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# Impact of a walking intervention on cardiorespiratory fitness, self-reported physical function, and pain in patients undergoing treatment for solid tumors

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## Abstract

**Background—**Cancer treatment is associated with decline in measured and self-reported physical function and increased pain. We evaluated the impact of a walking intervention on these outcomes during chemotherapy/radiation.

**Methods—**126 patients with breast, prostate, and other cancers were randomized to a home-based walking intervention (exercise) or usual care (control). Exercise dose during the intervention was assessed using a five-item Physical Activity Questionnaire (PAQ). Outcome measures were cardiorespiratory fitness, expressed as peak oxygen uptake ($VO_2$) measured during treadmill testing (n=85) or estimated by 12-minute walk (n=27), and self-reported physical function, role limitations, and pain derived from Medical Outcomes Study (MOS) SF-36. Linear regression was used to evaluate pre-to-post intervention change outcomes between groups.

**Results—**Mean (SD) age of patients was 60.2 (10.6). Diagnoses included prostate (55.6%) and breast (32.5%) cancer. Treatment included external beam radiation (52.3%) and chemotherapy (34.9%). Exercise patients reported worsening MOS-physical function role limitations by end of cancer treatment (p=.037). Younger age was associated with improved MOS-physical function (p=.048). In all patients, increased exercise dose was associated with decreased MOS-pain (p=.046), regardless of diagnosis. The percent change of peak $VO_2$ between prostate and non-prostate cancer patients when adjusted for baseline peak $VO_2$ and PAQ values was 17.45% (p=0.008), with better peak $VO_2$ maintenance in the prostate group.

**Conclusion—**Exercise during cancer treatment improves cardiorespiratory fitness and self-reported physical function in prostate cancer patients and in younger patients, regardless of

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diagnosis, and may attenuate loss of those capacities in patients undergoing chemotherapy. Exercise also reduces the pain experience.

### Keywords

cancer; physiology; chemotherapy; radiation; exercise; walking

## Introduction

While advances in cancer treatment with chemotherapy and radiation have contributed to better survival, they are associated with a number of side effects, including fatigue, anorexia, and emotional distress. Many chemotherapy regimens have become increasingly dose-dense and dose-intense and are often administered in combination with radiation therapy, which may intensify treatment-related symptoms. Furthermore, these symptoms can lead to a marked decrease in physical activity, which may result in reduced strength, muscle and bone mass, cardiorespiratory fitness, and increased pain. As treatment progresses, the accompanying physical deconditioning may result in treatment delay or drug dose reductions 1.

Population-based studies suggest that physical limitations exacerbated during cancer treatment continue beyond treatment completion if no actions are taken to counteract their effects 2, 3. Several trials have shown that individualized exercise programs are helpful in preserving or improving physical and cardiovascular fitness either during or following cancer treatment 4 5, 6 7–10. These studies were limited due to focus on a single diagnosis, such as breast cancer 7, 8, 10, 11, small numbers of patients 11–13, or requirement that patients exercise under supervision at a health care facility, often a barrier to exercise adherence 11, 14. In this randomized controlled trial it was hypothesized that a home-based walking program would increase cardiorespiratory fitness and physical function and decrease pain in patients undergoing curative treatment for a variety of cancer diagnoses.

## Patients and Methods

### Setting and Subjects

Study patients were recruited from a university teaching hospital and a community cancer center in Baltimore, Maryland (USA). The study target population was individuals aged 21 and older with diagnoses of cancer stage I–III who were scheduled to receive chemotherapy, radiation, or both. Exclusion criteria included co-morbidities such as cardiovascular disease and cognitive dysfunction, metastatic cancer, hematologic malignancies, and other conditions that could preclude the advisability or safety of a moderate-intensity walking program. Individuals who were already exercising more than 120 minutes per week were ineligible for the study.

### Recruitment and Enrollment

Potential patients were identified from patient lists in radiation oncology and medical oncology clinics and were screened by telephone interview. A total of 5,439 patients were assessed for eligibility, 620 were eligible, and 138 signed informed consent and were randomized to either the intervention or control arm (Figure 1). After enrollment and randomization, 12 patients withdrew, leaving 126 patients in the analytic sample, 68 of whom were in the walking intervention. Reasons for study dropouts in the walking intervention group (figure 1), included feeling overwhelmed (n=2), becoming too sick (n=1), change in cancer treatment plan (n=1), and refusal to be followed up (n=1). In the control group, reasons reported for dropout included change in cancer diagnosis to stage IV

following study enrollment (n=2), medical complications (n=1), psychological issues (n=2) , and objection to study group assignment (n=1).

