Effects of exercise on physiological and psychological variables in cancer survivors

TIMOTHY R. BURNHAM and ANTHONY WILCOX

Department of Physical Education, Health and Leisure Services, Central Washington University, Ellensburg, WA; and Department of Exercise and Sport Science, Oregon State University, Corvallis, OR

ABSTRACT

BURNHAM, T. R., and A. WILCOX. Effects of exercise on physiological and psychological variables in cancer survivors. *Med. Sci. Sports Exerc.*, Vol. 34, No. 12, pp. 1863–1867, 2002. **Purpose:** The primary purpose of this study was to examine the effect of aerobic exercise on physiological and psychological function in patients rehabilitating from cancer treatment. A second purpose was to evaluate the differential effects of low- and moderate-intensity exercise on these variables. **Methods:** Eighteen survivors of breast or colon cancer (15 female and 3 male, 40–65 yr of age) served as subjects. The subjects were matched by aerobic capacity and scores on a Quality of Life questionnaire, and then randomly assigned to a control, low- (25–35% heart rate reserve (HRR)), or a moderate- (40–50% HRR) intensity exercise group. The exercise groups performed lower-body aerobic exercise three times a week for 10 wk. After the exercise training, there were no statistically significant differences between the two exercise groups on any of the physiological variables. Therefore, the exercise groups were combined into one group for the final analysis. **Results:** The results revealed statistically significant increases in aerobic capacity ($P < 0.001$) and lower-body flexibility ($P = 0.027$), a significant decrease in body fat ($P < 0.001$), and a significant increase in quality of life ($P < 0.001$) and a measure of energy ($P = 0.038$) in the exercise group when compared with the control group. **Conclusion:** Low- and moderate-intensity aerobic-exercise programs were equally effective in improving physiological and psychological function in this population of cancer survivors. Aerobic exercise appears to be a valuable and well-tolerated component of the cancer-rehabilitation process. **Key Words:** CANCER SURVIVOR, LOW-INTENSITY ACTIVITY, BREAST CANCER, COLON CANCER, ONCOLOGY, QUALITY OF LIFE

As a result of improved diagnosis and treatment, more people are surviving cancer. Cancer survival, however, brings with it physiological and psychological side effects including muscular atrophy, weight changes, lowered aerobic capacity, decreased strength and flexibility, nausea, fatigue, depression, and an overall decrease in the quality of life (2,4,7,11,12,18,21,25). The majority of these side effects appear amenable to improvement through regular exercise, and the research that has been conducted with cancer survivors indicates that exercise can be an effective tool in the rehabilitation of cancer patients (5,6,9,19–21,28,30–32). These studies have shown that cancer patients who exercise as part of their rehabilitation can improve aerobic capacity (19,20), walking speed and distance (5,6), muscular strength (9), and body composition (31), reduce nausea (30) and fatigue (5,6), and improve quality of life (9,19,32).

Although exercise appears to have a positive effect on physiological and psychological function in people rehabilitating from cancer treatment, to date, there has been no single study of cancer survivors that has evaluated the effect of a supervised exercise program on the physiological measures of aerobic capacity, body composition, lower-body flexibility, as well as psychological measures of quality of life, energy, fatigue, and anxiety. In addition, the previous research on the effects of exercise for cancer survivors has used moderate (65–85% of peak heart rate) (19,20,30,31) or high (80% of maximum heart rate) (5,6) exercise intensities. In light of the Surgeon General's recommendation for the inclusion of moderate physical activity in daily living to improve the health of the American public (28), and the growing body of literature demonstrating the efficacy of low-intensity (17) or "lifestyle" physical activity (8) to yield health benefits, it was of interest in this study to evaluate the effects of two levels of exercise intensity. Therefore, the purpose of this study was to investigate the effect of low- and moderate-intensity aerobic exercise on physiological and psychological function in people who had survived cancer treatment.

