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ORIGINAL ARTICLE

Impact of a Combined Resistance and Aerobic Exercise Program on Motivational Variables in Breast Cancer Survivors: A Randomized Controlled Trial

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Abstract
Background Short term exercise interventions have been shown to be beneficial for breast cancer survivors soon after treatments but longer term adherence is needed.
Purpose To examine the effects of a supervised exercise program on motivational variables in breast cancer survivors using Self-Determination Theory (SDT).
Method Sixty breast cancer survivors were randomized in a cross-over design to either an immediate exercise group (IEG; n=30) that exercised from baseline to week 12 or a delayed exercise group (DEG; n=30) that exercised from week 12 to 24. SDT variables were assessed at baseline, 6, 12, 18 and 24 weeks using the Behavioral Regulation for Exercise Questionniare-2 and the Basic Psychological Needs Satisfaction Scale.
Results Fifty-eight participants completed the follow-up assessments and achieved a 61.3% adherence rate. Analyses of variance revealed significant time by group interactions for almost all psychological needs and motivations that favored the exercise intervention time periods. For example, autonomy increased in the IEG from baseline to 12 weeks by 2.0 points compared to the DEG where scores decreased by 0.1 points (mean group difference=2.0, p<0.001). The cross-over results further supported the main findings.
Conclusion Supervised exercise soon after breast cancer treatments may help to develop a positive exercise motivational profile among breast cancer survivors that could portend longer term adherence.

Keywords Breast cancer · Exercise · Self-Determination Theory · Quality of life · Randomized controlled trial

Introduction

A number of randomized controlled trials (RCT) have demonstrated the positive impact of exercise on quality of life (QoL) in cancer survivors during and after adjuvant therapy [1–4]. Despite these benefits, research has shown a significant decrease in exercise in cancer survivors during adjuvant therapy and continuing low levels of activity after treatments [5–6]. Exercising over the long-term is necessary to optimize health benefits for breast cancer survivors. We previously reported the effects of a 12-week, supervised, combined aerobic and resistance training exercise program on QoL, fatigue, social physique anxiety, and physical fitness in breast cancer survivors and noted significant and meaningful improvements in each of these endpoints [7]. Given the importance of long-term adherence, we were also interested in the effects of our exercise intervention on motivational constructs that may portend longer term behavior change. Our study was guided by Self-Determination Theory (SDT)

Although few studies have used SDT as a theoretical framework [8–10] for understanding exercise motivation,

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the theory has been utilized for other health behaviors [11–14] and shows a great deal of promise for examining exercise behavior. The central tenet of SDT is that motivation evolves from how well a person's innate psychological needs are met within their environment [15]. The central psychological needs are described as autonomy (or choice), competence, and relatedness. *Autonomy* refers to the extent to which someone feels they are experiencing a sense of volition or choice without control. *Competence* refers to a person's confidence in their ability to participate in challenging tasks such as exercise or other skilled behaviors and to achieve a positive outcome [16]. *Relatedness* refers to the degree to which someone feels a sense of connectedness to others in the immediate environment.

The second component of SDT is motivation or regulations. It is proposed that all regulations are located adjacently along a self-determination continuum [15, 17] from extrinsically motivated to intrinsically motivated. Additional to the continuum, a state of 'amotivation' has also been proposed, which refers to instances where individual's have no motivation towards performing a behavior, and concomitantly perceive no reason to engage in that behavior [18]. Within the continuum, SDT motives are anchored at each end by extrinsic motivation, describing someone exercising because of highly controlled motivations, to intrinsic motivation, which occurs when the exercise behavior is volitional or autonomously endorsed [15, 17]. Extrinsic motivation is the most highly controlled and describes exercise behavior that is done in response to an external demand or reward (extrinsic motivation). Following extrinsic motivation is 'introjected regulation' which is described as occurring when a person internalizes a behavior by imposing pressure on themselves out of a sense of obligation or coercion, or to avoid feelings of guilt or to increase their own perceived self-worth [19].

By contrast, the autonomous self-regulations reflect participation through personal volition and choice. Identified regulation follows along the continuum and occurs when someone chooses to exercise because they recognize the value in the activity, rather than because of a sense of obligation. Lastly, 'intrinsic motivation' describes when a person is motivated to perform a behavior purely for the inherent pleasure, sense of accomplishment, or satisfaction derived from the behavior. When a person is intrinsically motivated, the behavior is fully internalized [17, 20] and the individual experiences the greatest feelings of autonomy. This, in turn, can lead to greater interest and confidence, resulting in longer persistence [20].

