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Ease of walking associates with greater free-living physical activity and reduced depressive symptomology in breast cancer survivors: pilot randomized trial

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Abstract

Purpose—We hypothesized exercise training-induced improvements in ease of walking would associate with favorable changes in objectively measured physical activity (PA) and self-reported depressive symptoms following a PA behavior-change intervention in non-metastatic breast cancer survivors (BCS).

Methods—Twenty-seven BCS received random assignment to an intervention (INT) or control group (CON). INT included counseling/group discussions coupled with supervised exercise tapered to unsupervised exercise. PA, depressive symptoms, and ease of walking were evaluated pre-/post-intervention using 10-day accelerometry, HADS Depression subscale, and indirect calorimetry during a standardized treadmill test, respectively. PA composite score was calculated by converting weekly-minutes of moderate-to-vigorous PA and average steps/day to z-scores then dividing the sum by 2. Cardiac efficiency was determined by dividing steady-state oxygen uptake by heart rate to evaluate the volume of oxygen consumed per heartbeat.

Results—ANCOVA revealed a significant time by group interaction showing the INT group exhibited greater positive changes in the PA composite compared to the CON (INT, $+0.14 \pm 0.66$ au vs. CON, -0.48 ± 0.49 au; $p=0.019$; $\eta_p^2=0.21$). Changes occurring from baseline to follow-up, among all participants, revealed improved ease of walking (less oxygen uptake) associated with increased PA composite ($r=-0.52$; $p=0.010$) and lower depressive symptomology ($r=0.50$; $p=0.012$) adjusted for age, race, and months since cancer diagnosis. Increased cardiac efficiency during the standardized treadmill test also associated with less daily sedentary time ($r=-0.52$; $p=0.021$).

Conclusions—These data support the assertion that reducing the physiological difficulty of walking may contribute to greater engagement in free-living PA, less sedentary time, and decreased psychosocial distress among BCS.

Keywords

cardiovascular; exercise; mobility; quality of life; survivorship

Introduction

With approximately 245,000 new cases each year, the lifetime probability of breast cancer diagnosis among US women is 1 in 8 [1]. Recent evidence indicates 5-year survival rate is 91% (from 2005 to 2011), up nearly 16% compared to women diagnosed with breast cancer from 1975 to 1977 [2]. Such vast improvements are largely attributed to earlier detection methods and advances in curative therapies. However, these developments have also contributed to a growing number of breast cancer survivors (BCS) uniquely confronted with a myriad of persistent physiological and psychological challenges detrimental to their quality of life [3]. Given that incident cancer rises with age [4], targeting modifiable lifestyle factors is fundamental to efforts leading to proper restoration and preservation of overall health among BCS.

Adjusting to life can be especially difficult following breast cancer diagnosis, and as such, depression is one of the most frequently cited psychological disturbances [5]. Though multiple factors contribute to depression, the propensity for weight gain among BCS may be a significant component [6]. Likewise, late-age diagnosis of breast cancer increases the risk for functional impairment and physical inactivity [7]. Accordingly, many BCS are troubled by a cycle of weight gain and physical inactivity that may hasten deconditioning and exacerbate depressive symptomology. Therefore, increasing physical activity to mitigate both chronic-disease risk and psychological distress are widely supported for BCS [8, 9]. While a general dose-response exists between exercise and health benefits, the mechanisms by which exercise may attenuate feelings of depression is not completely understood. However, recent research has shown that increasing physical activity is independently associated with reduced depression following breast cancer diagnosis [10]. Taken together, habitual exercise may promote physical activity and psychological well-being through favorable adaptations (e.g., improved stroke volume, gas diffusion), including reduced oxygen uptake (VO_2) and reduced heart rate, thereby enabling individuals to walk with greater ease (i.e., increased physiologic reserve). Simply put, exercise-trained individuals are able to perform a given physical task while using a smaller proportion of their peak aerobic capacity.