Subjects who completed the study were compared to dropouts on age, weight, cancer diagnosis, cancer stage, cancer treatment, race and highest education level. Those who dropped out had a lower mean (SD) educational level of 14.77 years (3.52) versus 16.69 (2.74,p=.029) versus those who completed the study. A higher proportion of ethnic minorities who dropped from the study (18.1%) versus Caucasians (5.6%) (p=.024). Fitness was expressed as peak oxygen uptake ($VO_2$), either directly measured by treadmill testing or estimated from the 12-minute walk test. Subjects were given a choice of test to be administered. The treadmill test was done on a SensorMedics Vmax 229 Metabolic and ECG System. ECG and cardiorespiratory responses were continuously monitored. Subjects performed a modified Balke Protocol beginning at 3 mph, 0% grade, which increased 2.5% grade each 3 minutes. The rating of perceived exertion (RPE) using the Borg 6 to 20 scale 15 was obtained during each stage. The test was stopped at volitional fatigue. Subjects were encouraged to reach an RPE of at least 18. The respiratory exchange ratio was also monitored and patients were encouraged to reach a value of 1.1 as another indicator of maximal effort. The highest oxygen uptake reached was considered peak $VO_2$. For patients who did not perform the treadmill test due to constraints (i.e., unwillingness to travel to a separate location where testing was performed), a 12-minute walk test was administered, 16 during which patients were instructed to walk for 12 minutes as far as possible along a premeasured route, and the distance walked was measured. The distance walked was used to estimate peak $VO_2$ 17

Self-reported physical function status was measured by two subscales of the Medical Outcomes Survey Short Form 36 (MOS SF-36): a) the Physical Functioning subscale (MOS-PFS) a 10-item measure sensitive to perceived losses in functioning, which included limitations for vigorous activities, moderate activities, carrying groceries, climbing several flights of stairs, bending/kneeling/stooping, walking more than a mile, walking several blocks, walking one block, bathing or dressing oneself; and b) the Role Limitations Due to Physical Health subscale (MOS-RLPS), a 4-item measure reflecting diminishment of health-related daily activities within the preceding 4 weeks, including cutting back on work/activities, accomplishing less than desired, limitations in usual types of work/activities, and difficulty performing work/activities. Pain level was assessed using the 2-item self-report subscale (MOS-Pain), which reflects bodily pain and work interference caused by pain in the preceding 4 weeks.

## Exercise Dose

The exercise dose was measured using a five-item subscale of the Cooper Aerobics Center Longitudinal Study Physical Activity Questionnaire (PAQ), a 15-item scale which assesses degree of participation over the previous month in normal daily activities as well as in moderate or vigorous exercise activities 18. The questionnaire assigns metabolic equivalent (MET) values to the reported activities to derive MET hours expended per week. The five items chosen to reflect aerobic activity included: walking, jogging, running, swimming and biking. Although the focus of the study was on walking, which was the basis of the exercise prescription for those assigned to the exercise group, some patients performed other aerobic activities like cycling either as a substitute for or a supplement to walking. As such, these activities were included as components of the PAQ score.

## Study Protocol

The directly measured or estimated peak $VO_2$, the MOS-PFS, MOS-RLPS, and MOS-Pain subscales, and the PAQ, were administered before chemotherapy or radiation treatment (pre-

test) and after the completion of cancer treatment (post-test). Following the pre-test, which established baseline habitual activity, the two groups began their assigned programs which then continued throughout their cancer treatment.

The prescribed exercise intervention consisted of an individualized walking prescription based on American College of Sports Medicine guidelines, which encourages moderate intensity exercise that corresponds to approximately 50–70% of the maximum heart rate and is consistent with exercise recommendations for populations with chronic disease 19, 20. The exercise prescription was a brisk 20 to 30 minute walk followed by 5 minutes of slower walking (cool down), five times per week. Exercisers were telephoned biweekly by a study nurse to assess walking progress, to answer questions, and to offer support, such as listening to cancer treatment concerns. Subjects in the control group received biweekly telephone calls and were encouraged to maintain their current levels of activity, but no specific exercise advice was offered. Individuals in both groups received usual health care provided by their own oncology team. Adherence to the exercise prescription was defined as walking at least a total of 60 minutes over the course of at least 3 sessions weekly for more than two-thirds of the total number of weeks of each subject's cancer treatment. These criteria are in accordance with guidelines of the American College of Sports Medicine and CDC21. Among controls, if patients walked more than 60 minutes for more than 2/3 of their treatment weeks, they were considered non-adherent to their study assignment.

