



Physical Activity Interventions for Cancer Survivors

Melinda L Irwin

Br. J. Sports Med. published online 23 Oct 2008;
doi:10.1136/bjsm.2008.053843

Updated information and services can be found at:
<http://bjsm.bmj.com/cgi/content/abstract/bjsm.2008.053843v1>

These include:

Rapid responses

You can respond to this article at:
<http://bjsm.bmj.com/cgi/eletter-submit/bjsm.2008.053843v1>

Email alerting service

Receive free email alerts when new articles cite this article - sign up in the box at the top right corner of the article

Notes

Online First contains unedited articles in manuscript form that have been peer reviewed and accepted for publication but have not yet appeared in the paper journal (edited, typeset versions may be posted when available prior to final publication). Online First articles are citable and establish publication priority; they are indexed by PubMed from initial publication. Citations to Online First articles must include the digital object identifier (DOIs) and date of initial publication.

To order reprints of this article go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to *British Journal of Sports Medicine* go to:
<http://journals.bmj.com/subscriptions/>

TITLE: Physical Activity Interventions for Cancer Survivors

RUNNING HEAD: Physical activity interventions and cancer

AUTHOR: Melinda L. Irwin, PhD, MPH
Associate Professor of Epidemiology and Public Health
Yale School of Public Health
60 College St
New Haven, CT 06520-8034
PHONE: (203) 785-6392 FAX: (203) 785-6279
E-mail: melinda.irwin@yale.edu

ABSTRACT:

Obesity and a sedentary lifestyle are highly prevalent in cancer survivors, and a growing number of publications have shown statistically and clinically significant associations between low levels of physical activity, obesity and cancer recurrence and death. Adoption and maintenance of physical activity is a difficult challenge for healthy adults, and is likely to be even more difficult after a cancer diagnosis. More effective strategies to increase physical activity in cancer survivors should be explored. The purpose of this paper is to (1) provide a rationale for physical activity interventions and programs for cancer survivors, and (2) discuss successful approaches to adopting and maintaining physical activity to meet evidence-based recommendations and ultimately improve cancer survival and overall survival. Since a majority of cancer survivors are not currently participating in recommended levels of physical activity, resulting in greater disease risk and health care costs, targeted exercise therapy has the potential to benefit a large number of cancer survivors. Cancer survivors should seek out the opportunities that exist towards being physically active, and oncologists should also become aware of the benefits of exercise, assist their patients by endorsing existing physical activity guidelines and refer their patients to certified cancer exercise trainers.

INTRODUCTION

There is strong evidence showing that participating in recommended amounts of physical activity promotes health (1, 2). However, most people still remain physically inactive (1). Thus, the need to identify effective ways to promote physical activity has been identified as an urgent public health priority, especially in primary care settings among men and women living with a chronic disease (3).

There has been significant research directed towards lowering cancer rates and improving outcomes in affected men and women (2). Obesity and a sedentary lifestyle are highly prevalent in cancer survivors, and a growing number of publications have shown statistically and clinically significant associations between low levels of physical activity, obesity and cancer recurrence and death (4-9).

Adoption and maintenance of physical activity is a difficult challenge for healthy adults, and is likely to be even more difficult after a cancer diagnosis, as evidenced by the decreases in physical activity observed after diagnosis (10). Thus, more effective strategies to increase physical activity in cancer survivors should be explored. The purpose of this paper is to (1) provide a rationale for physical activity interventions and programs for cancer survivors, and (2) discuss successful approaches to adopting and maintaining physical activity to meet evidence-based recommendations and ultimately improve cancer survival and overall survival.

RATIONALE FOR PHYSICAL ACTIVITY INTERVENTIONS FOR CANCER SURVIVORS

A Cancer Diagnosis, Surgery, Treatment and Side Effects

Because of the continually improving survival rates, resulting in a large population of over 11 million cancer survivors in the United States alone, the psychological well-being and

physical functioning of survivors is important from a public health standpoint (2). Furthermore, treatment advances, new chemotherapeutic agents, hormone therapies, and biologic therapy have, at least in part, altered the psychological impact of a diagnosis of cancer.

As a result of the cancer diagnosis, surgery, and adjuvant treatments, some cancer survivors experience fatigue, depression, anxiety, reduced overall quality of life, and weight gain (2). Increased weight is of particular concern because of negative effects of chemotherapy on the cardiovascular system and because of the observed association between weight gain and cancer mortality (5). As an example, in the American Cancer Society Cancer Prevention Study II, a longitudinal cohort study, obesity was strongly associated with increased risk of dying due to breast cancer. These data suggest that approximately 30%-50% of breast cancer deaths among postmenopausal women in the US can be attributable to being overweight (5). Similarly, in an analysis of obesity on breast cancer survival in premenopausal women, Daling and colleagues reported that women younger than 45 years of age who had invasive breast cancer and a BMI > 25 kg/m² were 2.5 times as likely to die of their disease within five years of diagnosis compared with women with a BMI < 21 kg/m² (11). These findings of obesity and breast cancer death are apparent even after adjustment for stage at diagnosis and the adequacy of treatment.

Epidemiological studies have also shown that weight gain after a cancer diagnosis is associated with an increased risk for recurrence and death compared with maintaining normal weight after diagnosis (12). This is especially worrisome given the fact that, especially among women treated for breast cancer, a majority of them gain a significant amount of weight in the year following breast cancer diagnosis, and return to pre-diagnosis weight is rare (13). Analyses from the Nurses' Health Study showed that weight gain after diagnosis (~5 to 10 lbs) was related to approximately 50% higher rates of breast cancer recurrence and death (12). The findings were

especially apparent in women who never smoked, among women with earlier stage disease or those who were normal weight before diagnosis.