Autonomous motives have been shown to be positively associated with greater weight loss over the long-term and longer maintenance of exercise behavior in obese patients [12]; better glucose control for patients with diabetes [11]; as well as smoking cessation and greater abstinence [13–14]. More specifically, with regards to exercise behavior, Wilson et al. [21] demonstrated that more autonomous motivations were associated with more frequent exercise attendance. In breast cancer survivors, we previously reported a positive association between an autonomy-supportive environment and identified regulation and more frequent physical activity behavior, with autonomous regulations, competence and autonomy being the strongest predictors of physical activity [8]. Wilson et al. [10] reported that both controlled and autonomous motives predicted moderate to vigorous intensity physical activity amongst a sample of mixed adult cancer survivors. Both of these studies, however, are limited in that they were retrospective and relied upon self-reported physical activity. No study to date has examined the effects of supervised exercise on SDT constructs in cancer survivors [22].

The primary purpose of the present study was to examine the effects of participation in our exercise program on self-determined motivations and the psychological needs of autonomy, competence and relatedness of breast cancer survivors. Our primary objective was to determine if the SDT variables changed over time with a structured exercise program. Based on previous research, we hypothesized that the structured exercise program would result in increases in identified and intrinsic motivation and decreases in extrinsic motivation. Moreover, we expected a higher satisfaction of competence and autonomy and, to a lesser extent, relatedness. Finally, in terms of the theoretical tenets of SDT, we expected that variables more closely aligned along the continuum would show stronger associations and that the psychological needs would show greater associations with the autonomous regulations (i.e., identified and intrinsic motivation). Figure 1 illustrates the hypothesized relationships between the self-determination variables, motivations, and exercise behavior.

Methods

Our randomized controlled cross-over trial of combined aerobic and resistance training has been reported in detail in an earlier manuscript [7]. This trial was conducted in accordance with the CONSORT guidelines with clearly defined hypotheses and explicit primary and secondary outcome measures. We used randomized controlled trial

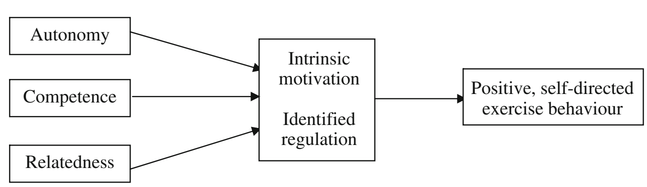

Fig. 1 Schematic representation of hypothesized relationship between the self-determination variables, motivation and exercise behavior

methodology including concealed randomization and intention-to-treat analysis. Here, we provide a brief summary of the methods as well as detailed information about the outcome (SDT) measures.

Participants

The trial was completed at the University of Western Australia's (UWA) Health and Rehabilitation Program (UHRP) Clinic where ethical approval was granted. Participants were recruited via poster displays in oncology centers or via advertisements in community newspapers. Informed consent was received before participation. Eligibility criteria included women with stage I–II breast cancer, ≥18 years old, English speaking, within 24 months of their cancer diagnosis, and having completed all treatments (by at least 1 month) except hormone therapy. Women were excluded if they had evidence of recurrent disease, had previously engaged in any formal exercise programs for six months prior to participation in this study, or if they failed the revised Physical Activity Readiness Questionnaire (rPAR-Q) [23].

Exercise Intervention

The study was a prospective, two-armed, RCT with a complete cross-over design. Participants were randomly assigned to either an immediate exercise group (IEG) or a delayed exercise group (DEG) in a 1:1 ratio using a computer-generated program after completing baseline measures. Group assignments were concealed from the project director who recruited participants to the trial. The IEG completed the supervised (by clinical physiologists), center-based, combined resistance and aerobic exercise program three times per week for at least 1 h per session from baseline to 12 weeks. The DEG was asked not to participate in any new or additional exercise over their normal activities during this time period. Contact with the DEG was maintained by phone calls made once every three weeks. The DEG then completed the exercise program from weeks 13 to 24, with the IEG receiving phone calls every third week. The IEG were not given any specific exercise instructions to follow during weeks 13–24. Participants completed self-report assessments at baseline, 6, 12, 18, and 24 weeks.