### Sample Size Calculation and Statistical Analyses

Based upon expected medium to large effect sizes reported from baseline to exercise completion for a study with similar outcomes5, our study was powered at ≥ 0.80 ($\alpha$ =0.05) with a sample size of 60 for each study group to show group differences for fitness, physical function, and pain. Descriptive statistics were calculated among those who completed the study, and for those who withdrew. Group comparisons were performed using chi-square or t-test analysis, as appropriate. Distributions of outcome measures were reviewed using histograms and boxplots; reliability coefficients were calculated for the MOS-subscales.

The primary analysis was based on Intent-to-Treat (ITT), in which group comparisons were made regardless of the degree of adherence to the assigned group. This approach is an effectiveness analysis that considers not only the efficacy of the treatment but is also influenced by whether patients actually carry out the intervention. The secondary analysis was a dose-response analysis, which evaluated outcomes based on the actual amount of exercise performed according to the PAQ, regardless of group assignment. This secondary analysis was necessitated by the fact that, contrary to study instructions, 22.4 % of the control patients performed exercise at a level at least equivalent to what was assigned for the exercise group.Pre-test group comparisons were evaluated with t-tests. Regression analyses using post-pre test change scores as outcomes and demographics and relevant pretest scores as covariates were performed under both statistical approaches. Covariates included pre-test outcome scores, pre-test and net (post-test minus pre-test) PAQ scores, and demographic variables. Data were analyzed using STATA v. 10.0 (StataCorp. 2005). Each subject provided written informed consent and the study was approved by the Western Institutional Review Board.

## Results

### Baseline Characteristics of Exercise and Control Groups

The final sample consisted of 126 patients who had a mean age of 60.2 (SD=10.6) years and were predominantly Caucasian (78.6%), male (61.1%), and partnered (84.9%). The most common diagnoses were prostate (55.6%) and breast cancer (32.5%). For the entire sample,

12 (10%) had stage I disease, 89 (70%) patients had stage II, and 25 (20%) on stage III disease. Although there was no difference in stage of disease between exercise and control groups, the non-prostate group was more heavily represented by patients with stage III disease (29%) than in the prostate group (13%; p=.013). All breast cancer patients were female. Patients were undergoing treatment with external beam radiation therapy (52.3%), chemotherapy (34.9%), combination chemotherapy and radiation (7.1%) or brachytherapy alone (5.6%). For the entire sample, mean (SD) number of cancer treatment weeks was 12.83 (5.15) with a range of 5–35 weeks. Mean (SD) total weeks of cancer treatment was 15.8 (5.89) for non-prostate and 10.44 (2.73) for prostate cancer patients. Patient characteristics are listed in Table 1. No significant differences were noted between groups except on education, where a higher percentage of exercisers versus controls had college experience or higher. Weight loss occurred in 85 (67.46%) participants during the exercise study, with more stage III patients experiencing weight loss (76%) than either stage I (67%) or II (65%).

A total of 112 patients completed a baseline and posttest treadmill or 12 minute walking test. Data from 126 patients were available for analyses of physical function and pain. Subjects completing both pre-test and posttest evaluations (n=112) in the treadmill (n=85) and 12-minute walk (n=27) groups were compared on cancer treatment type, diagnosis, randomization, and gender. No statistically significant differences were noted (data not shown). Adherence to the walking intervention was 67.6% in the exercise group, with an average walking time of 117 (SD=105) minutes per week. Among controls, adherence to their assignment was 77.6%, whereas 22% of these patients exercised more than 60 minutes during 3 sessions a week.