Address for correspondence: Tim Burnham, Central Washington University, Department of PEHLS, 400 E. 8th, Ellensburg, WA 98926-7572; E-mail: tim.burnham@cwu.edu.
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METHODS

Subjects. Twenty-one people (18 female and 3 male, ages 40–65 yr) who were at least 2 months postcancer treatment served as subjects. The subjects were recruited from the local area hospital and medical clinic. To be eligible, the subjects had to be cleared by their physician to participate, be surviving breast, colon, or lung cancer (the three most common cancers in the region), not currently taking any mood enhancing medications or herbal remedies, and receive a score of 70 or more on the Karnofsky Performance Status Scale (KPS) (22). The KPS measures functional status based on performance of physical activity. In addition, the subjects could be surviving any of the three main types of cancer treatment (surgery, radiation, and chemotherapy) or a combination of the three. All subjects signed and received a copy of the informed consent form following the procedures approved by institutional review boards of Oregon State University, Corvallis, OR, and the St. Charles Medical Center, Bend, OR.

Design and procedure. Subjects were matched by aerobic capacity (relative) and quality of life, and then randomly assigned to either a control group (no exercise, $N = 7$), a low-intensity exercise group (25–35% of heart rate reserve (HRR), $N = 7$) or a moderate-intensity exercise group (40–50% HRR, $N = 7$). All subjects reported to the laboratory at the onset of the study for collection of demographic and medical information. Subsequently, the following physiological pretest measures were collected: peak aerobic capacity (treadmill), body composition (3-site skinfold) (14,15), and lower-body flexibility (modified sit and reach). The aerobic capacity test was conducted on a treadmill (Leeson Speedmaster, Grafton, WI). Subjects first established a comfortable walking pace (1.5–4 mph) on the treadmill, then the grade of the treadmill increased 1° every minute. The subjects were verbally encouraged to perform maximally. The test continued to volitional exhaustion. Oxygen consumption was measured using an open circuit indirect calorimetry technique. Before each test, the metabolic cart (Vacu Med Vista Mini CPX, Ventura, CA) was calibrated to known concentrations of oxygen and carbon dioxide.

The subjects also completed the Quality of Life Index for Cancer Patients (100-mm analog, measuring quality of life) (23) and the Linear Analog Self-Assessment (LASA) (100-mm analog, measuring fatigue, anxiety, confusion, depression, energy, and anger) (27). The 10-wk study period followed the initial data collection, with the exercise groups reporting for the supervised exercise program three times a week. The same physiological and psychological measures were collected at the end of week 5 and after the end of week 10.

The aerobic-exercise program was performed on treadmills, stationary bicycles, and stair-climbing machines. The exercise intensity for the low-intensity group started at 25–35% HRR, building to approximately 40% HRR by week 10. Similarly, exercise intensity for the moderate-exercise group started at 40–50% HRR and rose to approximately 60% HRR by the 10th week. Heart rate was monitored by the subjects and the supervisor during exercise using a Polar heart rate monitor (Target model, Kempele, Finland). The duration of the aerobic exercise was initially 14 min and was divided equally among the three exercise modalities (4 min and 40 s on the treadmill, stair-climber, and stationary bicycle in a rotational order). In accordance with the American College of Sports Medicine recommendations (16), the aerobic-exercise period was increased by 2 min a week, such that it was 32 min during week 10.

TABLE 1. Subject characteristics (mean ± SD).

	Control ($N = 6$)	Low Intensity ($N = 6$)	Moderate Intensity ($N = 6$)
Age (yr)	56.0 ± 10.1	54.2 ± 8.1	50.7 ± 8.2
Height (cm)	163.8 ± 10.4	170.2 ± 8.8	166.3 ± 7.1
Weight (kg)	63.9 ± 19.3	90.9 ± 30.1	66.7 ± 10.9
Aerobic capacity ($mL \cdot kg^{-1} \cdot min^{-1}$)	26.4 ± 8.1	28.5 ± 12.8	28.3 ± 10.7
Quality of life	88.5 ± 8.3	83.3 ± 17.7	91.74 ± 4.5
Gender	Female = 5 Male = 1	Female = 5 Male = 1	Female = 5 Male = 1
Karnofsky score	95.8 ± 6.6	93.3 ± 12.1	92.5 ± 4.2
Type of cancer	Breast = 5 Colon = 1	Breast = 5 Colon = 1	Breast = 5 Colon = 1
Type of treatment (nos. may be greater than N due to combination therapy)	Chemotherapy = 5 Radiation = 2 Surgery = 4	Chemotherapy = 5 Radiation = 5 Surgery = 3	Chemotherapy = 4 Radiation = 3 Surgery = 4
Time posttreatment (months)	9.0 ± 5.3	10.3 ± 5.1	9.8 ± 4.2