Study participants were prescribed an exercise program that comprised a 20-min cardiovascular component using any of the following; cycle and rowing ergometers, the mini-trampoline, and the step-up blocks, followed by a 40-min resistance training component consisting of 12 different exercises targeting the major muscle groups. Although the program was supervised, the participants were able to choose the exercises that best suited them. While intensity was not formally monitored, participants were encouraged to work at a pace that approximated a moderate intensity (~70% of individual maximum heart rate), as this pace can result in improvement to aerobic capacity without causing discomfort to the participant [24]. For each resistance exercise, participants performed two sets of 10–15 repetitions of light weights and progressed to a heavier weight once the current weight and repetitions could be achieved easily and with good form. The program concluded with 5 min of stretching and cooling-down.

Assessments

The rPAR-Q [23] was administered, and medical and demographic information was collected at baseline using self-report measures. General demographic information included: age; smoking status; marital status; education; country of birth; and, the number of years residing in Australia. Medical details included: which breast was affected; date of diagnosis; surgery; other treatments received including hormone therapies; additional medical concerns; and, whether or not the participants had lymphedema. Both groups completed the questionnaire packages at home at baseline and weeks 6, 12, 18, and 24.

Motivation Continuum

The Behavioral Regulation for Exercise Questionnaire-2 (BREQ-2) [25] was developed in order to provide a measure that assessed the self-determination continuum in exercise [15, 17]. The BREQ-2 is a 19-item, closed-question, self-report measure that contains five subscales that measure amotivation (four items), external regulation (four items), introjected regulation (three items), identified regulation (four items) and intrinsic regulation (four items) of exercise behavior. Respondents are required to answer the question "why do you engage in exercise?" [26], and were offered statements such as "I feel guilty when I don't exercise; It's important to me to exercise regularly; and, I exercise because other people say I should". Responses to each question were scored on a five-point Likert scale (0–4) indicating how true each item was for the individual from not at all, to very true for them. The BREQ-2 total score is established by calculating the sum of each subscale score. The BREQ-2 has been validated in previous exercise research [27–28]. The internal consistency reliability estimates [29] for the present study for each BREQ-2 subscale item were as follows: Amotivation, α=0.53; intrinsic motivation, α=0.76; identified regulation, α=0.72; introjected regulation, α=0.68; extrinsic motivation, α=0.70.

Psychological Needs

As no cancer-specific psychological needs scale was available, we chose to adopt and modify the Basic Psychological

Needs Satisfaction Scale (BPNS) [30] to measure autonomy, competence, and relatedness. The BPNS is a revised version of the 21-item Basic Need Satisfaction at Work Scale, which was used to assess the extent to which employees experienced satisfaction of their three basic needs—autonomy (seven items), competence (six items) and relatedness (eight items)—on their job. The scale was modified by changing the words 'work' or 'job' to 'exercise', for example, "I get along with the people I work beside" became: "I get along with the people I exercise with". Participants responded to items on a seven-point scale (1–7). Respondents were instructed to read each item and respond with how they felt when they were exercising. The BPNS is scored by averaging item responses for each subscale (after reverse scoring the items worded negatively). The internal consistency reliability estimates [29] for the present study for each PNS subscale item were as follows: Autonomy, α=0.84; competence, α=0.79; relatedness, α=0.73.

Statistical Analysis

Twenty-six participants were needed per group to detect a large standardized effect size (d=0.80) with a power of 0.80 and a two-tailed alpha of 0.05. Our goal was to randomize 60 participants to allow for a 10% loss-to-follow-up. The primary analysis was a 2 (group) by 5 (time) split plot ANOVA used to test for interactions between Time and Group on basic needs and regulation scores. All interaction terms analyzed were determined a priori. Missing data were remedied using last-observation-carried-forward and all analyses were intention-to-treat. Huynh–Feldt degrees of freedom scores are reported where sphericity has been violated. Significant interactions were followed by paired- and independent-samples t tests in order to determine when the changes occurred within each group and at which time points the groups were different. These analyses were repeated using analysis of covariance with the respective baseline score as a covariate. Pearson product–moment correlations were used to determine the associations between the basic needs variables and the exercise regulations at week 12 and week 24.

Results

Participant recruitment took place between January and March 2005 and the trial commenced in April 2005. Flow of participants through the trial and the baseline characteristics of the sample are reported elsewhere [7]. Briefly, we recruited 60 of 131 (45.8%) eligible participants. Common reasons for refusal included not willing to travel (n=13) and having family or holiday commitments over the study period (n=16). Only 2 participants (3.3%) were lost to follow-up. The groups were balanced on all medical and demographic variables. The average IEG attendance was 60.4% (21.7 of 36 sessions) with a median of 23 (63.9%) and a range of 11–36. The average DEG attendance was 62.2% (22.4 of 36 sessions) with a median of 24 (66.7%) and a range of 12–35. Groups were balanced on baseline values for the motivation and need endpoints.

