercise partner with whom they exercised regularly (i.e., 0 = *no*, 1 = *occasionally*, 2 = *some of the time*, 3 = *most of the time*). Both the role model score and exercise partner item have demonstrated significant associations with physical activity in breast cancer survivors (Rogers, et al., 2005).

Data Management and Analysis

All planned accelerometer and survey assessments were provided by the 36 participants completing the study. No missing values existed for task self-efficacy, social support, negative outcome expectations, negative outcome value, physical activity enjoyment, and fear of exercise. The number of participants and missing items for the remaining scales were as follows: (a) barriers self-efficacy (two participants missing one item each), (b) perceived barriers interference (two participants missing one item each), (c) positive outcome expectations (six participants missing one item and one participant missing two items), positive outcome value (eight participants missing one item and two participants missing two items). Missing items were imputed by calculating the mean of the remaining items. For the 5 participants who did not complete the study, the last observation was carried forward and an intent-to-treat analytical approach was used. A significant p value was set at $p < .05$.

For the primary study aim, independent group t tests compared the intervention versus usual care group on change in SCT constructs (i.e., immediately postintervention minus baseline) with the exception of exercise partner and role model. The effect size for each construct was computed by taking the difference between the two groups on their mean change from baseline to 3 months and then dividing by the pooled standard deviation of the change scores from both groups. Small, medium, and large effect sizes were defined as 0.2, 0.5, and 0.8, respectively (Cohen, 1988). The direction of change was calculated for partner and role model (i.e., decrease = -1, no change = 0, increase = +1) due to the skewed distribution in responses (i.e., see results section for distribution data) and chi square analysis was performed for statistical significance.

For the secondary study aim, the Freedman and Schatzkin difference-in-coefficients test examined the strength of the SCT mediation of the intervention on physical activity maintenance 3 months after intervention completion (Cerin, Taylor, Leslie, & Owen, 2006; Freedman & Schatzkin, 1992). The Freedman and Schatzkin difference-in-coefficients test facilitates identification of mediators that might be missed with the Baron and Kenny causal steps approach when a study has limited statistical power (Cerin et al., 2006; Freedman & Schatzkin, 1992). Three regression models were performed as follows:

1. A residualized change score for daily minutes of physical activity that was greater than or equal to moderate intensity was calculated for physical activity at 3 months postintervention (i.e., Month 6 minus baseline) adjusted for physical activity at baseline. This assessed the intervention effect on physical activity independent of baseline activity levels (i.e., tau [τ]).
2. The effect of the intervention on SCT construct of interest (independent of baseline values) was assessed. The residualized change score for the SCT construct using the immediately postintervention construct value adjusted for baseline was calculated (i.e., Month 3 minus baseline).
3. The effect of the intervention on physical activity at 3 months postintervention after adjusting for the immediately postintervention SCT residualized change score was determined (i.e., tau prime [τ']).

To assess mediation (i.e., reduction in intervention effect on behavior after adjustment for the change in theory construct), τ' was subtracted from τ and divided by one standard error. Statistical significance was determined by comparing this value to a t distribution ($N - 2$ df) (Cerin et al., 2006). Lastly, the unadjusted τ minus the adjusted τ' was divided by the unadjusted τ , and multiplied by 100 to calculate the percent of intervention effect mediated by the construct.

The direction of the change (i.e., decrease $[-1]$, no change $[0]$, or increase $[+1]$) was used for exercise partner and role model in lieu of residualized change scores due to limited variability in responses. Because we have reported that participants in the intervention and usual care group were similar at baseline with regard to demographic, medical, and physical activity variables (Rogers, Hopkins-Price, Vicari, Pamentier, et al., 2009), inclusion of covariates was not required. Lastly, the specific time points of change in SCT from baseline to immediately postintervention as a predictor of physical activity 3 months postintervention was chosen because it maintained the temporal relationship required to document prediction of behavior maintenance.