While these findings are intriguing, not all studies have observed an association between obesity or weight gain and poor survival. Caan and colleagues did not observe an association between post-diagnosis weight gain and breast cancer recurrence risk in the first 5-7 years post-diagnosis (14). However, weight gain may still have adverse effects on risk of other new cancer and overall survival. Specifically, there is evidence that cancer survivors die of noncancer causes at a higher rate than persons in the general population (deaths being primarily from cardiovascular disease and diabetes) (15). Therefore, surviving cancer requires that patients not only treat the primary cancer, but also avoid second cancers for which they are at increased risk. To improve overall survival, it is critically important for cancer survivors to prevent obesity. One of the primary methods for preventing or treating obesity and weight gain is by increasing physical activity levels (1). Physical activity has therefore been presented as a therapeutic strategy to address both the psychological and physical concerns faced by cancer survivors.

Benefits of Physical Activity after a Cancer Diagnosis

Psycho-social Outcomes and Cardiovascular Fitness

Recent systematic reviews and meta-analyses have reported clear benefits of physical activity for cardiovascular fitness among cancer survivors but generally modest outcomes with respect to reducing fatigue or improving mood or quality of life (2, 16). A breast cancer-specific meta-analysis found exercise to be associated with small but statistically significant improvements in quality of life, physical functioning, and fatigue (16).

In one of the largest studies to date, Courneya and colleagues examined the effects of aerobic exercise alone, resistance exercise alone, or usual care, on fitness, muscular strength,

body composition, and quality of life in 242 breast cancer survivors initiating chemotherapy (17). There were significant favorable effects of both aerobic and resistance exercise on multiple outcomes including self esteem, fitness, and body composition, as well as increased chemotherapy completion rates compared with usual care. Furthermore, no significant adverse events were reported; lymphedema did not increase or was not exacerbated by aerobic or resistance exercise. Recently, other clinical trials of women with breast cancer have shown no increased risk for or exacerbation of lymphedema from either aerobic and/or resistance exercise (18).

Courneya and colleagues also completed a similar trial of aerobic exercise vs. usual care in breast cancer survivors who had completed adjuvant treatment, and observed similar favorable effects of exercise on fitness and overall quality of life (19). Overall, these, and other, studies have demonstrated that exercise is safe in cancer survivors and produces beneficial effects on quality of life and cancer-related symptoms with no adverse side effects.

Cancer Specific Survival and Overall Survival

A growing number of large observational studies have recently been published demonstrating that participation in moderate-intensity recreational physical activity after diagnosis is associated with improved survival in women who develop breast cancer (6-8). These studies have demonstrated a 24-67% reduction in the risk of total deaths and 50-53% reduction in the risk of breast cancer deaths in women who are physically active after breast cancer diagnosis compared with women reporting no recreational physical activity after diagnosis. While any amount of recreational physical activity performed after diagnosis was associated with a decreased risk of death, the maximal benefit occurred in women who performed the equivalent of brisk walking three hours per week. These studies also showed that the decreased risk of

death associated with physical activity was observed in pre- and post-menopausal women, overweight and normal weight women, and women with stage I-III disease.

Given that women who are more physically active after diagnosis may have been similarly active before diagnosis, these studies cannot exclude the possibility that physically active individuals who develop breast cancer acquire tumors that are biologically less aggressive. Therefore, being physically active prior to diagnosis may have been associated with a later diagnosis of breast cancer or earlier disease stage. However, one study examined change in physical activity from before to after breast cancer diagnosis; with an observed increased risk of death associated with decreasing physical activity (8). This finding emphasizes the importance of also participating in physical activity after a diagnosis of breast cancer to gain the maximum benefits of physical activity on survival. Lastly, one study examined whether the influence of physical activity on survival differs according to time since breast cancer diagnosis, with physical activity appearing to be beneficial in both early and late postdiagnostic time periods (7).

Two large observational studies have also demonstrated that participation in 3 hr/wk of moderate-intensity recreational physical activity after diagnosis is associated with a 39-59% reduction in the risk of colon cancer death and a 50-63% reduction in the risk of total deaths in men and women who are physically active after a colon cancer diagnosis compared with inactive men and women (4, 9). The inverse relations between postdiagnosis physical activity and colon cancer mortality remained largely unchanged across strata of sex, BMI, age, disease stage, or year of diagnosis.

These observational findings of post-diagnosis physical activity and improved survival suggest that exercise may confer additional improvements in breast cancer survival beyond surgery, radiation and chemotherapy. However, despite this growing body of observational

evidence suggesting a strong link between physical activity and breast cancer survival, there is still the potential for confounding by unknown or poorly characterized variables. For example, physical activity may be a marker of overall health behaviors including adherence to adjuvant treatments. Thus, randomized controlled trials testing the effects of physical activity on cancer survival and/or surrogate/biological markers mediating the association between physical activity and survival are necessary and would provide critical information for men and women about whether and how much lifestyle change can affect their prognosis. While a trial of physical activity on cancer survival has yet to be done, a small number of randomized trials of exercise on surrogate/biological markers of survival have been published.