Overall, the participants had a mean age of 55.1± 8.2 years, of whom the majority had been born in Australia (62.1%) and were married (70.7%). Fifty-five percent of the participants were working either full or part time, with 53.4% having at least a high school education. All the participants had received surgery, with a slightly higher percentage experiencing the cancer in their left breast (56.9%) than their right. Fifty-one percent had received a lumpectomy, while the remainder of participants opted for mastectomies, either with or without a reconstruction. Seventy percent of participants had received chemotherapy, while 60.3% had received radiotherapy. Almost three quarters (74.1%) of the group went onto receive hormone therapy and 22.4% of participants had experienced lymphedema.

Changes in Needs and Motivation from Baseline to 24 Weeks by Group Assignment

Table 1 reports the basic needs and Table 2 reports the exercise regulations. A Split Plot ANOVA revealed a significant Time by Group interaction for Autonomy [F= 24.0, p<0.001]. Follow-up paired t tests on the interaction effects revealed that the IEG demonstrated a significant increase in autonomy from baseline to week 6 [mean change=1.4; 95% CI=1.0 to 1.8, p<0.001], from week 6 to week 12 [mean change=0.6; 95% CI=0.3 to 0.9, p<0.001], and from week 12 to week 18 [mean change=0.6; 95% CI=0.3 to 0.8, p<0.001], with no further increase from week 18 to week 24 [mean change=0.1; 95% CI=−0.1 to 0.3, p=0.340]. The DEG demonstrated a significant increase in autonomy from baseline to week 6 [mean change=0.2; 95% CI=0.1 to 0.4, p=0.015], followed by a significant decrease from week 6 to week 12 [mean change=−0.3; 95% CI=−0.4 to −0.1, p=0.001], followed again by a significant increase from weeks 12 to 18 [mean change=2.0; 95% CI=1.5 to 2.4, p<0.001] and from week 18 to week 24 [mean change=0.5; 95% CI=0.3 to 0.7, p< 0.001]. Follow-up independent t tests revealed that there were no significant differences between the groups for autonomy at baseline [mean difference=0.2; 95% CI=−0.4 to 0.4, p=0.916] or at week 24 [mean difference=0.3; 95% CI=−0.2 to 0.8, p=0.275], however, the scores for the IEG were significantly higher at week 6 [mean difference=1.2; 95% CI=0.9 to 1.5, p<0.001], week 12 [mean difference= 2.1; 95% CI=1.7 to 2.4, p<0.001] and at week 18 [mean

Table 1 Effect of supervised exercise on basic psychological needs

	Baseline Mean (±SD)	6 weeks Mean (±SD)	12 weeks Mean (±SD)	18 weeks Mean (±SD)	24 weeks Mean (±SD)	Time x group p value
Autonomy						
IEG	3.5 (±0.8)	4.9 (±0.6)	5.5 (±0.8)	6.0 (±0.7)	6.1 (±0.7)	
DEG	3.5 (±0.6)	3.7 (±0.6)	3.4 (±0.6)	5.4 (±1.0)	5.9 (±1.1)	<0.001
Competence						
IEG	3.3 (±0.6)	4.6 (±0.8)	5.2 (±0.9)	5.6 (±0.8)	5.8 (±0.7)	
DEG	3.2 (±0.6)	3.5 (±0.6)	3.4 (±0.6)	5.0 (±0.7)	5.4 (±1.1)	<0.001
Relatedness						
IEG	3.3 (±0.7)	4.7 (±0.8)	5.2 (±0.7)	5.5 (±0.8)	5.8 (±0.7)	
DEG	3.3 (±0.8)	3.5 (±0.6)	3.3 (±0.6)	5.3 (±1.1)	5.5 (±1.2)	<0.001

IEG (n=29); *DEG* (n=29). p value for time by group interaction

difference=0.7; 95% CI=0.2 to 1.1, p=0.006]. These changes are illustrated in Fig. 2. The secondary need variables of competence (as seen in Fig. 3) and relatedness demonstrated the same pattern as autonomy (Table 1).

