

Physical activity among cancer survivors: a literature review

Ewa A Szymlek-Gay, Rosalina Richards, Richard Egan

Abstract

Aim Physical activity offers a variety of health benefits to cancer survivors, both during and post-treatment. The aim here is to review: the preferences of cancer survivors regarding exercise counselling and participation in a physical activity programme; adherence rates among cancer survivors to physical activity programmes; and predictors of adherence to exercise training.

Methods Two electronic databases, Ovid MEDLINE(R) 1950 to Present with Daily Update and SCOPUS, were used to undertake literature searches for studies examining exercise preferences of adult cancer survivors, and physical activity programmes for adults at any point of the cancer trajectory.

Results Studies suggest that, while physical activity levels are low among cancer survivors, most are interested in increasing their participation. Preferences and adherence to physical activity programmes differ across a range of demographic, medical, and behavioural variables, suggesting the importance of tailoring exercise programmes to patient-specific and disease-specific needs.

Conclusions Current evidence supports the benefits of physical activity for improving risk factors associated with cancer prognosis. Physical activity programmes developed for oncology patients and cancer survivors need to take into account the needs of the target population in order to optimise adherence, outcomes, and long-term behavioural changes in this population.

Impact of cancer in New Zealand

Cancer is a major public health problem in New Zealand with approximately 19,000 new cases diagnosed annually.¹ In 2005, the age-standardised incidence of cancer was 340.3 cases per 100,000 persons, with the highest incidence recorded for Pacific males (389.3 cases per 100,000), and the lowest for non-Māori, non-Pacific females (308.1 cases per 100,000).¹ The cancers of breast; colorectum and anus; prostate; malignant melanoma of skin; and trachea, bronchus and lung are the most common cancers in New Zealand accounting for 61% of the incident cancers.¹

Although cancer remains the leading cause of death in New Zealand, accounting for a third of all deaths,¹ survival rates have improved over the last two decades.² The overall cumulative relative 5-year survival rate across all cancers and all disease stages is currently estimated at 61%,³ although the chances of survival are greater if diagnosed with early-stage disease.³

The number of survivors to 5 years in New Zealand is estimated to be approximately 60,000,³ which represents 1.5% of the New Zealand population. Continued advances in early diagnosis and treatment are likely to further increase the number of cancer survivors.

As the population of cancer survivors in New Zealand grows, it is important to acknowledge that surviving cancer is associated with several distinct health issues. Compared with persons who have not had cancer, cancer survivors have an increased lifetime risk of developing new primary cancers,⁴⁻⁶ cardiovascular disease,⁶⁻⁹ diabetes,^{8,9} osteoporosis,¹⁰ and functional decline.^{8,11,12}

Furthermore, the risk of cancer recurrence is high among cancer survivors.¹³⁻¹⁸ These risks are believed to result from cancer treatment, genetic predisposition, or common lifestyle factors.^{11,19-21} Most of these adverse physiological and quality of life outcomes can be reduced by healthy lifestyle practices, including regular exercise.^{8,9}

Physical activity

Despite methodological limitations and modest sample sizes, existing evidence strongly suggests that physical activity both during and post-treatment can improve cardio-respiratory fitness,²²⁻²⁶ flexibility,¹² muscular strength,²⁶ physiological outcomes,²² vigour,^{22,26} cancer-related fatigue^{23,26-30} and other cancer-related symptoms,^{22,28} nausea,¹² physical well-being,¹² physical functioning,^{23,26,28,30} anxiety,¹² and overall quality of life.^{12,23,25,30,31} Furthermore, physical activity appears to minimise functional decline in cancer survivors,³² improve immune system function,³³ maintain or minimise bone loss,^{34,35} and reduce cancer-related chronic diseases.^{8,9}

Evidence from prospective observational studies suggests that regular physical activity is associated with improved cancer prognosis, although data are few and limited to breast and colon cancer survivors. Specifically, breast cancer survivors who engage in at least 8–10 metabolic equivalent (MET)-hours a week of physical activity (approximately 3 hours of walking per week at a moderate pace) compared with less active survivors have a 40% to 50% reduced risk of death from breast cancer,^{36,37} a 24% to 67% decreased risk of overall mortality,³⁶⁻⁴⁰ and a 26% to 43% decreased risk of recurrence of breast cancer,³⁷ although this finding is not unanimous.⁴⁰

Similarly, physically active colon cancer survivors (at least 9 MET-hours/week) appear to have a 43% to 61% lower risk of colon cancer mortality compared with less active survivors,⁴¹ and a 29% to 63% lower risk of overall mortality.^{41,42} Physical activity may also protect against the development of primary cancers,⁴³ although this is less clear in cancer survivors.