Due to the precipitous decline in cardiorespiratory fitness following breast cancer treatment [11], participation in activities of daily-living may become especially troublesome for many BCS. Indeed, research has demonstrated that BCS tend to be more sedentary and participate in less physical activity compared to non-cancer controls [12]. However, a large body of evidence shows that reduced VO_2 and heart rate, both of which contribute to improved cardiac efficiency (i.e., more oxygen/heartbeat) alleviate the cardio-metabolic strain for a

standardized task [13–15]. While greater ease of walking can preserve cardiovascular/metabolic health among older non-cancer populations [15, 16], it is unclear how ease of walking may influence engagement in spontaneous physical activity and feelings of depression among BCS. Since longitudinal data demonstrates an inverse relationship linking poorer cardiorespiratory fitness and increased mortality from breast cancer [17], frequent participation in moderate-to-vigorous physical activity (MVPA) is strongly recommended [9]. Still, given the high prevalence of comorbid conditions among BCS [18], simply reducing sedentary time (i.e., sitting) could also prove vital. To this end, exercise-related adaptations supporting ease of walking may ultimately facilitate greater free-living physical activity and attenuate depressive symptomology in BCS.

Therefore, in this proof-of-concept pilot investigation, we explore the interrelationships of objectively measured physical activity, self-reported depressive symptoms, and walking performance following a physical activity behavior-change intervention among non-metastatic BCS. The following hypotheses were made: 1) the intervention group would exhibit a significant reduction in the physiological strain while performing a standardized walking test (i.e., ease of walking); 2) among all participants, positive changes in ease of walking would be associated with greater physical activity, less sedentary time and less self-reported depressive symptoms.

Methods

Participants and design

A two-armed randomized controlled design was employed. Participants were recruited using periodical advertisements, media releases, institutional websites, institutional cancer registry, and local cancer support groups. All participants were English-speaking females from 18–70 years of age, with a previous diagnosis of ductal carcinoma *in situ* or stage I-IIIa breast cancer. Participants were ambulatory and not receiving or planning to receive radiation/chemotherapy during study participation. Based on self-report and during the previous 6 months, only participants engaging in < 60 minutes of moderate-intensity or < 30 minutes of vigorous-intensity physical activity per week were included. Exclusion criteria were as follows: 1) metastatic or recurrent breast cancer; 2) current participation in another exercise study; 3) planned travel that would interfere with scheduled study sessions; and 4) those not receiving physician's clearance (e.g., contraindicated to participate in a regular physical activity program). Recruitment took place over a 16-month period from January 2015 through May 2016 (Figure 1). Interested participants were screened using an IRB-approved telephone script, after which, an orientation visit was scheduled for eligible participants. To enhance participant familiarization, all protocols and expectations were covered at length. Written informed consent was then provided among those intent on study involvement and scheduled for a baseline examination. Group allocation was determined at random with aid of a computer-based number generator in blocks of four. Each number was kept in a sealed envelope until completion of the baseline measures. All study procedures were approved by the local Institutional Review Board and were in accordance with the guidelines set forth by the Declaration of Helsinki. Measurement of all variables occurred at baseline and immediately following a 12 week period (i.e., M3).

Physical activity behavior-change intervention

Individuals randomized to the intervention (INT) completed 12 supervised exercise sessions during the first 6 weeks, after which, workouts were tapered solely to home-based exercise in the concluding 6 weeks. Exercise volume was advanced so that during the final 4 weeks of the intervention, participants were performing at least 150 minutes of moderate-intensity exercise per week. Treadmill workload was adjusted to elicit a target heart rate $\approx 40\text{--}60\%$ of heart rate reserve throughout. During the supervised sessions, all participants were required to perform the exercise training component on a treadmill. Following the sixth week, all forms of exercise were encouraged provided they were consistent with the guidelines of the exercise progression (i.e., target intensity and duration). To support greater precision of the target exercise intensity, all participants were given heart rate monitors (Polar Electro, Kempele, Finland) to wear during their supervised/unsupervised workouts. Following each workout, a guided, total-body stretching routine was performed. During the concluding six weeks of the intervention, at 2-week intervals, participants attended face-to-face counseling sessions with an exercise specialist. Additionally, attendance at six group discussions was required for the purpose of addressing themes relevant to exercise barriers, time/stress management, and goal setting. Supplemental materials including information concerning exercise safety, healthy nutrition, and exercise log sheets were provided. INT participants also received materials identical to that provided to the control condition.