Biological/Surrogate Markers of Survival

The beneficial effects of physical activity on cancer survival may be mediated through a reduction in body fat, and beneficial changes in metabolic (e.g., insulin) and sex hormones (e.g., androgens and estrogens), growth factors (e.g., insulin-like growth factor (IGF)-I and IGFBP-3), adipokines (e.g., leptin, adiponectin), and/or inflammation (e.g., C-reactive protein) (20). In a recent publication, moderate-intensity aerobic exercise, such as brisk walking, performed for approximately 120 min/wk, was associated with modest, yet favorable, changes in body fat in postmenopausal breast cancer survivors (21). A dose-response effect was also observed with greater decreases in body fat occurring with higher doses of exercise per week. Another recent study investigated a resistance training program on body composition and observed significant decreases in body fat (-1.15% for exercisers vs. 0.23%, $p = .023$) with a twice-weekly year-long resistance training program in pre- and post-menopausal breast cancer survivors (22). Their observed between-group effect sizes in body fat were similar to the effect sizes observed in the aerobic exercise study. Furthermore, both studies observed maintenance of bone mass or an

attenuation of bone loss. This finding is clinically meaningful given that some of the hormonal therapies given to breast cancer survivors to improve their survival are associated with adverse side effects including bone loss, osteoporosis and increased risk of fractures.

A second strong surrogate or biological marker associated with breast cancer survival is insulin levels. There has been increasing evidence that high insulin levels strongly increase the risk of breast cancer recurrence and death. Three recent studies have observed an approximate three-fold risk of all-cause mortality among women with high insulin levels, measured approximately two years after diagnosis, relative to women with low insulin levels (23-25). The strong association between fasting insulin levels and breast cancer death has led a number of oncologists and scientists to consider the targeting of insulin as a therapeutic modality in breast cancer, particularly because insulin can be modified by lifestyle and pharmacologic interventions. Therapies to reduce insulin levels in breast cancer survivors could dramatically decrease cancer-related deaths. A lowering of insulin levels by 25% may improve survival by 5%, the same order of magnitude as the beneficial effect of adjuvant chemotherapy (26). While pharmacological interventions, e.g., metformin, decreased insulin levels, nonpharmacologic interventions including physical activity have been shown to have clinically meaningful effects on insulin levels.

Recently, Ligibel and colleagues observed a 28% reduction in insulin levels in breast cancer survivors randomized to four months of twice-weekly resistance training and 90 min/wk of home-based aerobic exercise compared to a 3% decrease in insulin levels in breast cancer survivors randomized to control (27). Irwin and colleagues also demonstrated that moderate-intensity aerobic exercise, such as brisk walking, performed on average for 120 min/wk over six months was associated with a borderline statistically significant 21% between-group difference

(i.e., comparing women randomized to exercise vs. usual care) in fasting insulin levels ($p = .089$) (28). Both studies observed reductions in insulin without concomitant decreases in body weight or fat.

Obesity and a high insulin level are also associated with a less favorable sex hormone profile. Sex steroid hormones have powerful mitogenic and proliferative influences and are strongly associated with the development of breast cancer (29, 30). A number of clinical trials also show that estrogen ablation increases survival following a diagnosis of breast cancer (31, 32). Changes in sex hormones are perhaps the most consistently cited potential mechanism for the association between physical activity and breast cancer. The primary mechanism of physical activity influencing sex hormones in postmenopausal women is via decreased body fat, a substrate for estrogen and testosterone production, which results in less tissue capable of aromatization of the adrenal androgens to estrogens (33). To date, only one randomized controlled exercise trial has been published examining the effect of exercise on sex hormone concentrations in healthy women (33). While an overall effect of exercise was significantly associated with decreased serum estrogens and androgens, and increased SHBG resulting in lower amounts of free, active estrogens and androgens, in healthy postmenopausal women, a stronger effect was observed among women who lost body fat with exercise compared to women who did not lose body fat with exercise.

Physical Activity Levels in Cancer Survivors

Despite these and other well documented benefits of physical activity, a large proportion of cancer survivors do not perform regular physical activity (34-36). Similarly, many cancer survivors decrease their physical activity level after diagnosis, highlighting the need for intervention (10). Exercise adherence is a difficult challenge for healthy adults,(1) and is likely

to be even more difficult after a cancer diagnosis and during medical treatments, as evidenced by the decreases in exercise participation during cancer treatment. It has been reported that only 37% of colorectal cancer survivors and 28% of breast cancer survivors exercise regularly during treatment (37, 38). Furthermore, only 32% of breast cancer survivors participated in recommended levels of physical activity defined as 150 min/week of moderate- to vigorous-intensity sports/recreational physical activity after completing treatment (35). Similarly and most recently, Blanchard and colleagues examined the prevalence of physical activity across six major cancer survivor groups (breast, prostate, colorectal, bladder, uterine, skin melanoma) (36). A total of 9,105 survivors completed a national cross-sectional survey that revealed only 30-47% of cancer survivors are meeting the physical activity recommendations.

Not only are few cancer survivors exercising at recommended levels, a majority of them decrease their participation in physical activity after diagnosis, with a return to prediagnosis levels occurring in less than half of the survivors. Irwin and colleagues reported that, compared to physical activity levels reported in the year before diagnosis, breast cancer survivors, on average, decreased their total post-diagnosis physical activity levels by 2 hr/week (10, 13). Thus, while a cancer diagnosis has been referred to as a possible "teachable moment" where survivors are likely to be motivated to make lifestyle changes to improve health outcomes (39), few are actually making these changes. Breast cancer survivors benefit from arguably the widest variety of support groups, networks, and resources of any cancer type, and yet they have largely failed to adopt recommended levels of physical activity levels even in the face of such a severe threat to their health and life. This highlights dramatically the need for further investigation of ways to promote adoption and maintenance of physical activity. Recently, several studies have indicated few differences in the prevalence of physical activity between cancer survivors and those without

a history of cancer (34, 36); thus, perhaps examining predictors and barriers to adoption and maintenance of physical activity in healthy populations may guide the promotion of physical activity in cancer survivors.