Patients completing both the pre-test and post test (n=112) and those who did not (n=14) were compared on group assignment, cancer diagnosis, cancer treatment type, and gender. Significant differences between the groups were noted on all of the variables (p<.002) except exercise group assignment (data not shown). Of the 14 patients not completing both tests, 71.4% had a diagnosis of breast cancer, and 14.3% colorectal cancer. These individuals were predominantly female (78.6%) and receiving chemotherapy (78.6%). Furthermore, one of those missing the pre-test, and 7 of those missing the posttest were breast cancer patients. Of the 4 patients missing both tests, two had breast cancer and two had colorectal cancer.

Baseline outcome measures between assigned groups were not statistically different. Because the number of prostate cancer patients in the study (n=70) was relatively large, comparisons of baseline outcome measures were also performed between patients with a diagnosis of prostate and non-prostate cancers. Significant differences between these groups included higher baseline pain and role limitation related to physical function in patients with non-prostate diagnoses (breast, colorectal) (Table 2).

## Reliability Analysis of Measures

Cronbach's alpha for subscale reliability was estimated at 0.77 for MOS-PFS, 0.91 for MOS-RLPS, and 0.86 for MOS-Pain, indicating acceptable reliability of the measures among patients in the study.

## Changes in Cardiorespiratory Fitness

**Dose-response analysis—**The Intent-To-Treat analysis showed an average 2.9% decrease in post-pre change of $VO_2$ max among exercisers, and a 5.6% increase among controls. However, the difference in change (−8.4%) between exercisers and controls was not significant (p=0.26). In the dose-response analysis, there was a significant difference (p

= 0.008) of 17.45% in the percent change of peak $VO_2$ max (post-pre) between prostate and non-prostate patients when adjusted for baseline $VO_2$ max test, and baseline and change of PAQ scores (Table 3). Because % change in peak $VO_2$ was the primary outcome, its association with PAQ score was ascertained by including change in PAQ as a covariate. In addition, because level of change in PAQ and peak $VO_2$ were potentially influenced by the pre-test measures, these values were also included in the regression model. On average prostate patients experienced a nearly 8 % increase, whereas those in the non-prostate group suffered a more than 9% loss (% are adjusted for covariates in the model). A similar analysis including type of $VO_2$ peak test administered showed that individuals taking the 12-min walk test had an average decrease of 17% change in $VO_2$ peak (SE=9.9, p=0.85) compared to those taking the treadmill test (data not shown).

### Physical Functioning

In Intent-to-Treat analysis, patients assigned to exercise had greater limitations in physical role (MOS-RLPS) from pre- to posttest versus controls (p=0.037)(Table 4A), when adjusting for baseline MOS-RLPS, age, cancer diagnosis, and cancer diagnosis and treatment group. Prostate cancer diagnosis was predictive of a larger increase in physical functioning compared to non-prostate cancer diagnosis when controlling for exercise group assignment and baseline MOS-PFS (p=0.19)(Table 4B). Age was inversely associated with a change in level of physical functioning (p=0.048).

### Pain

An Intent-to-Treat analysis of change in pain level (MOS-Pain), controlling for pre-test pain, age, cancer diagnosis and interaction of treatment group and cancer diagnosis, indicated no significant difference between the change in pain scores of the exercise and usual care groups (p = 0.55).–In dose response models including change in PAQ and either treatment group, cancer diagnosis or both with interaction, the only significant and consistent relationship with a change in pain was the change in PAQ. For example, an average increase in PAQ was associated with a decrease in reported pain at the end of cancer treatment (p=0.046), with adjustment for age, cancer diagnosis, and baseline pain and physical functioning (Table 5). Furthermore, an increase in reported pain was associated with an increase in physical role limitations (MOS-RLPS) (p<.01), when controlling for exercise group assignment, cancer diagnosis, baseline pain scores, and age (data not shown).

## Discussion

The key findings from this study suggest that patients who exercise during cancer treatment maintain or increase cardiorespiratory fitness and self-reported physical function and experience less pain than those who are sedentary. Regarding fitness, individuals who were undergoing treatment for prostate cancer improved fitness levels from baseline compared to those with other cancers who declined in their fitness levels. Patients with prostate cancer received radiation therapy primarily, often in association with androgen deprivation therapy, where treatment and treatment-related side effects are typically more easily tolerated than treatment with chemotherapy with or without radiation 22. The ability to adhere to an exercise regimen due to relatively minimal treatment toxicity may, in part, explain these findings. The 17% difference between prostate and non-prostate patients in net V02 max function from the beginning to end of the study does not indicate a meaningful clinical improvement in the prostate patients but does suggest a relative and potentially meaningful clinical loss of cardiorespiratory fitness for non-prostate patients, nearly all of whom were receiving chemotherapy. Thus, it is possible that differences between prostate and non-prostate patients related to the outcome of fitness improvement may be a proxy for treatment duration and intensity.