Control

Individuals randomized to the control group (CON) were given materials available from the American Cancer Society describing the recommendations for exercise/physical activity. The control group did not receive any further contact apart from periodic check-ins conducted via telephone with research personnel.

Instrumentation and measurements

The following were self-reported: age, race, cancer stage, months since diagnosis, menopausal status, history of radiation/chemotherapy, current hormonal therapy, number of comorbidities, depression medication, smoking status, and alcohol use. Self-reported depression was evaluated using the Hospital Anxiety and Depression Scale (HADS) [19] wherein higher ratings corresponded with greater depression. Body mass index was calculated from measured body weight in kilograms divided by standing height in meters-squared. Waist circumference was measured, following exhalation, from the smallest circumference of the torso. Hip circumference was measured from maximal extension at the level of the buttocks. Averaged results from three measurements of the waist and hips were used to calculate the waist-to-hip ratio. Prior to the standardized walking test, resting heart rate was measured using a heart monitor and recorded by research personnel after a 5-minute period of quietly sitting. Age-predicted maximum heart rate ($\%HR_{\max}$) was calculated from $220 - \text{age}$ [20]. To quantify ease of walking (i.e., standardized walking test), oxygen uptake (VO_2) and carbon dioxide production were objectively measured via indirect calorimetry (MAX II Metabolic Cart, AEI Technologies, Pittsburgh, PA) where data was collected in 30-second averages during treadmill walking. After the initial equilibration period, participants performed two, continuous 4 minute stages of 0.89 m/s (2.0 mph) at 0%

grade and 2.5% grade. Steady-state VO_2 , for each stage, was defined as the highest 30-second average and used for analysis. Respiratory quotient was determined from the VCO_2/VO_2 ratio thereby providing an indicator of substrate oxidation during steady-state exercise [21]. Metabolic equivalents (METs) were calculated for each stage by dividing the measured VO_2 by 3.5 [20]. Cardiac efficiency, the amount of oxygen consumed (i.e., VO_2) per heartbeat, was calculated from steady-state VO_2 ($\text{mLO}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) and divided by the corresponding heart rate (bpm). Units are expressed in milliliters per kilogram body mass per heart beat (mL/kg/beat) to account for the weight-bearing task of walking, where higher values indicate greater cardiac efficiency (i.e., more oxygen consumed per heartbeat) [22]. Physical activity was objectively measured over 10 consecutive days using a triaxial accelerometer (GT3X, Actigraph, Pensacola, FL). Each participant wore a numbered unit to ensure the same device was worn at baseline and post-intervention follow-up (i.e., M3). Data were reduced and analyzed in a manner consistent with previously published guidelines [23]. Specific cut-points were used to examine the time spent at various intensities: [sedentary (0–100 cpm); inactive (0–499); light (500–1951); moderate (1952–5724 cpm); and vigorous (5725 cpm) [24]. In agreement with accepted physical activity guidelines [25], vigorous-intensity minutes were multiplied by 2 then added to moderate-intensity minutes. Finally, a physical activity composite was developed by converting the weekly minutes of MVPA and average steps per day to z-scores then dividing the sum by 2. This strategy permitted an objective evaluation into all forms of physical movements, in addition to activity within the moderate-to-vigorous intensity spectrum.