Why the high prevalence of physical inactivity in cancer survivors?

A question that remains is why are a majority of cancer survivors not physically active when it is known that physical activity programs carry tremendous potential to affect length and quality of survival, as well as prevent or control morbidity associated with cancer or its treatment? One explanation may be that while survey studies have shown that cancer survivors are highly motivated to become physically active and want to receive information about physical activity and cancer survivorship (40), physical activity counseling has not traditionally been a part of the cancer treatment/survivorship plan. Perhaps, because clinical trial data are lacking to show that physical activity directly impacts cancer survival, physical activity is not a standard treatment recommendation for cancer survivors. Unfortunately, the result is a reluctance of oncologists to prescribe physical activity (41), a lack of prioritization of lifestyle/behavior change in health care systems, non-availability of insurance coverage for physical activity counseling, and confusion of patients on whether physical activity might improve their chances of survival. Therefore randomized clinical trials demonstrating that physical activity after a cancer diagnosis improves survival may lead to the widespread incorporation of physical activity into treatment recommendations for cancer survivors, as well as providing a mandate for the development of lifestyle programs for cancer survivors, as are available for patients after myocardial infarction. However, until these studies are conducted, cancer survivors should seek out the growing number of opportunities that exist towards being physically activity, and

oncologists should also become aware of the benefits of being physically active after a cancer diagnosis, as well as existing referral networks (see Figure).

APPROACHES TO INCREASING PHYSICAL ACTIVITY IN CANCER SURVIVORS

Oncologist-Based Physical Activity Counseling and Referrals

Becoming physically active is a difficult challenge for healthy adults and is likely to be even more difficult after a cancer diagnosis and during medical treatments. In reviewing papers that examined predictors of physical activity adoption and maintenance in healthy men and women and cancer survivors, a physician's recommendations to exercise has been shown to be a strong predictor (42). It has been recognized that physician-based exercise counseling may have a number of distinct advantages over traditional methods of exercise delivery, such as exposure to a high percentage of the population and enhanced credibility regarding the recommendation of certain health practices (43).

Survey studies have shown that cancer survivors want to receive information about physical activity. Specifically, in a descriptive study, Jones and colleagues mailed a self-administered survey to 311 survivors of prostate, breast, colorectal, or lung cancer. A total of 84% of the participants indicated that they would prefer to receive exercise counseling during their cancer experience (40). Yet, in their study, only 28% of cancer survivors reported that their oncologist initiated a discussion of exercise during their treatment consultation, and that 14% of participants said that they initiated a discussion about physical activity (41). This finding is surprising given only 16% of the survivors in this study reported exercising at recommended levels. The rate of 28% oncologist-initiated and 14% patient-initiated (or 42% in total) discussions of the benefits of physical activity is comparable to those in other recent studies. Young-McCaughan and Sexton found that only 41% of breast cancer survivors said that their

physician mentioned exercise to them as part of their rehabilitation (44). Segar and colleagues reported that 50% of breast cancer survivors had received a physician recommendation to exercise (45), and Demark-Wahnefried found that only 34% of breast cancer survivors and 36% of prostate cancer survivors reported receiving a recommendation to exercise from their physician (41, 46).

Furthermore, in the Jones and colleague study, of the 42% who reported discussing physical activity with their oncologist, only 14% were referred to a specialist for further exercise counseling (41). Most oncologists likely do not have the training or resources to develop individualized exercise prescriptions for cancer survivors, and the low number of referrals may have resulted from a lack of referral opportunities. Most recently, working together, the American Cancer Society and the American College of Sports Medicine developed a certification called “the certified cancer exercise trainer” for personal trainers, physical therapists, nurse practitioners or other health professionals to become certified in counseling and training cancer survivors in how to exercise safely and at recommended levels. These “Certified Cancer Exercise Trainers” are knowledgeable of the potential physical limitations associated with surgery and treatment, and have the skills and abilities to help cancer survivors overcome some of the recent and late effects of surgery and treatment (go to www.acsm.org for more information). In the near future, it will be of interest to know if oncologists refer their patients to these certified cancer exercise trainers, and in turn whether physical activity levels improve in cancer survivors. We are optimistic that physicians may improve their exercise prescription rates. Using a national survey, Jones and colleagues interviewed 281 oncologists regarding physical activity after a cancer diagnosis (47). The majority of oncologists agreed that exercise was beneficial, important and safe for cancer survivors during and after treatment. Thus, oncologists

appear to have a favorable attitude toward recommending exercise to cancer survivors, yet several barriers, such as not being aware of the benefits of exercise or referral opportunities, may prevent them from providing exercise advice.

We also hypothesize that an oncologist recommendation or referral may increase exercise behavior in cancer survivors given, in another study by Jones and colleagues, a randomized control trial designed to compare the effects of two oncologist-based interventions (recommendation only and recommendation plus referral) vs. usual care on self-reported physical activity showed an improvement in physical activity(43). Specifically, a total of 450 breast cancer survivors were randomly assigned to these interventions or usual care. The recommendation groups reported higher physical activity levels, but only modest effects (~30 min moderate-intensity physical activity per week compared to usual care). However, these findings indicate that an oncologist-initiated discussion of exercise during treatment consultations may be a cost-effective strategy for promoting exercise in cancer survivors, even if only associated with short-term increases in moderate amounts of exercise among previously sedentary individuals.