A Split-plot ANOVA revealed a significant Time by Group interaction for identified regulation [F(3.6, 204.8)= 7.4, p<0.001]. Follow-up paired t tests on the interaction effects revealed that the IEG demonstrated a significant increase in scores from baseline to week 6 [mean change= 0.6; 95% CI=0.4 to 0.9, p<0.001], from week 6 to week 12 [mean change=0.3; 95% CI=0.07 to 0.6, p=0.017] and from week 12 to week 18 [mean change=0.4; 95% CI= 0.09 to 0.6, p=0.013] but not between weeks 18 and 24 [mean change=0.09; 95% CI=−0.3 to 0.5, p=0.607]. Conversely, the DEG did not demonstrate a significant change from baseline to week 6 [mean change=0.0; 95% CI=−0.1 to 0.2, p=0.601], from week 6 to week 12 [mean change=0.1; 95% CI=−0.4 to 0.09, p=0.231] or from week 18 to week 24 [mean change=0.3; 95% CI=−0.06 to 0.7, p=0.097], however, a significant change was demonstrated between week 12 and week 18 [mean change=1.2; 95% CI=0.8 to 1.6, p<0.001]. Follow-up independent t tests revealed that scores for the DEG were significantly higher than the IEG at baseline [mean difference=−0.5; 95% CI=−0.7 to −0.1, p=0.002]. Conversely, scores for the IEG were significantly higher at week 12 [mean difference=0.6; 95% CI=0.3 to1.0, p=0.001]. There were no significant differences between the groups at week 6 [mean difference= 0.1; 95% CI=−0.9 to 0.4, p=0.226], or at week 18 [mean difference=−0.1; 95% CI=−0.5 to 0.3, p=0.515], while there was a borderline significant difference between the groups at week 24 [mean difference=−0.4; 95% CI=−0.7 to 0.02, p=0.069], with the DEG demonstrating higher identified regulation than the IEG (Fig. 4). Intrinsic motivation demonstrated the same pattern for both groups as was shown in identified regulations (Fig. 5). Extrinsic

Table 2 Effects of supervised exercise on motivational regulations

	Baseline Mean (±SD)	6 weeks Mean (±SD)	12 weeks Mean (±SD)	18 weeks Mean (±SD)	24 weeks Mean (±SD)	Time x group p*
Amotivation						
IEG	3.6 (±0.5)	3.5 (±0.9)	2.9 (±1.2)	2.2 (±1.3)	1.8 (±1.1)	
DEG	3.6 (±0.5)	3.6 (±0.4)	3.2 (±0.8)	2.0 (±1.6)	1.1 (±1.4)	0.061
External						
IEG	3.6 (±0.4)	3.4 (±1.0)	2.8 (±1.1)	2.1 (±1.2)	1.8 (±1.2)	
DEG	3.4 (±0.7)	3.2 (±0.7)	3.2 (±0.7)	1.8 (±1.6)	1.1 (±1.3)	0.048
Introjected						
IEG	1.5 (±0.9)	2.1 (±0.9)	2.3 (±0.7)	2.7 (±0.8)	2.6 (±0.8)	
DEG	2.2 (±0.9)	2.2 (±0.8)	2.3 (±0.8)	2.6 (±0.9)	2.3 (±0.9)	0.016
Identified						
IEG	1.4 (±0.6)	2.1 (±0.4)	2.4 (±0.7)	2.8 (±0.8)	2.9 (±0.7)	
DEG	1.9 (±0.5)	1.9 (±0.5)	1.8 (±0.7)	2.9 (±0.8)	3.3 (±0.8)	<0.001
Intrinsic						
IEG	1.2 (±0.7)	1.7 (±0.7)	2.2 (±0.8)	2.6 (±0.9)	2.8 (±0.6)	
DEG	1.6 (±0.6)	1.4 (±0.6)	1.4 (±0.8)	2.6 (±1.0)	3.1 (±0.7)	<0.001