Statistical Analyses

Descriptive data are reported as means and standard deviations unless noted otherwise. The Shapiro-Wilk test was used to assess the normality of distributions. Where appropriate, dependent/independent t tests and chi-squared tests were used to compare continuous and categorical variables, respectively. The changes (deltas; Δ) in variables were examined by computing the differences between M3 and baseline. A two by two, repeated-measures (baseline and M3) analysis of covariance was used to compare between-group differences after adjusting for body weight as a covariate. In instances where the assumption of sphericity was violated, subsequent degrees of freedom (df values) for within-subject effects were adjusted using the Greenhouse-Geisser correction. Two tailed, parametric and nonparametric bivariate correlations were used for exploratory purposes, wherein subsequent, multivariate regressions were used to evaluate independent associations of interest while adjusting for age, race, and months since cancer diagnosis. Collinearity of diagnostics for all variables were within acceptable limits and variable inflation factors for each analysis were less than 1.24. All data were analyzed using the Statistical Package for the Social Science (SPSS version 23.0; IBM, Armonk, NY). Statistical significance was accepted if the p -value was ≤ 0.05 .

Results

Overview

Descriptive data are shown in Table 1. Following baseline assessments, no between-group differences were detected. Consistent with BMI classification, 15 of 27 (56%) participants

were obese ($> 30 \text{ kg/m}^2$) while 14 of 27 (52%) exhibited an elevated risk of incident cardiovascular disease as specified by waist-to-hip ratio (> 0.80) [26]. A notable proportion (81%) of participants reported at least one comorbidity, and thus, comorbidity score was associated with both BMI ($r = 0.410$; $p = 0.042$) and waist-to-hip ratio ($r = 0.443$; $p = 0.027$) independent of age and race. Relative exercise-intensity for stage 1 of the walking test (used to measure ease of walking) corresponded with an average VO_2 of $9.9 \pm 1.4 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ or $2.8 \pm 0.4 \text{ METs}$. Additionally, %HRmax among all participants was $65 \pm 12\%$. As expected, the transition to graded walking produced a significant increase (+12%) in VO_2 of $11.2 \pm 1.2 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ or $3.2 \pm 0.3 \text{ METs}$. Percent of age-predicted maximum heart rate also rose to $70 \pm 14\%$ during stage 2. Accelerometry-based measurement of physical activity showed the percent of total weekly-minutes were heavily comprised of sedentary ($59 \pm 6\%$) time with just $15 \pm 3.3\%$ and $3.5 \pm 1.6\%$ encompassing light and moderate-to-vigorous intensities, respectively.

Post-Intervention Follow-Up (M3)

Greater positive changes in the physical activity composite (INT, $+0.14 \pm 0.66 \text{ au}$ vs. CON, $-0.48 \pm 0.49 \text{ au}$; $p = 0.019$; $\eta_p^2 = 0.21$) were found among the INT compared to the CON. However, upon initial statistical analyses, a significant time effect ($p = 0.012$; $\eta_p^2 = 0.23$) was observed for body weight which revealed significant within-group differences. Specifically, body weight among the CON was significantly increased ($+1.5 \pm 2.2 \text{ kg}$; $p = 0.039$) which was not seen in the INT ($+0.8 \pm 2.3 \text{ kg}$; $p = 0.170$). Indeed, this finding demonstrates the susceptibility of BCS to gain weight while also underscoring the critical role of PA to modulate this risk. While both groups had a significant decrease (time effect; $p < 0.001$; $\eta_p^2 = 0.50$) in VO_2 during stage 1 of the walking test, the magnitude of change was not different between groups. Nevertheless, a significant time by group interaction (INT, $-7.8 \pm 5.2\%$ vs. CON, $+0.2 \pm 6.6\%$; $p = 0.02$; $\eta_p^2 = 0.28$) revealed the INT had a greater reduction in the %HRmax during stage 1 adjusted for body weight. Significant improvements (time effect; $p < 0.001$; $\eta_p^2 = 0.45$) in VO_2 were also seen during stage 2, although to a similar extent among groups. A time by group interaction indicated greater improvements in self-reported depressive symptoms among the INT (INT, $-2.4 \pm 4.2 \text{ au}$ vs. CON, $0.5 \pm 1.3 \text{ au}$; $p = 0.044$; $\eta_p^2 = 0.15$), although, significance was lost after adjusting for body weight. Among all participants, depressive symptoms was significantly associated with body weight ($r = 0.442$; $p = 0.031$), physical activity composite ($r = -0.500$; $p = 0.013$), and ease of walking ($r = 0.504$; $p = 0.012$) independent of age, race, and months since diagnosis (Figure 2). Of note, ease of walking was negatively associated ($r = -0.515$; $p = 0.010$) with the physical activity composite, which partly suggests, participants who performed the walking test with less difficulty (as measured by a lower VO_2) tended to engage in more physical activity (Figure 3). Accordingly, a significant time by group interaction showed the INT, albeit modestly, increased the percent of total weekly-minutes spent at light-intensity physical activity compared to the CON (INT, $+0.5 \pm 1.5\%$ vs. CON, $-1.1 \pm 1.6\%$; $p = 0.020$; $\eta_p^2 = 0.21$). Interestingly, the changes in percent of total weekly-minutes spent at light-intensity physical activity, among all participants, were associated ($r = 0.498$; $p = 0.030$) with increased cardiac efficiency during the more physiologically demanding phase of the walking test (i.e., stage 2). As shown in Figure 4, a significant association ($r = -0.471$; $p = 0.036$) revealed that