Types of Physical Activity Programs Preferred by Cancer Survivors

In the above- mentioned survey study by Jones and colleagues, cancer survivors were asked about their physical activity levels, discussions with their oncologists, and physical activity programming preferences (40). Overall, some of the cancer survivors preferred face to face or “supervised” counseling, while others preferred “home-based” telephone- or mail-based counseling. Some cancer survivors mentioned a preference to exercise alone, and others in a group setting. Some cancer survivors also mentioned a preference to begin an exercise program immediately after diagnosis, while others preferred to wait until after completing chemotherapy

and/or radiation. A majority preferred to participate in recreational activities such as brisk walking. In summary, this important study indicated that cancer survivors have unique and varied exercise counseling and programming preferences, yet, they all want to receive exercise counseling.

In regards to when to initiate an exercise program after diagnosis, some scientists and oncologists feel the timing of physical activity programs may be critically important because the teachable moment may best be capitalized on if interventions are offered soon after diagnosis (39). In a survey study of 978 breast and prostate cancer survivors, Demark-Wahnefried and colleagues found that the most preferred lifestyle interventions were initiated at diagnosis or soon thereafter; however, interventions that were offered “anytime” also garnered high scores (48). Certainly issues such as concurrent demands of treatment are key concerns in the timing of programs, and therefore appropriate balance is necessary in determining the optimal time at which the patient is both physically and psychologically ready to undertake behavior change (48).

Furthermore, in regards to approaches or types of exercise programs, a supervised program may have advantages over a home-based program in that cancer survivors can be directly observed (which may decrease risk of injury and also improve adherence to exercise). However, home-based programs may result in better long-term adoption and maintenance of exercise, especially if the patient finds cost-effective ways to incorporate exercise into his/her daily routine. Another approach could involve an exercise intervention consisting of a combined home exercise and supervised program. Cancer survivors may be taught exercise techniques and principles in an initial in-person visit at a local health club with the certified exercise trainer and then provided with a home-based program.

Most recently, Vallance and colleagues examined the effects of a non-intensive “home-based” exercise program using breast-cancer specific print materials and step pedometers on physical activity in 377 women diagnosed with breast cancer (49). A combination of print material and step pedometers was associated with an approximate 60 min/week increase in moderate- to vigorous-intensity physical activity compared with usual care group. This study shows that a distance-based approach or a low-cost, non-supervised, home-based approach, encouraged patients to increase weekly physical activity. Future studies and physical activity programs should explore the use of pedometers and information-based (i.e., print, telephone, and/or web-based) programs on improving physical activity levels in cancer survivors.

In summary, whether a home-based or supervised-exercise program is implemented soon after a cancer diagnosis or years after a diagnosis, the high level of interest in physical activity counseling creates a strong rationale for providing physical activity counseling services as part of the standard of care in comprehensive cancer centers (see Figure). Thus, oncologists should discuss with their patients the benefits of physical activity after a diagnosis of cancer, reassure them that exercise is safe and associated with improved overall survival and quality of life, and to refer them to a certified cancer exercise trainer who will prescribe an exercise program that is tailored to them. The oncologist and certified exercise trainer should also consider any pre-existing conditions and adverse effects of treatment. Patients should be screened for osteoporosis, bone metastasis, cardiac toxicities, and lymphedema.

CONCLUSIONS

One of the most common questions cancer survivors ask is: “What can I do to improve my survival?” (2) Physical activity is a modifiable behavior with a multitude of health benefits (1). A growing number of publications show a strong relationship between physical activity and

cancer survival (6-8). Numerous observational studies have also demonstrated that obesity and weight gain adversely affect cancer prognosis (12, 50), adding further evidence to the hypothesis that physical activity, one of the critical components of obesity and weight gain, influences cancer survival.

Furthermore, many existing cancer therapies are costly and have significant side effects that can result in long-term morbidity. Therefore, non-pharmacologic methods, such as participating in physical activity to lower the risk of cancer mortality, especially methods that are also associated with improvements in quality of life and other chronic diseases, may offer an attractive addition to the currently available treatment options. Thus, oncologists and primary care physicians should be encouraged to counsel their patients proactively about physical activity.

In summary, there are, clearly, many questions to be answered concerning who, in terms of cancer survival, would benefit from increasing physical activity, when physical activity would be most beneficial, and how much physical activity would be optimal. Given the high level of physical inactivity in the population, and the heavy burden that cancer creates for the individual and for society, the need for well-designed trials of exercise on cancer survival, and programs available to cancer survivors, are an urgent public health priority. More studies are needed to determine what types of interventions work best at various times after diagnosis and how to encourage adoption and maintenance of physical activity.