Results

Study Flow and Participant Characteristics

Participant characteristics, participant flow, and adverse events have been reported (Rogers, Hopkins-Price, Vicari, Markwell et al., 2009; Rogers, Hopkins-Price, Vicari, Pamentier, et al., 2009). In brief, participant recruitment and follow-up took place from April 2006 until December 2007. With regard to retention, 93% ($n = 38$) of the 41 randomized participants completed the immediately postintervention assessment and 88% ($n = 36$) completed the 3 month postintervention follow-up. With regard to adherence to intervention activities, participants completed 100%, 95%, and 98% of the supervised individual exercise sessions, group sessions, and individual face-to-face counseling sessions, respectively (Rogers, Hopkins-Price, Vicari, Pamentier, et al., 2009). The majority of participants were white (93%). Mean years for age and education were 53 ± 9 and 15 ± 2 , respectively. The most prevalent breast cancer stage was II (51%) followed by Stage I (29%) and Stage III (20%). As reported, no statistically significant differences between the groups at baseline existed for

demographic, medical, and physical activity outcomes (Rogers, Hopkins-Price, Vicari, Pamenter, et al., 2009). Relevant to this report, no statistically significant differences between the groups at baseline existed for the SCT constructs. The small number of participants lost to follow-up precluded comparison with those completing follow-up (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009).

Effect of the BEAT Cancer Intervention on Social Cognitive Theory Constructs Immediately Postintervention

The between group differences examining the effect of the BEAT Cancer physical activity behavior change intervention on each of the SCT constructs is provided in Tables 1 and 2. A medium to large effect size decrease in barrier interference was noted for the intervention versus usual care group (-12.1 versus -4.4 , mean difference = -7.8 , 95% confidence interval $[-15.1, -0.4]$, $d = -0.67$; $p = .04$). A borderline statistically significant medium effect size increase in enjoyment was noted for the intervention versus usual care group (0.57 versus -0.15 , mean difference = 0.7 , 95% confidence interval $[0, 1.5]$, $d = 0.61$; $p = .06$). As noted in Table 1, statistically nonsignificant small-to-medium positive effect size increases were noted for barriers self-efficacy, family social support, and total social support, while positive outcome expectations, negative outcome expectations, and negative outcome values demonstrated small-to-medium negative effect size changes for the intervention versus usual care group. Of note, the positive effect size for barriers self-efficacy was due to a decrease in the usual care group rather than an increase in the intervention group.

For exercise partner, 17 (85%) of usual care and 18 (86%) of the intervention group did not have an exercise partner at baseline (i.e., exercise partner score = 0). The majority continued without an exercise partner immediately postintervention (i.e., 14 [70%] for usual care and 13 [62%] for the intervention group). For role model score, 19 (95%) usual care and 16 (76%) intervention group participants did not report a role model at baseline (i.e., role model score = 0). Immediately postintervention, 15 (75%) of the usual care and 12 (57%) of the intervention group denied exposure to an exercise role model. As mentioned, the direction of change was used for exercise partner and role model in lieu of residualized change scores due to skewness and limited variability. Although the percent of participants reporting an increase in the partner and role model scores was higher in the intervention group, this difference was not statistically significant (Table 2).

Mediation of the Intervention Effect on Physical Activity at 3 Months Postintervention

Because we have reported a significant increase in objective physical activity after intervention completion that was maintained 3 months after intervention completion (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009), we examined the SCT mediators of this improvement using the Freedman and Schatzkin difference-in-coefficients test (Table 3) with the intervention significantly predicting minutes of activity that was of moderate or better intensity 3 months postintervention ($\tau = 12.7$, $p = .009$). As reported, means for weekly minutes of activity that was greater than or equal to moderate intensity measured by accelerometer at baseline, immediately postintervention, and 3 months postintervention were 113.4, 116.5, and 92 for the usual care group and 96.2, 165.8, and 174.9 for the intervention group (Rogers, Hopkins-Price, Vicari, Markwell, et al., 2009). If the magnitude of mediation is considered regardless of statistical significance, the greatest reductions in intervention effect on physical activity 3 months after intervention completion occurred when adjusted for the during intervention change in barrier interference, barriers self-efficacy, and social support (Table 3). However, only barrier interference ($p = .004$) and barriers self-efficacy ($p = .02$) demonstrated significant mediation effects. To quantify this effect, the improvements in barrier interference and barriers self-efficacy during the intervention mediated 39% and

19%, respectively, of the intervention effect on physical activity maintenance 3 months after intervention completion. Although mediation was not statistically significant, 7.7% of the intervention effect was mediated by improvements in social support (primarily family support).