IEG (n=29); DEG (n=29). p value for time by group interaction

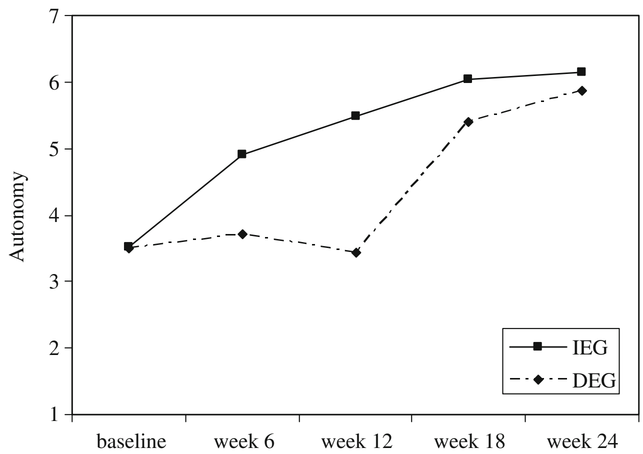

Fig. 2 Autonomy from baseline to week 24 by group assignment (N=58)

motivation demonstrated a significantly decreasing pattern over time across both groups whereas introjected regulation showed a relatively flat pattern over time. For amotivation, there was a borderline significant interaction effect [F(3.4, 190.1)=2.4, p=0.061].

Analyzing the data using analysis of covariance procedures indicated that the observed changes in all the basic needs variables and external, identified, and intrinsic regulations were independent of the respective baseline values. After adjustment, however, amotivation approached significance [F (3.2, 177.9)=2.6, p=0.051] while introjected regulation became non-significant [F(3.6, 195.8)=0.4, p=0.756].

Associations Between Basic Needs and Motivation at Week 12

Table 3 lists the correlations between basic needs and motivations at week 12. Autonomy demonstrated significantly large correlations with both competence (p<0.001) and relatedness (p<0.001). Equally, a large correlation was shown between competence and relatedness (p<0.001). Autonomy demonstrated a medium strength correlation

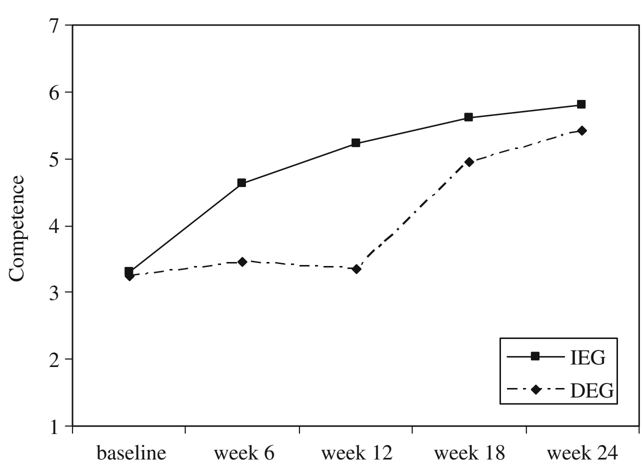

Fig. 3 Competence from baseline to week 24 by group assignment (N=58)

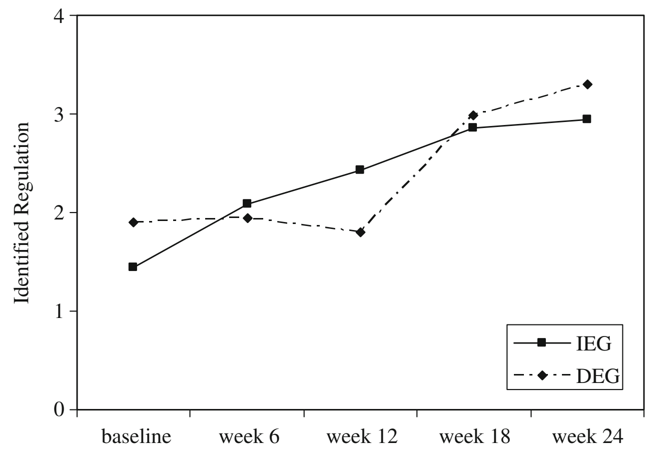

Fig. 4 Identified regulation from baseline to week 24 by group assignment (N=58)

with intrinsic regulation (p<0.001) and identified regulation (p<0.001). Competence demonstrated a small negative correlated with amotivation (p=0.029) and a medium strength correlation with external regulation (p=0.015), however showed a large positive correlation with identified regulation (p<0.001), and intrinsic regulation (p<0.001). Relatedness also showed a medium significant negative correlation with amotivation (p=0.013) and external regulation (p=0.003) Also, relatedness demonstrated a medium positive correlation with identified regulation (p<0.001), and a large positive correlation with intrinsic regulation (p<0.001).