Not surprisingly, all patients who dropped out early were receiving chemotherapy, providing further evidence for the physical and other strains that are experienced with this mode of treatment. Anemia, infections, nausea, and peripheral neuropathy are among chemotherapy-related toxic effects which may interfere with ability to exercise. It is also possible that patients receiving chemotherapy who do not benefit from exercise during active treatment, such as those with severe gastrointestinal side effects, may be having problems with maintaining adequate nutrition. Evidence of weight loss in more than two thirds of patients in this study suggest that inadequate nutrition was a factor in reduced exercise, either as a result of inadequate caloric intake to allow for exercise participation, or as an indicator of reduced overall function. Future work implementing and evaluating exercise interventions that begin when chemotherapy is completed should be considered. Although length of treatment for cancer was not estimated for the exercise and control groups, there were no significant group differences on cancer site, diagnostic stage, or cancer treatment type. Attention to length of time for each cancer treatment type, and, correspondingly, the length of exercise regimen duration, however, will allow for ascertainment of fitness, physical function, and other outcomes specific to each cancer treatment type. It is well established that chemotherapy involves the greatest time to completion and often includes delays due to low blood counts or other problems. Thus, chemotherapy patients are most likely to be the heterogeneous in terms of exercise regularity and may merit separate study to identify exercise regimen components which could enhance activity benefit.

Increased doses of exercise were associated with decreased pain at the end of cancer treatment. Pain etiology (somatic, visceral, or neuropathic) and causation (directly from malignancy or from treatment side effects), and impact on daily function were not the primary focus of this study, but these data suggest that exercise decreases the pain experienced by patients undergoing cancer treatment. Additional study of exercise and its impact on specific types of cancer and cancer treatment-related pain will add important information to this understudied yet important clinical issue. Individuals with prostate cancer reported lower baseline pain levels than those with other diagnoses, so our results should be interpreted cautiously as some types of pain may be more amenable to exercise than others. Exercise has been shown to aid in management of post-radiation breast cancer pain 23, in alleviating musculoskeletal pain in the elderly 24, and in decreasing perceptions of non-cancer related pain in healthy adults 25. However, the relationship between exercise and pain has been little studied. 26 The role of exercise in cancer patients with acute or chronic pain represents a rich area for future study.

In our study, younger age was associated with better maintenance of physical function when adjusted for treatment group and cancer diagnosis. This finding, though not entirely unexpected, suggests that more work needs to be done with older patients who are at risk for physical decline even before a cancer diagnosis occurs. Older patients who are better conditioned at the onset of serious illness may be more likely to maintain that condition than those with poor levels of fitness who are also experiencing a cancer diagnosis and subsequent treatment. Aging is a risk factor for malignancy, with nearly 60% of all newly diagnosed cancers in this age group 27? The associated increased risk for cancer emphasizes the need to identify effective, low cost, easily implemented physical activities that patients can use to maintain functional status during and after cancer treatment, especially in older patients. Low-impact exercise programs such as walking may be a feasible approach to maintaining function, and more study of walking programs focused on older cancer patients is warranted.

Adherence to the assigned group was lower than expected, especially in the intervention group, but our experience is not dissimilar from other studies which involved exercise 6, 28. Though randomized controlled trials are the gold standard for testing any intervention, this

study demonstrates the difficulty in maintaining the group assignment given the mounting public knowledge and increasing promotion about the benefits of exercise for treating and managing chronic health conditions. Despite the high crossover in this study, pooling patients and analyzing results based upon actual exercise performed provides important information about the value of exercise on study outcomes. Given that those who crossed over were minimally different at baseline, the study has considerable internal validity.