Statistical analysis. A repeated-measures ANOVA was used to determine whether the changes to the physiological dependent variables were statistically significant. Nonparametric statistics (Friedman two-way analysis of ranks) were used to test for differences between groups for the psychological dependent variables. A follow-up Mann-Whitney *U*-test was used to determine which groups were significantly different from each other. An alpha level of $P < 0.05$ was considered statistically significant. All analyses were conducted with SPSS 10 software (SPSS, Inc., Chicago, IL).

RESULTS

Demographic data pertaining to age, height, weight, gender, Karnofsky score, type of cancer, type of treatment, time postcancer treatment, initial aerobic capacity, and quality of life appear in Table 1. No significant differences were found between the groups on age, height, weight, Karnofsky score, time postcancer treatment, initial aerobic capacity, or quality of life.

No subject in any group withdrew from the study, nor did any subjects in the exercising groups suffer an exercise-related injury during the investigation. The combined exercise group attendance rate was 95%. One subject was excluded from the control group when a poststudy questionnaire revealed that she had engaged in significant exercise training during the course of the study, contrary to the instructions received for her participation as a control subject. To maintain the matched group status, the two subjects matched with the excluded control subject were also removed from the analysis. This reduced the size of each group from seven subjects to six.

TABLE 2. Physiological measures for the low- and moderate-intensity exercise groups (posttreatment mean ± SD).

Dependent Variables	Low Intensity ($N = 6$)	Moderate Intensity ($N = 6$)	P
Aerobic capacity ($mL \cdot kg^{-1} \cdot min^{-1}$)	33.0 ± 12.6	34.4 ± 9.7	0.824
% body fat	25.1 ± 11.3	21.8 ± 5.9	0.512
Sit and reach (cm)	34.4 ± 11.2	36.4 ± 6.6	0.722

Analysis of variance results revealed no significant differences between the exercise groups on any of the physiological study variables (Table 2). The intent of using two exercise intensities in this study was to ascertain which level brought about the greatest benefit. Because the analysis indicated that the two exercise groups did not respond differently, the results of the two exercise groups were combined into one group ($N = 12$) and compared with the control group ($N = 6$) for final analysis. The means and standard deviations for the three dependent physiological variables for the control group and the combined exercise groups appear in Table 3.

The repeated measures ANOVA results revealed a statistically significant within subjects difference for aerobic capacity ($P < 0.001$), body composition ($P < 0.001$), and modified sit and reach ($P = 0.027$). The interaction effect for group by time was significantly different for all three variables (aerobic capacity: $P = 0.007$; body composition: $P = 0.020$; and modified sit and reach: $P = 0.002$). Therefore, the exercise group significantly increased on measures of aerobic capacity and modified sit and reach, and significantly decreased body fat percentage over the three test periods when compared with the control group. The groups did not differ significantly on body weight over time (control group $P = 0.509$; exercise group $P = 0.560$) or between groups ($P = 0.244$).

The psychological variables assessed in this study are presented in Table 4. With the quality of life measure, the higher score means a higher quality of life, whereas the lower score in the LASA data is the more desirable score (less fatigue). The analysis revealed a significant increase in quality of life ($P < 0.001$) and a measure of energy ($P = 0.038$) in the exercise group when compared with the control group. Measures of fatigue and anxiety significantly decreased ($P = 0.029$ and $P = 0.011$, respectively) in the exercise group between the pre and post-study measurements but were not significantly different from controls ($P = 0.160$ and $P = 0.373$, respectively).

DISCUSSION

This study found that 10 wk of a low- to moderate-intensity aerobic-exercise program significantly improved aerobic capacity, body composition, lower-body flexibility, quality of life, and a measure of energy over time in exercising cancer survivors compared with the control group. Further, a measure of fatigue and anxiety significantly decreased in the exercise group but not in the control group.