participants who exhibited greater cardiac efficiency tended to decrease the percent of total weekly-minutes spent sedentary independent of age and months since diagnosis. Lastly, RQ did not differ between groups, however, RQ during stage 1 was significantly associated ($r = -0.472$; $p = 0.017$) with physical activity composite suggesting greater lipid oxidation, an index of physical exertion, associated with more free-living physical activity (Figure 5).

Discussion

Given the persistent physiological and psychological difficulties following breast cancer diagnosis, many face an unrelenting cycle of physical inactivity that may ultimately contribute to accelerated weight gain, systemic deconditioning, and increased depressive symptomology. Accordingly, the hypotheses of the present work were predicated on the notion that exercise training-induced adaptations would enhance ease of walking (i.e., lower heart rate and VO_2), and as a result, would associate with favorable changes in objectively measured physical activity and depressive symptoms in BCS. Consistent with our hypotheses, the INT group exhibited significant changes for the following at M3: decreased cardio-metabolic strain during the standardized walking test (as represented by decreased %HRmax), increased physical activity, and decreased depressive symptomology. Notably, among all participants, we report a framework illustrating the link between physiological and psychological constructs, as significant associations were found between ease of walking, body weight, physical activity and depressive symptoms.

Although complex and often varied, depressive symptoms can affect up to 50% of women within 1 year of breast cancer diagnosis [27]. While social/family support ease depressive symptomology, a growing body of evidence recommends aerobic exercise to attenuate symptom severity and improve quality of life [28, 29]. In the present work, a significant time by group interaction revealed the INT had a decrease in depressive symptoms compared to the CON; however, significance was lost after adjusting for body weight. A positive relationship was found between body weight and depressive symptoms, suggesting participants who gained weight also tended to report greater depressive symptoms. Still, mean between-group difference during the post-intervention assessment exceeded the minimally important difference of 1.3 for depressive symptomology [30]. While the benefits of exercise to relieve depressive symptoms have been widely reported [31], no previous work has considered ease of walking as a contributor to such benefits. In the present work, we can only speculate about the mechanisms wherein exercise training modulates depressive symptoms. However, increased physiologic reserve coupled with greater physical activity may support serotonin activity and thus psychological well-being [32]. Consistent with this premise, significant associations were observed between ease of walking, body weight, depressive symptoms, and physical activity, thus underscoring the link between physiological and psychological constructs. Despite the correlative nature of our findings, it appears that even a modest quantity of exercise training improves overall mobility and reduces depressive symptoms in deconditioned BCS. Though speculative, it seems reasonable that ease of walking may have abated depressive symptoms, due in part to an increased physiologic reserve known to be essential for independent-living [33]. Participants may have felt less constrained by their physical capacities, and thus, were able to enjoy a greater range of free-living physical activities.