Discussion

The primary purpose of this study was to examine the effects of a structured exercise program on the psychological needs and motivations of breast cancer survivors. The main findings of our study showed increases in self-determined

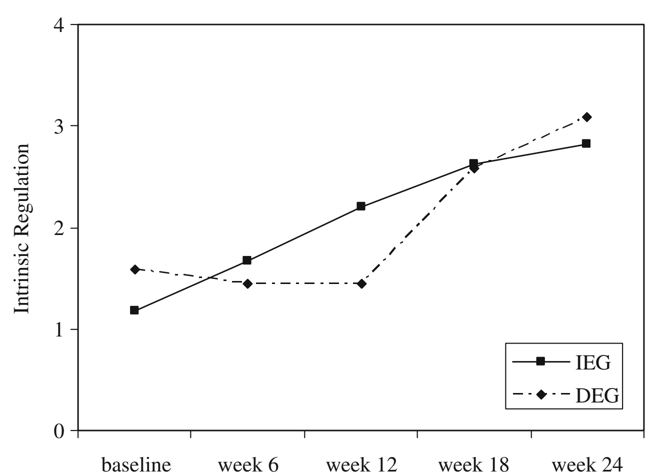

Fig. 5 Intrinsic regulation from baseline to week 24 by group assignment (N=58)

Table 3 Associations between basic needs and motivation at week 12 (N=58)

Week 12	Autonomy	Competence	Relatedness	Amotivation	External	Introjected	Identified	Intrinsic
Autonomy								
Competence	0.847[a]							
Relatedness	0.803[a]	0.858[a]						
Amotivation	−0.233	−0.287[b]	−0.325[b]					
External	−0.224	−0.318[b]	−0.379[a]	0.863[a]				
Introjected	0.153	0.095	0.028	−0.041	−0.021			
Identified	0.455[a]	0.556[a]	0.451[a]	−0.529[a]	−0.458[a]	0.340[a]		
Intrinsic	0.464[a]	0.590[a]	0.588[a]	−0.605[a]	−0.534[a]	0.214	0.845[a]	

[a] Association significant at the 0.01 level (two-tailed).
[b] Association significant at the 0.05 level (two-tailed).

regulations for exercise (i.e., identified regulation and intrinsic motivation), as well as perceived autonomy, competence, and relatedness, over the course of the 12-week program. These data provided promising evidence that supervised aerobic and resistance exercise soon after breast cancer treatments may lead to autonomously motivated exercise behavior which may result in longer term exercise adherence.

This is an important finding given that breast cancer survivors have been shown to decrease or even cease exercising after their treatment has finished [6]. Previous research has shown that in the early stages of exercise adoption, more extrinsically motivated reasons such as weight loss dominate [31]. Therefore, we expected more extrinsic motives to dominate during the early stages of exercise adoption, which we speculated to have stemmed from issues such as a perceived reward (e.g., weight loss) from engaging in the program or as a result of feelings of guilt because a significant other (e.g. doctor or partner) believed that they should engage in exercise. We found that the participants' exercise regulations became more intrinsic after completing the exercise program. The IEG developed more self-determined regulations for exercise during their 12-week exercise program compared to the DEG. This finding was replicated during the cross-over portion of the study wherein the DEG also experienced significant changes. These patterns were replicated for the psychological needs of competence, autonomy and relatedness. Across all the SDT constructs, by week 24, the DEG had replicated the patterns of improvement seen by the IEG at the end of their 12-week program. Given that we were also able to show positive associations between the psychological needs and the autonomous regulations, our findings support the primary postulate of SDT that greater need satisfaction is associated with more autonomous regulations.

The increase in self-determined regulations for exercise reported by the participants is in accordance with the propositions of Deci and Ryan [17] for maintenance of an activity. This supports the findings of Wilson et al. [21] who demonstrated a positive association between autonomous motivations and more frequent exercise attendance. It can be suggested that as the participants continued in the exercise program for sustained periods, their primary motive or regulation for participation changed. Thus, the implication of this finding is that the participants were no longer exercising simply for extrinsically motivated reasons, but were developing an interest or value in exercise [17]. This improved motivational state would be expected to result in greater long-term behavior change and possibly better outcomes such as improved fitness and overall well-being. A more intrinsically motivated state may be achieved by offering interventions designed to support autonomy (e.g., by providing a non-controlling environment in which to exercise), develop perceived competence (e.g., by teaching correct techniques), and enhance relatedness (e.g., by offering group classes).

A question that remains unanswered is whether or not the participants progressed from one regulation to the next in an orderly fashion (from extrinsic regulations to intrinsic motivation). Our associations between the psychological needs and exercise regulations offer partial support for previous reports that adjacent regulations along the continuum are more strongly associated than the distal regulations [19, 26]. These findings also support previous research illustrating the usefulness of the BREQ-2 as an instrument for analyzing the motivation continuum [8, 27].