In keeping with recent trends in exercise prescription to encourage even modest levels of physical activity for health benefits, this study evaluated the effects of two levels on exercise intensity (low and moderate). No statistically significant differences were found in any of the physiological and psychological variables studied between the exercise groups. It is possible that the combination of low- to moderate-intensity and moderate-duration exercise for a 10-wk period did not impose sufficient differential overload to produce significant differences between the exercise groups. Within the time period studied in this project, low-intensity exercise was as beneficial as moderate-intensity exercise in this group of subjects. This is in keeping with several other studies that have shown that lower-intensity exercise produced health benefits similar to those from moderate-intensity exercise (8,17). There is a growing body of research demonstrating that physical activity, when performed on a regular basis, need not be strenuous to achieve health benefits (28). It is unknown whether or not any differences in fitness outcomes would have been evident had the exercise treatment continued beyond the 10-wk duration of this study.

The low- to moderate-exercise intensities used in this study appear to be well tolerated by people surviving cancer. The attendance rate for the participants was very high (95%). Direct comparisons to other studies are difficult to make because attendance and adherence rates have not been widely reported (10). However, the lower-intensity level may have allowed the subjects in the current study to adapt more easily to the exercise and so attend more of the sessions. In addition to the high attendance rate, no subjects withdrew or were injured during this training regimen, which indicates that this population can exercise safely and effectively for a 10-wk period.

Rehabilitating cancer patients often experience prolonged inactivity due to treatment side effects (19). This can lead to a progressive decline in physiological function characterized by weakness and rapid fatigue upon exertion (19). The development of aerobic capacity is an important factor in reducing fatigue and increasing the ability to take part in daily activities (19,21,29). The physiological improvements may be responsible for the psychological effects noted in this study.

The psychological data revealed a significant increase in energy for the exercise group when compared with the control group, and a significant pre- to poststudy decrease in fatigue and anxiety in the exercise group. These findings are similar to those reported by other researchers (5,6,9,19, 21,24), who found that exercise reduces fatigue and measures of emotional distress. In particular, Schwartz et al. (24) found that women undergoing chemotherapy for breast cancer significantly reduced fatigue with a home-based, low- to moderate-intensity aerobic-exercise program. Fatigue is a common side effect of cancer treatment, occurring in approximately 70% of patients and often lasting for months or even years (2,3,26). Rest is one approach often taken to counteract fatigue. However, if patients become inactive after cancer treatment, physiological and psychological deterioration will occur (6,21). The results of this study indicate that exercise can reduce fatigue and anxiety and increase energy, counteracting some of the negative consequences of cancer treatment and recovery.

TABLE 3. Physiological measures for the control and combined exercise groups (mean ± SD).

Dependent Variables	Pretreatment	Mid-treatment	Posttreatment	% Change Pre to Post-Treatment
Aerobic capacity ($mL \cdot kg^{-1} \cdot min^{-1}$)				
Control	26.4 ± 8.1	27.3 ± 7.3	27.1 ± 7.8	+2.7%
Exercise	28.4 ± 11.2	32.2 ± 11.3	33.7 ± 10.7	+18.6%*†
Aerobic capacity ($L \cdot min^{-1}$)				
Control	1.7 ± .8	1.7 ± .7	1.7 ± .7	0.0%
Exercise	2.1 ± .7	2.4 ± .7	2.5 ± .6	+19.2%*†
Weight (kg)				
Control	63.9 ± 19.3	64.6 ± 21.1	63.7 ± 19.1	−0.2%
Exercise	78.7 ± 25.0	78.7 ± 25.0	78.2 ± 24.3	−0.6%
% body fat				
Control	24.7 ± 6.6	24.5 ± 5.6	24.6 ± 5.5	−0.1%
Exercise	25.8 ± 9.5	24.7 ± 9.2	23.4 ± 8.7	−2.4%*†
Sit and reach (cm)				
Control	30.8 ± 6.1	32.9 ± 5.3	29.6 ± 8.5	−3.9%
Exercise	30.3 ± 10.5	32.7 ± 10.2	35.4 ± 8.8	+16.8%*†

* Significant within group difference over time, $P < 0.05$.
† Significant between group difference, $P < 0.05$.