Discussion

Conclusions and Comparison with Prior Studies

Although beneficial changes were noted for several SCT constructs during the BEAT Cancer physical activity behavior change intervention, only barrier interference and physical activity enjoyment demonstrated at least medium effect size improvements. Little to no change was noted for task self-efficacy, friend social support, importance of positive outcomes, fear of exercise, exercise partner, and role models. With regard to our mediation study aim, barrier interference significantly mediated the effect of the intervention on physical activity 3 months after intervention completion while enjoyment did not. Barriers self-efficacy significantly mediated the intervention effect but the small effect size improvement with the intervention was not statistically significant.

Most prior studies testing mediation of physical activity interventions in cancer populations have used the TPB (Jones et al., 2005; Mosher et al., 2008; Vallance et al., 2008). The mediation by barriers self-efficacy in our report is similar to perceived behavioral control mediation of a oncologist delivered intervention (Jones et al., 2005) with our lack of intervention effect on self-efficacy being similar to that reported after a mail-delivered intervention in breast and prostate cancer survivors (Mosher et al., 2008). Although we reported mediation by barriers interference, no mediation occurred for control beliefs of the TPB (i.e., likelihood of barrier occurrence) with a pedometer and/or print materials intervention in breast cancer survivors (Vallance et al., 2008). This inconsistency is best explained by the differences in intervention theoretical frameworks (e.g., control beliefs do not focus on frequency of interference but only on likelihood of the presence or absence of the barrier), content (e.g., our intervention may have placed a greater emphasis on dealing with barriers), and contact intensity (e.g., our intervention included intensive group and face-to-face counseling as compared with mail delivered intervention that did not include personal contact [Vallance et al., 2008]).

Methodological, Theoretical, and Clinical Plausibility of Results

It is not unexpected that barrier interference played a significant role in intervention mediation (i.e., 39%) because individualized counseling regarding overcoming barriers was emphasized in both the group and individual intervention sessions. The fact that barriers self-efficacy may act as a mediator is consistent with Bandura's theory that, in addition to a direct effect, self-efficacy indirectly influences behavior through an individual's response to barriers (Bandura, 2004). For example, self-efficacious individuals are more apt to attempt to overcome obstacles rather than "give up" because they feel the obstacles are insurmountable (Bandura, 2004). Furthermore, the reduction in perceived interference by barriers due to the intervention could potentially maintain or improve barriers self-efficacy through reciprocal determinism (Bandura, 1986), a theory supported in a prior cross-sectional study in breast cancer survivors (Rogers, McAuley, et al., 2008). It is noteworthy that barriers interference accounted for only 25% of the variance in barriers self-efficacy in a previous population-based sample of breast cancer survivors (i.e., correlation = $-.5$) (Rogers, McAuley, et al., 2008) and only 1.7% of the variance (i.e., correlation = $-.13$) in the sample for this report supporting the consideration of these two constructs as conceptually different. Future adequately powered studies with multiple follow-up assessments are needed to test whether the change in barrier interference mediates a change

in self-efficacy and/or whether the change in self-efficacy mediates the change in barrier interference or whether both are independent mediators of physical activity. Such studies should also examine the trajectory of the decline in barriers self-efficacy in the usual care group and test whether this decline influences physical activity behavior beyond the 6-month follow-up period.