It is well-established that systemic deconditioning, following diagnosis, is a direct and indirect consequence of cancer therapies and lifestyle perturbations, respectively [11]. Certainly, these alterations can make even the mundane tasks of daily-living a challenge. In an effort to arrest declining cardiorespiratory fitness, multiple clinical trials have shown prescribed exercise training to be safe and effective for BCS [34–36]. While peak oxygen uptake during a graded exercise test offers diagnostic and prognostic insight concerning global cardiovascular function, evaluating physiological responses (e.g., heart rate and VO_2) during steady-state walking may also prove vital. Among all participants in the present study, the energetic cost of walking was reduced by an average of -7.4% (stage 1; 9.9 to $9.2 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) which associated with increased physical activity (i.e., physical activity composite). Similar to our previous work, albeit in a non-cancer cohort, ease of walking was shown to associate with activity-related energy expenditure and non-exercise activity thermogenesis (NEAT) [37]. Given the known propensity for weight gain [38], risk of metabolic dysfunction [39], and physical inactivity in BCS [40], exercise-related efforts optimizing ease of walking may be critical to overcoming some of the known barriers to weight control and metabolic health following breast cancer diagnosis.

At the onset of physical exertion, there is an intensity-dependent rise in heart rate to ensure tissue perfusion matches metabolic demands. For a given workload, a lower heart rate is a phenotypic response to habitual exercise training that parallels greater physiologic reserve [41]. In the present study, heart rate and VO_2 were significantly reduced during the standardized walking test post-intervention. Since BCS have an elevated risk for occult cardiovascular disease/cardiomyopathies, evaluating cardiac efficiency ($\text{VO}_2/\text{heart rate}$) during physical exertion is of clinical relevance [42]. Indeed, the quotient of VO_2 and heart rate provides an index of physiologic reserve, as values represent the volume of oxygen consumed by peripheral tissues per heartbeat. Independent of age and months since diagnosis, the present work revealed greater cardiac efficiency was associated with an increase in total weekly-minutes of light-intensity physical activity and a decrease in the percent of total weekly-minutes spent sedentary. Moreover, average VO_2 decreased by -7.1% (11.2 to $10.4 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) while $\%\text{HR}_{\text{max}}$ fell by -5.0% (70 to 65%) during stage two of the standardized walking test. Since research indicates $15 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ represents the minimum VO_2 needed for functional independence among older women [33], improvements of this magnitude may be especially meaningful.

Several limitations are present in this study. First, we recognize the restrictions of our small sample size, but it should be noted that this work was intended to be exploratory (pilot) and not intended to confirm efficacy. Nevertheless, the primary outcomes of this work are novel and provide a framework to generate future hypotheses linking ease of walking, physical activity, and psychosocial constructs in BCS. Second, it is important to note that the design was a behavior-change intervention, rather than an exercise training study [43]. It is likely that the magnitude of between-group differences may have been more pronounced if the INT included supervised aerobic and resistance exercise training [14, 15]. Third, inherent with associative data, we recognize the inability to establish causality or identify the direction of the observed outcomes. Fourth, occult cardiovascular disease can elicit atypical heart rate responses among individuals, such that managing an exercise progression solely on heart rate among this population should be performed with caution. Lastly, we acknowledge that

the INT received more contact time with research staff, and thus, differences in depressive symptoms may have been resulted from this disparity. Still, it is important to emphasize that depressive symptoms were associated with ease of walking, body weight, and physical activity among all participants. Several aspects of this work add strength to our findings, notably a randomized controlled design. Additionally, the influence of circadian rhythm on heart rate responses were minimized, as all procedures were conducted under standardized conditions controlled for time of day following an overnight fast. Breath-by-breath indirect calorimetry was used to measure oxygen uptake during treadmill walking, while parameters of physical activity were objectively evaluated over a 10-day period using a triaxial accelerometer.

Conclusion

As hypothesized, exercise training-induced improvements in ease of walking associated with greater objectively measured physical activity, less sedentary time, and reduced depressive symptomology in BCS. These findings extend the breadth of knowledge concerning the utility of exercise training to advance physiological and psychological well-being in women with a history of breast cancer. Within this context, perhaps the benefits of exercise to alleviate depressive symptoms among BCS are linked to greater physiologic function [44], as evidenced by increased ease of walking and ability to perform everyday tasks corresponding with independent living. Future work is needed to explore additional cardiovascular and biomechanical parameters contributing to the variance in ease of walking among BCS.