Several RCTs have been conducted examining the effects of exercise interventions on motivation for cancer survivors that offer support for the present study. For example, Courneya et al. [22], using the Theory of Planned Behavior [32], were able to show that a structured exercise intervention resulted in more positive exercise attitudes, perceptions of control, and perceived support in a sample of post-treatment breast cancer survivors. Although the level of support was not measured in these studies, it is possible that the autonomously supportive environment allowed participants to make their own exercise choices as well as work within their own abilities. The participants also received continued supervision during their time at the fitness center.

Certainly, while future research needs to examine how we can increase cancer survivors' receptivity for exercise interventions, it is possible that the same factors that entice people into exercise programs may also help maintain their interest. As has been successfully shown in other health behaviors such as smoking cessation, diabetes control, or weight management [11–14], offering an autonomously supportive environment can result in sustained behavior. In our study, we encouraged a commitment to attend the exercise program by offering personalized exercise programs with one-on-one supervision, as well as interaction with other cancer survivors in a friendly, non-threatening fitness center. Although only anecdotally observed, we believe these factors helped maintain adherence and, therefore, indirectly had an impact on participants' motivations and basic needs, and perhaps most significantly, on perceived competence. If we can increase survivors' exercise motivation shortly after treatment so that they enjoy and value exercise rather than simply participate for extrinsic reasons, we may be able to have a more sustained impact on psychological and physiological outcomes.

The main strengths of our trial include being the first study to examine the effects of structured exercise on motivational constructs from SDT; the supervised combined aerobic and resistance exercise program; the excellent retention rate, and the RCT with a complete cross-over design and replication of results. The main limitations of our trial include the modest sample size, the modest internal consistency for two of the BREQ-2 subscale items (amotivation α=0.53; introjected regulation α=0.68) and the modest adherence rate. We also acknowledge that a number of multiple statistical comparisons were made which can potentially increase the likelihood of chance findings occurring. Nevertheless, given the highly significant results and consistency of the overall pattern of findings combined with a robust study design, we believe that our results are reliable. However, our results need to be replicated in additional studies so to determine the generalizability of our findings, as well as to determine the validity and suitability of the BREQ-2 in measuring motivation amongst breast cancer survivors.

Finally, although the exercise program was supervised, we made every attempt to ensure that autonomy was not undermined as the study design afforded opportunities for autonomous decision-making to occur in terms of the participants' choices within the exercise program, as well as in attendance time and length of stay. One drawback of this flexibility may have been that participants did not have to attend the fitness center at a designated time and, therefore, could easily choose not to attend. Also, as participants were new to gym-based exercise, it is likely that they may have experienced some muscle soreness and fatigue at the commencement of the program, as well as when individual workload was periodically increased. Each of these reasons may have contributed to the modest 61% adherence rate [7].

Future research with cancer survivors should examine the interplay between relatedness and exercise regulations more fully. To date, relatedness has largely been excluded in the literature [33], yet satisfaction of all three psychological needs can lead to stability in self-esteem, which in turn, can lead to the pursuit of goals for more autonomous (intrinsic and identified) reasons [34]. Therefore, development of relatedness in conjunction with autonomous support has the potential to enable a cancer survivor to develop a sense of belonging, and integrate exercise into their sense of self as a survivor. This may only be possible as long as the exercise environment supports a person's psychological needs and may wane if only short-term exercise solutions are available. One factor worth considering is that previous research examining long-term behavior change has reported that at least 6 months of continuous adherence to a new behavior is required to see a lasting change [35]. Thus, future research should recognize that there is a need to test SDT across more diverse cancer survivor groups with regard to actual exercise behavior, using more objective measures of performance. In addition, consideration should be given towards conducting longitudinal studies that examine the changes in motivation and psychological needs after cessation of a short-term exercise program, but also, with people who adhere to long-term exercise programs. This latter point is particularly applicable with long-term cancer survivorship. This will provide more information for health professionals with regards to long-term changes, as well as identify critical periods at which motivations may be compromised which could then serve as a prompt for appropriate intervention.

In summary, the results from this current study demonstrated that a structured exercise program can positively affect the psychological needs and exercise motivations of breast cancer survivors in a manner that is conducive to long-term exercise behavior change. However, further research is required to fully understand the efficacy of SDT in examining cancer patients' and survivors' motivation and in predicting and understanding their future exercise behavior.

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