Other noteworthy patterns were identified. Task (rather than barriers) self-efficacy may have demonstrated a smaller effect size and no mediation of the intervention because our study population did not have significant physical limitations related to medical comorbidities or severe cancer treatment side effects (Blanchard, Rodgers, et al., 2002; Rogers, Courneya, Robbins, et al., 2008; Rogers, McAuley, et al., 2007; Rogers et al., 2005) and our walking intervention did not involve strenuous or difficult to perform activities (i.e., walking does not require much practice or skill). With regard to positive outcome expectations, the high mean score at baseline suggests that a “ceiling effect” may have prevented additional improvement with the intervention (Linden & Satin, 2007). In addition, the small to medium negative effect size change in positive outcome expectations may have been related to participants overestimating exercise benefits before they became regular exercisers. Because participants may drop out when exercise does not meet their expectations regarding benefits, our low attrition rate suggests that the intervention may facilitate continued exercise in the face of developing more realistic expectations. Also related to outcome expectations, the low mean scores for negative outcome expectations and values suggest that most participants felt exercise carried little personal risk. Although not significant, further study is warranted to determine if the small to medium effect size decrease in negative outcome expectations and values represents a true beneficial effect of the intervention on negative outcome beliefs.

Interestingly, enjoyment did not mediate the intervention effect but demonstrated a medium to large effect size increase postintervention. Although we targeted enjoyment by teaching positive self-talk and adjusting the home-based setting based on preference, women participating in the intervention discussion groups often expressed a feeling of responsibility to “take care of” their friends and family, even at the expense of their own health (Rogers et al., 2010). Given that our intervention addressed “downstream” barriers that result from family and job responsibilities through time and stress management (Rogers et al., 2010) and perceived barriers significantly mediated the intervention effect, we theorize that enjoyment alone is not enough to mediate the intervention effect if the participants are not given the tools to overcome barriers. Alternatively, the intervention staff and group member support may have caused participants to interpret their exercise experiences more positively rather than increase enjoyment of physical activity exclusive of the intervention activities (McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003). If this occurred, enjoyment would be less likely to mediate physical activity once the staff and group support are no longer available. Finally, the impact of enjoyment on physical activity may vary depending on the measurement tool suggesting the possibility that our single item measure was inadequate for detecting a mediation effect (Dishman, 1994). Further study is required to more fully evaluate these possibilities.

Surprisingly, the role model score showed little improvement postintervention although a “role model” speaker attended one of the group sessions. It is conceivable that participants did not consider the speaker a role model because the speaker was not personally known by the participants for a longer period of time. Future interventions might consider more purposeful partnering of breast cancer survivors with other regularly active breast cancer survivors, especially since role models have been a strong physical activity correlate in a cross-sectional study (Rogers et al., 2005). Another explanation is that the survey items asked about role models “during treatment,” which the investigators intended to include

hormonal therapy yet participants may have interpreted this as primary treatment only. Not all “role models” used for the intervention had exercised during primary treatment. Future assessments should clarify the wording.

Although we have chosen a mediation analysis approach appropriate for small randomized trials (Cerin et al., 2006), our major limitation is that our pilot study was powered to detect a change in the primary outcome of physical activity (Rogers, Hopkins-Price, Vicari, Pamentier, et al., 2009) rather than change in SCT constructs. Nevertheless, the study pilot tests SCT effect sizes and suggests several constructs worthy of future study in larger trials. Moreover, confirming the generalizability of our results for cancer types other than breast is warranted.

Several study aspects add strength to our report. First, the randomized controlled study design provided the necessary causal and temporal relationships for examining mediation and its prospective design minimizes the potential for overestimating associations when physical activity “predictors” are examined with cross-sectional studies (Weinstein, 2007). In addition, most interventions, for practical reasons, need to enable participants to continue active lifestyles without ongoing intervention. Therefore, our examination of the intervention mediation 3 months after participants have completed the intervention is particularly useful. Lastly, we are among only a few studies examining SCT mediation of physical activity behavior in the breast cancer population with fewer still using an objective physical activity measure.

Research and Clinical Implications

Our study continues to support the SCT as a valid framework for understanding physical activity behavior in breast cancer survivors. However, we acknowledge the preliminary nature of our study and larger trials (powered for detecting the smaller effect size changes in SCT constructs) are needed. Such studies should include multiple follow-up assessments to facilitate testing SCT mediation relationships reflective of reciprocal determinism (e.g., mediating effect of barrier interference on change in barriers self-efficacy) allowing more complex understanding of health behavior. Although the pattern of mediation in larger studies may differ based on intervention components and emphasis, such studies are expected to identify additional SCT mediators not detectable in our study (e.g., social support).