Future research might also benefit from specifically targeting those survivors who are experiencing psychosocial impairment or reduced quality of life. This could be accomplished by screening all potential participants for psychosocial functioning and enrolling those who fall below a certain cutoff. Another strategy is to target exercise trials towards specific subgroups of

survivors. Despite overall improvements in the health and well-being of cancer survivors, quality of life remains a major concern for certain subgroups of survivors, including young survivors, survivors with a lower level of education, survivors who are diagnosed with later-stage cancer and those who undergo chemotherapy, hormone therapy, or extensive and debilitating treatment regimens. These survivors, who are at risk of greater quality of life impairment, constitute an appropriate and interesting target for future interventions aiming to improve well-being via physical activity. Improved understanding in these research areas will pave the way for physical activity interventions/programs to become a routine component of cancer treatment and recovery, and will hopefully provide the necessary evidence to convince policy makers for the inclusion of exercise counseling in cancer management, and second party payers in reimbursing cancer survivors for receipt of their exercise counseling.

However, until these studies are conducted, cancer survivors should seek out the opportunities that exist towards being physically activity, and oncologists should also become aware of the benefits of exercise, assist their patients by endorsing existing physical activity guidelines and refer their patients to certified cancer exercise trainers. The simplest, evidence-based recommendation at present would be to undertake 30 minutes of moderate-intensity recreational physical activity, such as brisk walking, five times per week. Since a majority of cancer survivors are not currently participating in recommended levels of physical activity, resulting in greater disease risk and health care costs, this targeted therapy has the potential to benefit a large number of cancer survivors.

Figure 1. Strategies and barriers to implementing physical activity interventions and programs in cancer survivors

Competing interests statement:

Competing interests: None

Copyright statement

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in British Journal of Sports Medicine editions and any other BMJ PGL products to exploit all subsidiary rights, as set out in our licence (<http://bjsm.bmj.com/misc/ifora/licenceform.shtml>)

REFERENCES

1. U.S. Department of Health and Human Services: Physical activity and health: A report of the Surgeon General. Atlanta GCfDCaP, National Center for Chronic Disease Prevention and Health Promotion, 1996.
2. Doyle C, Kushi LH, Byers T, et al. Nutrition and physical activity during and after cancer treatment: an American Cancer Society guide for informed choices. *CA Cancer J Clin*. 2006 Nov-Dec;56(6):323-53.
3. Orleans CT. Addressing multiple behavioral health risks in primary care: broadening the focus of health behavior change research and practice. *Am J Prev Med* 2004; 27:1-3.
4. Meyerhardt JA, Heseltine D, Niedzwiecki D, et al. Impact of physical activity on cancer recurrence and survival in patients with stage III colon cancer: findings from CALGB 89803. *J Clin Oncol*. 2006 Aug 1;24(22):3535-41.
5. Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, Obesity, and Mortality from Cancer in a Prospectively Studied Cohort of U.S. Adults. *The New England Journal of Medicine*. 2003;348(17):1625-38.
6. Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis. *JAMA*. 2005 May 25;293(20):2479-86.
7. Holick CN, Newcomb PA, Trentham-Dietz A, et al. Physical activity and survival after diagnosis of invasive breast cancer. *Cancer Epidemiol Biomarkers Prev*. 2008 Feb;17(2):379-86.
8. Irwin ML. Influence of pre- and post-diagnosis physical activity on survival in breast cancer survivors: the Health, Eating, Activity, and Lifestyle (HEAL) Study. *Journal of Clinical Oncology*. 2008; 26(24):1-7.
9. Meyerhardt JA, Giovannucci EL, Holmes MD, et al. Physical activity and survival after colorectal cancer diagnosis. *J Clin Oncol*. 2006 Aug 1;24(22):3527-34.
10. Irwin ML, Crumley D, McTiernan A, et al. Physical activity levels before and after a diagnosis of breast carcinoma: the Health, Eating, Activity, and Lifestyle (HEAL) study. *Cancer*. 2003 Apr 1;97(7):1746-57.