Intent to treat analysis yielded only a few significant findings. This can be largely attributed to the crossover effect in both groups, where 32.4% of patients assigned to exercise "dropped out", and and 22% of controls "dropped in" to exercise. The finding that group assignment to exercise was associated with an increased limitation in physical role by the end of treatment compared to controls may imply that walkers were engaging in fewer other activities because of the time committed to walking. Alternatively, walkers may have experienced more fatigue related to increased energy expenditure during walking exercise. Energy conservation has been suggested for reducing fatigue during cancer treatment, but, more recently, exercise has been found to be helpful in managing these cancer and treatment-related conditions [6–8]. The finding that exercise in this study yielded improvement in some subscales of the MOS instrument, a quality of life measure, is consistent with other studies, in which regular exercise has been associated with improved quality of life for patients receiving cancer treatment [9, 10].

The recruitment of patients who were exercising up to 120 minutes per week may have allowed individuals with meaningful pre-treatment levels of fitness into the study, thereby obscuring baseline to follow-up changes in fitness among individuals who were not similarly active upon study entry. Dropping the baseline exercise level ceiling for study inclusion, although it may slow time to accrual completion, will help to alleviate this potential confounding issue in future research.

Strengths of this trial included an intent-to-treat analysis to evaluate an at-home exercise intervention that can be replicated by patients independently as well as in subsequent intervention studies. Although the literature supporting the benefits of exercise is considerable and continues to grow, much of it addresses its use in patients with breast cancer exclusively [8–13, 29–33]. Thus, the broad findings from published studies may not be applicable to individuals experiencing other types of cancer and their associated treatments. The present study included patients with a variety of cancer diagnoses and showed that exercise benefits are attainable for all patients in terms of pain and for maintaining physical function status among younger patients.

Though the study was designed to include more than one cancer diagnosis, the final sample size limited statistical power for subset analysis by cancer diagnosis and other variables. Another limitation was allowing the patient a choice of test for cardiorespiratory fitness assessment. This choice was made because the treadmill testing was done at a facility about 10 miles from the main study site and required a separate visit and travel whereas the 12-minute walk could be done at the main study site. The use of two methodologies for the assessment of this primary variable may have obscured study results. Offering the treadmill test at the site where patients receive treatment may preserve enrollment and allow for greater consistency in administering outcome assessments, thereby improving data intergrity

An important goal of exercise during cancer treatment should be to preserve or improve fitness, physical function, and to reduce pain. [8–10, 12–14, 33, 34]. Future intervention studies among patients receiving cancer treatment should focus on developing more specific exercise guidelines based on upon age, treatment type, and, possibly, cancer diagnosis. Though a brisk walking program is well-tolerated by prostate cancer patients and younger

individuals undergoing any type of treatment, older patients receiving chemotherapy may benefit from an exercise program that is milder, such as more leisurely walking, possibly combined with strength training, which may enhance fitness and function, and reduce pain.

**Condensed Abstract**

This randomized, controlled trial evaluated the impact of a home-based walking intervention on outcomes of cardiovascular and physical function, and pain during chemotherapy/radiation treatment (N=126). Exercise during cancer treatment improves cardiorespiratory fitness and self-reported physical function in patients with prostate cancer, younger patients, and may attenuate the loss of those capacities in patients undergoing chemotherapy.

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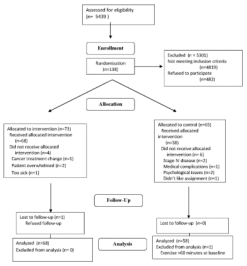