Theory-based interventions can influence SCT constructs, which can, in turn, mediate physical activity behavior. Overcoming barriers appears to be an effective construct target for facilitating physical activity maintenance and should be included in future interventions. Barriers (or impediments) are considered to be a major sociocognitive determinant in the SCT. In contrast, assessments of the TPB often focus on the likelihood of overcoming barriers (i.e., perceived behavioral control, which is similar to barriers self-efficacy) rather than frequency of barrier interference (Bandura, 2004). Importantly, we are the first to report the mediation effect of barriers interference on physical activity behavior and our use of the SCT has facilitated our ability to identify this important intervention target. In addition to barriers, emphasizing social support (especially family) is worthwhile and may increase the mediation role of the social support construct.

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Effects of the BEAT Cancer Intervention on Social Cognitive Theory Constructs Immediately Postintervention ($n = 41$; UC = Usual Care Group; INT = Intervention Group)

Table 1

Variable and Possible Range	Baseline		Immediately Postintervention		Within-Group Mean Change			Between-Group Difference			d	p-value
	M	SD	M	SD	M	95%LCL ^a 95%UCL ^b		M	95%LCL ^a 95%UCL ^b			
Barriers self-efficacy (0–100)												
UC = 20	42.7	25.5	36.2	24.5	–6.5	–17.7	4.8	7.0	–8.9	22.9	0.28	.38
INT = 21	46.8	19.7	47.3	22.3	0.5	–11.4	12.4					
Task self-efficacy (0–100)												
UC = 20	49.0	22.3	54.8	22.5	5.8	–0.7	12.2	2.4	–7.2	12.0	0.16	.61
INT = 21	56.9	23.4	65.0	18.0	8.2	0.7	15.6					
Barrier interference (0–105)												
UC = 20	57.8	14.4	53.4	12.0	–4.4	–8.9	0.2	–7.8	–15.1	–.4	–0.67	.04
INT = 21	57.9	10.1	45.8	14.4	–12.1	–18.1	–6.2					
Family social support (0–8)												
UC = 20	2.1	2.1	2.5	2.2	0.5	–0.4	1.3	0.8	–0.5	2.2	0.40	.21
INT = 21	2.4	2.7	3.7	2.6	1.3	0.2	2.4					
Friend social support (0–8)												
UC = 20	2.3	2.5	3.0	2.6	0.8	–0.5	2.0	0.3	–1.4	2.0	0.11	.73
INT = 21	1.8	2.1	2.8	2.7	1.1	–0.2	2.3					
Total social support (0–16)												
UC = 20	4.3	4.2	5.5	3.9	1.2	–0.2	2.6	1.1	–1.1	3.3	0.33	.30
INT = 21	4.2	4.0	6.5	4.2	2.3	0.6	4.1					
Positive outcome expectations (14–70)												
UC = 20	58.3	6.8	60.2	5.8	1.8	–1.2	4.9	–2.4	–6.1	1.2	–0.43	.18
INT = 21	60.9	4.8	60.2	5.2	–0.6	–2.8	1.6					
Positive outcome value (14–17)												
UC = 20	52.8	9.9	53.5	10.4	0.7	–1.9	3.3	–0.2	–3.9	3.6	–0.03	.93
INT = 21	56.4	8.6	56.9	7.8	0.5	–2.3	3.3					
Negative outcome expectations (3–15)												
UC = 20	7.1	2.1	7.1	2.4	–0.1	–1.1	1.0	–0.6	–2.2	1.0	–0.23	.47