11. Daling JR, Malone KE, Doody DR, Johnson LG, Gralow JR, Porter PL. Relation of body mass index to tumor markers and survival among young women with invasive ductal breast carcinoma. *Cancer*. 2001 Aug 15;92(4):720-9.
12. Kroenke CH, Chen WY, Rosner B, Holmes MD. Weight, weight gain, and survival after breast cancer diagnosis. *J Clin Oncol*. 2005 Mar 1;23(7):1370-8.
13. Irwin ML, McTiernan A, Baumgartner RN, et al. Changes in body fat and weight after a breast cancer diagnosis: influence of demographic, prognostic, and lifestyle factors. *J Clin Oncol*. 2005 Feb 1;23(4):774-82.
14. Caan BJ, Emond JA, Natarajan L, et al. Post-diagnosis weight gain and breast cancer recurrence in women with early stage breast cancer. *Breast Cancer Res Treat*. 2006 Sep;99(1):47-57.
15. Carver JR, Shapiro CL, Ng A, et al. American Society of Clinical Oncology clinical evidence review on the ongoing care of adult cancer survivors: cardiac and pulmonary late effects. *J Clin Oncol*. 2007 Sep 1;25(25):3991-4008.
16. Courneya KS, Friedenreich CM. Physical exercise and quality of life following cancer diagnosis: a literature review. *Ann Behav Med*. 1999 Spring;21(2):171-9.
17. Courneya KS, Segal RJ, Mackey JR, et al. Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: a multicenter randomized controlled trial. *J Clin Oncol*. 2007 Oct 1;25(28):4396-404.
18. Ahmed RL, Thomas W, Yee D, Schmitz KH. Randomized controlled trial of weight training and lymphedema in breast cancer survivors. *J Clin Oncol*. 2006 Jun 20;24(18):2765-72.
19. Courneya KS, Mackey JR, Bell GJ, Jones LW, Field CJ, Fairey AS. Randomized controlled trial of exercise training in postmenopausal breast cancer survivors: cardiopulmonary and quality of life outcomes. *J Clin Oncol*. 2003 May 1;21(9):1660-8.
20. McTiernan A, Ulrich C, Slate S, Potter J. Physical activity and cancer etiology: associations and mechanisms. *Cancer Causes Control*. 1998 Oct;9(5):487-509.
21. Irwin ML. Randomized controlled trial of exercise on body fat, lean mass, and bone mineral density in breast cancer survivors. *Obesity*. 2008. In Press.
22. Schmitz KH, Ahmed RL, Hannan PJ, Yee D. Safety and efficacy of weight training in recent breast cancer survivors to alter body composition, insulin, and insulin-like growth factor axis proteins. *Cancer Epidemiol Biomarkers Prev*. 2005 Jul;14(7):1672-80.
23. Goodwin PJ, Ennis M, Pritchard KI, et al. Fasting insulin and outcome in early-stage breast cancer: results of a prospective cohort study. *J Clin Oncol*. 2002 Jan 1;20(1):42-51.
24. Irwin ML, McTiernan A, et al. . Associations between fasting c-peptide and breast cancer death: The Health, Eating, Activity, and Lifestyle (HEAL) Study. *JNCI*. In Press.
25. Pisani P. Hyper-insulinaemia and cancer, meta-analyses of epidemiological studies. *Arch Physiol Biochem*. 2008 Feb;114(1):63-70.
26. Goodwin PJ. Insulin in the adjuvant breast cancer setting: a novel therapeutic target for lifestyle and pharmacologic interventions? *J Clin Oncol*. 2008 Feb 20;26(6):833-4.
27. Ligibel JA, Campbell N, Partridge A, et al. Impact of a mixed strength and endurance exercise intervention on insulin levels in breast cancer survivors. *J Clin Oncol*. 2008 Feb 20;26(6):907-12.
28. Irwin ML. Randomized controlled trial of exercise on insulin and IGFs in breast cancer survivors. *Cancer, Epidemiology, Biomarkers, Prevention*. 2008. In Press.
29. ACS. *Breast Cancer Facts and Figures: 2006-2007*. Atlanta: American Cancer Society I, 2006.

30. Key T, Appleby P, Barnes I, Reeves G. Endogenous sex hormones and breast cancer in postmenopausal women: reanalysis of nine prospective studies. *J Natl Cancer Inst.* 2002 Apr 17;94(8):606-16.
31. Howell A, Cuzick J, Baum M, et al. Results of the ATAC (Arimidex, Tamoxifen, Alone or in Combination) trial after completion of 5 years' adjuvant treatment for breast cancer. *Lancet.* 2005 Jan 1-7;365(9453):60-2.
32. Thurlimann B, Keshaviah A, Coates AS, et al. A comparison of letrozole and tamoxifen in postmenopausal women with early breast cancer. *N Engl J Med.* 2005 Dec 29;353(26):2747-57.
33. McTiernan A, Tworoger SS, Ulrich CM, et al. Effect of exercise on serum estrogens in postmenopausal women: a 12-month randomized clinical trial. *Cancer Res.* 2004 Apr 15;64(8):2923-8.
34. Bellizzi KM, Rowland JH, Jeffery DD, McNeel T. Health behaviors of cancer survivors: examining opportunities for cancer control intervention. *J Clin Oncol.* 2005 Dec 1;23(34):8884-93.
35. Irwin ML, McTiernan A, Bernstein L, et al. Physical activity levels among breast cancer survivors. *Med Sci Sports Exerc.* 2004 Sep;36(9):1484-91.
36. Blanchard CM, Courneya KS, Stein K. Cancer survivors' adherence to lifestyle behavior recommendations and associations with health-related quality of life: results from the American Cancer Society's SCS-II. *J Clin Oncol.* 2008 May 1;26(13):2198-204.
37. Courneya KS, Friedenreich CM. Relationship between exercise pattern across the cancer experience and current quality of life in colorectal cancer survivors. *J Altern Complement Med.* 1997 Fall;3(3):215-26.
38. Courneya KS, Friedenreich CM. Determinants of exercise during colorectal cancer treatment: an application of the theory of planned behavior. *Oncol Nurs Forum.* 1997 Nov-Dec;24(10):1715-23.
39. Demark-Wahnefried W, Rock CL, Patrick K, Byers T. Lifestyle interventions to reduce cancer risk and improve outcomes. *Am Fam Physician.* 2008 Jun 1;77(11):1573-8.
40. Jones LW, Courneya KS. Exercise counseling and programming preferences of cancer survivors. *Cancer Pract.* 2002 Jul-Aug;10(4):208-15.
41. Jones LW, Courneya KS. Exercise discussions during cancer treatment consultations. *Cancer Pract.* 2002 Mar-Apr;10(2):66-74.
42. Fletcher GF, Balady G, Blair SN, et al. Statement on exercise: benefits and recommendations for physical activity programs for all Americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. *Circulation.* 1996 Aug 15;94(4):857-62.
43. Jones LW, Courneya KS, Fairey AS, Mackey JR. Effects of an oncologist's recommendation to exercise on self-reported exercise behavior in newly diagnosed breast cancer survivors: a single-blind, randomized controlled trial. *Ann Behav Med.* 2004 Oct;28(2):105-13.
44. Young-McCaughan S, Sexton DL. A retrospective investigation of the relationship between aerobic exercise and quality of life in women with breast cancer. *Oncol Nurs Forum.* 1991 May-Jun;18(4):751-7.
45. Segar ML, Katch VL, Roth RS, et al. The effect of aerobic exercise on self-esteem and depressive and anxiety symptoms among breast cancer survivors. *Oncol Nurs Forum.* 1998 Jan-Feb;25(1):107-13.