As more patients are surviving cancer diagnosis and treatment, the quality of a person's life may be as important as the length of life (1,11,21,32). For this reason, the effort to improve the quality of life is a main focus of cancer rehabilitation (12). This study found that the quality of life measure was significantly improved in the exercise group but not in the control group, which is in keeping with other reports (9,19,32). Quality of life encompasses both psychological and physiological function. Common psychological side effects of cancer treatment include fatigue, depression, anxiety, confusion, body-image concerns, and a sense of a loss of control over normal activities (12). Coupled with these psychological side effects is the physiological decline associated with inactivity. A number of primarily psychological interventions such as education and support groups are available to help patients cope with disease and treatment. Recently, the value of support groups for cancer patients has come into question (13). Helgeson and coworkers (13) report that support groups were effective for women surviving breast cancer if they lacked social support at home; however, for the women with high social support at home, a decrease in physical functioning was seen after attending support groups.

This study found that an exercise intervention provided both physiological and psychological benefits. Although causal relationships between the physiological and psychological variables studied cannot be ascertained within the design of the present study, it is possible that the subjects felt more self-sufficient and in control of their lives as they improved their aerobic capacity and flexibility, and decreased their body fat. In addition, the small-group exercise sessions may have, as an unintended effect, created a support group-like environment for these cancer survivors, because it united people who had faced similar serious health challenges and, in a carefully monitored and encouraging setting, allowed them to initiate an exercise program together.

This study may be the first investigation to attempt to identify the effect of two levels of exercise intensity on both physiological and psychological functioning in cancer survivors. Other strengths of the study included the

TABLE 4. Psychological measures (mean ± SD).

Dependent Variables	Pretreatment	Mid-treatment	Posttreatment	% Change Pre- to Post-Treatment
Quality of life				
Control	88.5 ± 8.3	86.5 ± 7.3	86.6 ± 6.2	−1.9
Exercise	85.7 ± 13.7	89.8 ± 12.9	95.1 ± 4.4	+9.4*†
LASA				
Fatigue				
Control	29.0 ± 23.3	26.5 ± 19.6	32.2 ± 34.5	+3.2
Exercise	31.4 ± 21.1	21.6 ± 24.0	15.3 ± 21.4	−16.1*
Anxiety				
Control	23.5 ± 20.0	25.8 ± 12.3	19.7 ± 26.1	−3.8
Exercise	21.3 ± 21.8	22.4 ± 24.9	5.9 ± 5.6	−15.4*
Confusion				
Control	11.7 ± 18.7	21.2 ± 17.5	11.5 ± 15.7	−0.2
Exercise	11.2 ± 20.2	5.9 ± 11.2	6.6 ± 10.2	−4.6
Depression				
Control	9.7 ± 14.8	15.7 ± 17.5	17.5 ± 16.0	+7.8
Exercise	11.1 ± 15.9	12.0 ± 15.5	4.8 ± 5.2	−6.3
Energy				
Control	35.2 ± 13.5	31.2 ± 13.5	38.7 ± 13.4	+3.5
Exercise	36.3 ± 26.1	20.5 ± 16.9	19.7 ± 15.7	−16.6*†
Anger				
Control	11.2 ± 15.5	10.8 ± 11.4	13.0 ± 21.6	+1.8
Exercise	14.4 ± 17.6	10.6 ± 18.1	15.5 ± 22.1	+1.1

* Significant within group difference over time; $P < 0.05$.
† Significant between group difference, $P < 0.05$.

utilization of a control group and matching all groups at the onset on two variables (aerobic capacity and quality of life). In addition, this study evaluated both psychological and physiological responses to exercise training. The generalizability of this study is limited to subjects who were 9–10 months posttreatment exercising at a low to moderate intensity for 10 wk. More study is needed to evaluate the effectiveness of a similar exercise program over a longer period of time and with a larger, more varied population of cancer survivors.

CONCLUSION

The results of this study indicate that a low- to moderate-intensity aerobic-exercise regimen can be a safe and effective means to improve aerobic capacity, body composition, flexibility, quality of life, and measures of energy, fatigue, and anxiety in cancer survivors. Furthermore, the exercise regimen was well tolerated by the subjects, and exercise adherence was excellent. These findings make a strong case for incorporating low- or moderate-intensity exercise in the rehabilitation of cancer survivors.

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