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Figure 1.
Participants' flow through the study

Figure 2.

Proposed model illustrating the inter-relationships concerning ease of walking, physical activity composite, depressive symptoms and body weight in breast cancer survivors. Among the depicted variables, solid arrows ($\leftrightarrow$) represent a statistically significant, $p < 0.05$, relationship in the changes (Δ) from baseline to M3 adjusted for age, race and months since diagnosis. Note the dashed arrow ($\dashleftrightarrow$) denotes a nonsignificant ($p > 0.05$) relationship in deltas, however, a significant ($r = -0.420$, $p = 0.029$) relationship was observed between the physical activity composite and body weight at M3. Depressive symptoms were measured using the depression subscale of the Hospital Anxiety and Depression Scale. Greater ease of walking was determined by oxygen uptake during a standardized walking test (i.e., lower values indicating greater ease). The physical activity composite was calculated by converting weekly minutes of moderate-to-vigorous physical activity and average steps per day to z-scores then dividing the sum by 2.

Figure 3.

Unadjusted scatterplot of the changes () occurring from baseline to M3 concerning the physical activity composite and changes in oxygen uptake during a standardized treadmill test of walking 2.0 mph at 0% grade. Average relative exercise-intensity corresponded to $9.2 \pm 1.1 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ or 2.6 METs at M3. Note the intervention (●) tended to walk with greater ease (i.e., less oxygen uptake) compared to the control (○) while also exhibiting more physical activity ($n = 27$) (*denotes $p < 0.05$).

Figure 4.

Unadjusted scatterplot of the changes () occurring from baseline to M3 concerning percent of weekly sedentary minutes as evidenced by a 10-day period of accelerometry and changes in cardiac efficiency during a standardized walking test of 2.0 mph at 2.5% grade. Average relative exercise-intensity corresponded to $10.4 \pm 1.1 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ or 3.0 METs at M3. Note the favorable increase in amount of oxygen per heartbeat associated with a reduction in weekly sedentary time ($n = 22$) (*denotes $p < 0.05$).

Figure 5. Unadjusted scatterplot of the changes () occurring from baseline to M3 concerning the physical activity composite and changes in respiratory quotient (RQ) during a standardized treadmill test of walking 2.0 mph at 0% grade. Note the tendency for favorable gains in physical activity corresponded with greater lipid oxidation as indicated by a lower RQ. ($n = 27$) (*denotes $p < 0.05$).

Table 1Baseline descriptive characteristics ($n = 27$)

Variables	
Race [no., (%)]	
African American	11, (41%)
European American	16, (59%)
Age (y)	55 ± 7
Height (m)	1.62 ± 0.06
Weight (kg)	85.3 ± 23.2
Body Mass Index (kg/m ²)	32.3 ± 8.7
Waist-to-Hip Ratio	0.80 ± 0.06
Current Smoker [yes, (%)]	2, (7%)
Employment [yes, (%)]	13, (48%)
Marital Status [yes, (%)]	
Married/living with sig. other	17, (63%)
Other	10, (37%)
Number of Comorbidities [no., (%)]	
0	5, (19%)
1–2	9, (33%)
>3	13, (48%)
Post-menopausal [yes, (%)]	21, (78%)
Months since diagnosis	52 ± 59
Cancer Stage [no., (%)]	
1	9, (33%)
2	14, (52%)
3	4, (15%)
History of Chemotherapy [yes, (%)]	18, (67%)
History of Radiation [yes, (%)]	15, (56%)
Hormonal Therapy [yes, (%)]	5, (18%)
HADS Depression Scale ^a	4.9 ± 3.5
Antidepressant Medication [yes, (%)]	10, (37%)

Values are shown in means and standard deviations unless noted otherwise.

^aHospital Anxiety and Depression Scale (HADS), higher scores indicating greater disturbance.