46. Demark-Wahnefried W, Peterson B, McBride C, Lipkus I, Clipp E. Current health behaviors and readiness to pursue life-style changes among men and women diagnosed with early stage prostate and breast carcinomas. *Cancer*. 2000 Feb 1;88(3):674-84.
47. Jones LW, Courneya KS, Peddle C, Mackey JR. Oncologists' opinions towards recommending exercise to patients with cancer: a Canadian national survey. *Support Care Cancer*. 2005 Nov;13(11):929-37.
48. Demark-Wahnefried W, Clipp EC, Lipkus IM, et al. Main outcomes of the FRESH START trial: a sequentially tailored, diet and exercise mailed print intervention among breast and prostate cancer survivors. *J Clin Oncol*. 2007 Jul 1;25(19):2709-18.
49. Vallance JK, Courneya KS, Plotnikoff RC, Yasui Y, Mackey JR. Randomized controlled trial of the effects of print materials and step pedometers on physical activity and quality of life in breast cancer survivors. *J Clin Oncol*. 2007 Jun 10;25(17):2352-9.
50. Chlebowski RT, Aiello E, McTiernan A. Weight loss in breast cancer patient management. *J Clin Oncol*. 2002 Feb 15;20(4):1128-43.

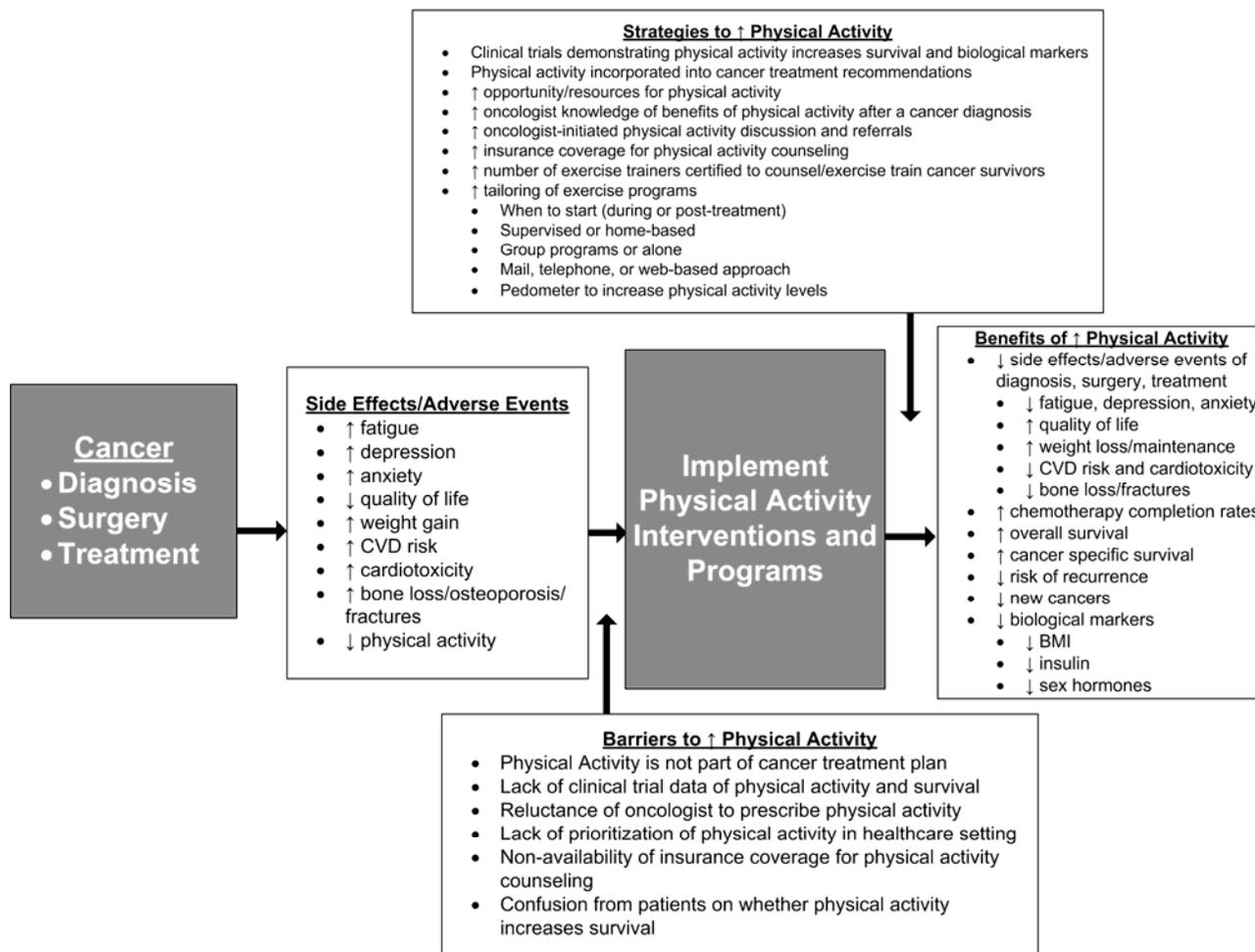


Figure 1. Strategies and barriers to implementing physical activity interventions and programs in cancer survivors