**Figure 1.**
Consort Diagram Indicating Subject Flow Through the Study

## Table 1

Comparison of Demographic Characteristics for Intent-to-Treat Groups

| | | Study Groups | | |
|---|---|---|---|---|
| | **Total** | **Exercise** | **Control** | **p-value[a]** |
| **Age** | N = 126 | N = 68 | N = 58 | |
| **Mean [Median](SD)** | 60.2 (10.6) | 59.8 (10.8) | 60.6 (10.8) | 0.70 |
| | **N (%)** | **N (%)** | **N (%)** | |
| **Gender** | | | | 0.84 |
| Male | 49 (38.9) | 27 (39.7) | 22 (37.9) | |
| Female | 77 (61.1) | 41 (60.3) | 36 (62.1) | |
| **Marital Status** | | | | 0.10 |
| Partnered | 107 (84.9) | 61 (89.7)) | 46 (79.3) | |
| Unpartnered | 19 (15.1) | 7 (10.3) | 12 (20.7) | |
| **Education** | | | | 0.04 |
| High school | 15 (11.9) | 7 (10.3) | 8 (13.8) | |
| College | 52 (41.3) | 35 (51.5) | 17 (29.3) | |
| Grad school | 59 (46.8) | 26 (38.2) | 33 (56.9) | |
| **Employment Status** | | | | 0.59 |
| Full time | 60 (55.1) | 31 (54.4) | 29 (55.8) | |
| Part time | 11 (10.1) | 5 (8.8) | 6 (11.5) | |
| Resigned | 30 (27.5) | 15 (26.3) | 15 (28.9) | |
| Disabled | 8 (3.9) | 6 (10.5) | 2 (3.9) | |
| Leave of Absence | 4 (3.17) | 1 (1.7) | 3 (4.4) | |
| Other | 13 (10.3) | 8 (11.8) | 5 (8.6) | |
| **Ethnicity/Race** | | | | 0.20 |
| Am. Indian | 1 (0.8) | 0 (0.0) | 1 (1.8) | |
| Asian/Pac. Is | 2 (1.6) | 0 (0.0) | 2 (3.6) | |
| Black/NHP | 20 (16.4) | 9 (13.6) | 11 (19.6) | |
| White | 99 (81.2) | 57 (86.4) | 42 (75.0) | |
| **Cancer Site** | | | | 0.55 |
| Breast | 41 (32.5) | 23 (33.8) | 18 (31.0) | |
| Colorectal | 7 (5.6) | 2 (2.9) | 5 (8.6) | |
| Prostate | 70 (55.6) | 38 (55.9) | 32 (55.2) | |
| Other | 8 (6.4) | 5 (7.4) | 3 (5.2) | |
| **Treatment** | | | | 0.48 |
| XRT | 66 (52.4) | 38 (55.9) | 28 (48.3) | |
| Chemotherapy | 44 (34.9) | 24 (35.3) | 20 (34.5) | |
| Both | 9 (7.1) | 4 (5.9) | 5 (8.6) | |
| Brachytherapy | 7 (5.6) | 2 (2.9) | 5 (8.60 | |

[a] t-test performed to compare age between groups; Chi-square contingency analysis performed to compare categorical demographic characteristics

**Table 2**

Comparison of Baseline Outcome Measures by Cancer Type and Exercise Group Assignment

| | | | | Cancer Diagnosis | | | |
|---|---|---|---|---|---|---|---|
| | | Prostate | | Non-Prostate | | | |
| **Outcome[a]** | **Mean** | **SD[b]** | **N** | **Mean** | **SD** | **N** | **p-value[c]** |
| Peak $V0_2$ | 13.6 | 4.5 | 70 | 13.5 | 3.9 | 51 | 0.92 |
| MOS-RLPS | 83.6 | 28.8 | 70 | 33.9 | 41.9 | 56 | < 0.001 |
| MOS-PFS | 87.7 | 13.6 | 70 | 82.9 | 15.2 | 56 | 0.07 |
| MOS-Pain | 85.3 | 16.9 | 70 | 69.2 | 22.5 | 56 | < 0.001 |

| | | | | Study Group | | | |
|---|---|---|---|---|---|---|---|
| | | Exercise | | Control | | | |
| **Outcome** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **p-value** |
| Peak $V0_2$ | 13.9 | 4.5 | 65 | 13.2 | 3.9 | 56 | 0.32 |
| MOS-RLPS | 59.2 | 43.1 | 68 | 64.2 | 42.9 | 58 | 0.51 |
| MOS-PFS | 84.3 | 15.0 | 68 | 87.1 | 13.7 | 58 | 0.27 |
| MOS-Pain | 77.8 | 22.3 | 68 | 78.5 | 19.8 | 58 | 0.86 |

[a] MOS scales range from 0 to 100; higher scores are associated with less limitation or pain

[b] SD - standard deviation

[c] t-test analyses with unequal variances were performed to compare groups on baseline outcome measures

## Table 3

Impact of exercise (dose) on percent change in $VO^2$ max (N=112)

| Summary of $VO_2$ Max scores by Cancer Diagnosis | | | |
|---|---|---|---|
| | **Other cancer (N=44) Mean [SE][a]** | **Prostate cancer (N= 68) Mean [SE]** | **Total (N=112) Mean [SE]** |
| Pre-test $VO_2$ Max score | 13.13 [0.59] | 13.73 [0.54] | 13.50 [0.40] |
| Post-test $VO_2$ Max score | 12.04 [0.69] | 13.33 [0.56] | 12.83 0.44] |
| % change[b] $VO_2$ Max score unadjusted | −7.11 [5.08] | 6.45 [6.44] | 1.12 [4.42] |
| % change $VO_2$ Max score adjusted[c] | −9.47 [5.51] | 7.98 [4.84] | 1.12 [4.03] |

[a] SE - standard error.