Variable and Possible Range	Baseline		Immediately Postintervention		Within-Group Mean Change			Between-Group Difference			d	p-value
	M	SD	M	SD	M	95%LCL ^a	95%UCL ^b	M	95%LCL ^a	95%UCL ^b		
INT = 21	7.9	2.1	7.3	2.7	-0.6	-1.9	0.7					
Negative outcome value (3–15)												
UC = 20	9.6	3.7	10.5	3.4	0.9	-0.1	1.9	-0.9	-2.4	.6	-0.38	.23
INT = 21	10.8	3.0	10.8	3.2	0.0	-1.2	1.2					
Physical activity enjoyment (1–5)												
UC = 20	3.4	1.2	3.2	1.5	-0.2	-0.8	0.5	0.7	0.0	1.5	0.61	.06
INT = 21	3.6	1.2	4.2	0.8	0.6	0.1	1.0					
Fear of exercise (1–5)												
UC = 20	1.5	0.9	1.3	0.7	-0.2	-0.5	0.2	-0.0	-0.5	0.4	-0.06	.86
INT = 21	1.2	0.6	1.1	0.2	-0.2	-0.5	0.1					

^a95% lower confidence limit;

^b95% upper confidence limit.

Table 2

Effects of the BEAT Cancer Intervention on Exercise Partner and Role Model Score Immediately Postintervention

<u>Change From Baseline to Immediately Postintervention</u>				
Scores	Decrease <i>n</i> (percent)	No Change <i>n</i> (percent)	Increase <i>n</i> (percent)	<i>p</i> -value ^a
Exercise Partner Score				
Usual care group (<i>n</i> = 20)	0 (0%)	17 (85%)	3 (15%)	.106
Intervention group (<i>n</i> = 21)	2 (10%)	12 (57%)	7 (33%)	
Role Model Score				
Usual care group (<i>n</i> = 20)	0 (0%)	15 (75%)	5 (25%)	.202
Intervention group (<i>n</i> = 21)	2 (10%)	11 (52%)	8 (38%)	

^a Chi-square *p*-value.

Table 3

Mediation of the BEAT Cancer Intervention on Physical Activity 3 Months After intervention Completion by the Change in Social Cognitive Theory Constructs From Baseline to Immediately Postintervention

Variable ^a	Intervention Effect on 3-Month Postintervention Activity Adjusted for Baseline		Reduction in Intervention Effect Adjusted for Construct Change Immediately Postintervention		Mediation of Intervention Effect by Construct		Percent of Intervention Effect Mediated by Variable	
	τ	SE	τ'	SE	$\tau - \tau'$	<i>t</i> statistic ($\tau - \tau'/SE$)	<i>p</i> -value	$\tau - \tau'/\tau \times 100\%$
Barriers self-efficacy	12.7	4.6	10.2	4.5	2.4	1.0	.020	19.2
Task self-efficacy	12.7	4.6	12.5	4.8	0.2	0.9	.809	1.7
Barrier interference	12.7	4.6	7.7	4.4	5.0	1.6	.004	39.2
Family social support	12.7	4.6	11.9	4.8	0.8	1.3	.518	6.4
Friend social support	12.7	4.6	12.6	4.7	0.1	0.1	.350	0.5
Total social support	12.7	4.6	11.7	4.7	1.0	0.8	.252	7.7
Positive outcome expectations	12.7	4.6	12.4	4.7	0.3	0.5	.534	2.5
Positive outcome value	12.7	4.6	12.7	4.7	0.0	0.3	.937	-0.2
Negative outcome expectations	12.7	4.6	12.4	4.6	0.3	0.2	.185	2.1
Negative outcome value	12.7	4.6	12.8	4.7	-0.2	0.6	.794	-1.3
Physical activity enjoyment	12.7	4.6	12.8	5.1	-0.2	2.0	.939	-1.2
Fear of exercise	12.7	4.6	12.8	4.8	-0.2	1.1	.882	-1.2
Exercise partner	12.7	4.6	12.9	4.7	-0.2	0.4	.668	-1.4
Exercise role model	12.7	4.6	12.9	4.6	-0.2	0.2	.126	-1.9

^aResidualized change scores used for all variables with the exception of partner and role model scores, which used the direction of change (i.e., -1 = decrease, 0 = no change, +1 = increase).