[b] % change $VO_2$ Max score = (post-test $VO_2$ max - pre-test $VO_2$ max)/ pre-test $VO_2$ max.

[c] Mean estimates of % change in $VO_2$ max score based on regression analysis of cancer diagnosis adjusted for pre-test peak $VO_2$, age, baseline PAQ and net PAQ, using the mean values of predictors across 112 subjects.

## Table 4

ITT analysis of predictors of change in physical functioning and role limitations (N=126)

**A. Summary of MOS-RLPS[a] Scores by Treatment Group**

| | Usual care (N=58) Mean [SE][b] | Exercise (N=68) Mean [SE] | Total (N=126) Mean [SE] |
|---|---|---|---|
| Pre-test MOS-RLPS score | 64.22 [5.64] | 59.19 [5.24] | 61.51 [3.83] |
| Post-test MOS-RLPS score | 53.45 [5.41] | 39.71 [5.19] | 46.03 [3.78] |
| Net MOS-RLPS score unadjusted | −10.78 [6.03] | −19.49 [6.26] | −15.48 [4.37] |
| Net MOS-RLPS score adjusted[c] | −8.41 [5.08] | −21.55 [4.69] | −15.48 [3.45] |

**B. Summary of MOS-PFS[d] Scores by Cancer Diagnosis**

| | Other cancer (N= 56) Mean [SE] | Prostate cancer (N= 70) Mean [SE] | Total (N=126) Mean [SE] |
|---|---|---|---|
| Pre-test MOS-PFS score | 82.90 [2.03] | 87.69 [1.62] | 85.56 [1.29] |
| Post-test MOS-PFS score | 70.27 [3.18] | 85.32 [1.89] | 78.63 [1.85] |
| Net MOS-PFS score unadjusted | −12.63 [2.73] | −2.37 [1.58] | −6.93 [1.56] |
| Net MOS-PFS score adjusted [e] | −15.71 [3.10] | 0.07 [1.64] | −6.93 [1.45] |

[a] SE - standard error.

[b] MOS-RLPS scores range from 0 to 100; higher scores are associated with less limitations.

[c] Mean estimates of net MOS-RLPS score are based on regression analysis of treatment group, adjusted for pre-test MOS-RLPS, cancer diagnosis, treatment group x cancer diagnosis and age, using the mean values of predictors across 126 subjects.

[d] MOS-PFS scores range from 0 to 100; higher scores are associated with less limitations.

[e] Mean estimates of net MOS-PFS score are based on regression analysis of cancer diagnosis adjusted for pre-test MOS-PFS, treatment group, treatment group x cancer diagnosis and age, using the mean values of predictors across 126 subjects.

## Table 5

Impact of Physical Activity (Dose) on Change in Reported Level of Pain (N=126)

| **Summary of Net MOS-Pain[a] Scores by Exercise (Dose)** | |
|---|---|
| | **Total (N=126) Mean [SE][b]** |
| Pre-test MOS-Pain score | 78.13 [1.88] |
| Post-test MOS-Pain score | 76.45 [1.93] |
| Net MOS-Pain score unadjusted | −1.68 [2.30] |
| Net MOS-Pain score adjusted at 50th percentile Net PAQ[c] (2.28)[d] | −2.49 [2.01] |
| Net MOS-Pain score adjusted at 99th percentile Net PAQ (30.67)[d] | 10.63 [5.88] |

[a] MOS-Pain scores range from 0 to 100; higher scores are associated with less pain.

[b] SE - standard error.

[c] PAQ score measures level of exercise in mets/hr based on walking, treadmill, jogging, biking, and swimming activities.

[d] Mean estimates of net MOS-Pain score are based on regression analysis of Net PAQ, adjusted for pre-test MOS-Pain, cancer diagnosis, pre-test PAQ and age, using the mean values of predictors across 126 subjects. Specific values from distribution of study's net PAQ scores are used to show the predicted level of change in MOS-Pain scores.