Physical activity has been shown to play a role in weight management as it appears to positively affect body composition^{12,24,28} and facilitate weight loss⁴⁴ in oncology patients and cancer survivors. This is of importance because being overweight may increase the risk of cancer recurrence and decrease survival for many cancers.⁴⁵⁻⁵¹ Furthermore, recent results from some,^{50,52} but not all,⁵³ large prospective studies have indicated that weight gain after cancer diagnosis may be associated with poorer prognosis.

Indeed, weight gain post-diagnosis in large cohorts of breast cancer survivors appeared to increase the risk of death from breast cancer by up to 78%,^{50,52} and the risk of breast cancer recurrence by up to 53%.⁵² Furthermore, for each 5-kg gain in weight, the risk of mortality from breast cancer may increase by 13%.⁵⁰ This is of particular concern because weight gain is common in breast cancer survivors.⁵⁴⁻⁵⁶

Whether weight reduction in overweight or obese cancer survivors would improve the disease outcomes is still under debate. Kroenke et al. and Nichols et al. found that post-diagnosis weight loss was not associated with breast cancer mortality^{50,52} or recurrence⁵² in breast cancer survivors.

In contrast, Caan et al. reported that breast cancer survivors who lost at least 10% of their body weight post-diagnosis had an increased risk of breast cancer recurrence, although this relationship was no longer significant once women who recurred within a year of study entry were removed from the analysis thus this finding should be interpreted with caution.⁵³ It is clear, however, that weight management via regular physical activity should be emphasised as a key part of the strategy to prevent the recurrence and cancer death in survivors.⁵⁷

Preventing weight gain and achieving and maintaining a healthy weight in oncology patients and cancer survivors may also be important in reducing the risk for co-morbid conditions associated with excess weight for which this population is at particularly high risk.⁶⁻⁹

Physical activity may also reduce or avert cancer cachexia,⁵⁸ which is a common yet often undiagnosed multi-factorial syndrome that is characterised by loss of skeletal muscles and subcutaneous fat, fatigue, anorexia, abnormal metabolism, and decreased muscle strength.^{59,60} Resistance exercise training in particular may attenuate or prevent muscle wasting in those affected by cancer cachexia, although the evidence for this is still limited.^{58,61-63}

Several mechanisms have been proposed to explain the links between physical activity and cancer outcomes. Physical activity may improve cancer prognosis through reducing the amount of adipose tissue, which in turn may reduce circulating levels of sex hormones, decrease the production of inflammatory cytokines in adipose tissue, increase adiponectin levels, improve insulin resistance, reduce hyperinsulinaemia, and enhance immune function.⁶⁴⁻⁶⁶

Physical activity has also been shown to directly reduce systemic inflammation, improve immune function, reduce sex hormones production, improve insulin sensitivity and glycaemic control, thus positively affecting cancer prognosis without changes in body composition.⁶⁴

Objectives

Current evidence supports the benefits of physical activity for improving the risk factors associated with cancer prognosis. Therefore, for long-term cancer survivors, regular physical activity should be a priority to improve post-treatment quality of life and help reduce the risk of cancer recurrence, second primary cancers, chronic diseases, and cancer-related mortality and overall mortality. For interventions emphasising regular physical activity to be effective, however, the specific needs of this population must be considered.

The aim of this article is therefore to review the following:

- The preferences of cancer survivors regarding exercise counselling and participation in a physical activity programme;
- Adherence rates among cancer survivors to physical activity programmes; and
- Predictors of adherence to exercise training. Current availability of exercise counselling and programmes for oncology patients and cancer survivors is also briefly discussed.

Methods

Two electronic databases, Ovid MEDLINE(R) 1950 to Present with Daily Update and SCOPUS, were used to undertake literature searches for studies examining exercise preferences of adult cancer survivors, and physical activity programmes for adults at any point of the cancer trajectory. The searches were conducted between 1 July 2009 and 1 December 2009. The terms used to identify relevant studies are shown in Table 1 below.

Table 1. Summary of literature review strategy

Keyword	Articles retrieved	
	Ovid MEDLINE(R)	SCOPUS
Neoplasm	217,040	1,581,834
Survivors	9,115	12,617
Exercise	49,100	209,656
Physical activity	57,571	67,057
Adult	3,301,584	4,358,443
Neoplasm AND Survivors AND Exercise	60	289
Neoplasm AND Survivors AND Exercise AND Adult	22	178
Neoplasm AND Survivors AND Physical activity	17	229
Neoplasm AND Survivors AND Physical activity AND Adult	9	162
Neoplasm AND Survivors AND (Exercise OR Physical activity)	76	400
Neoplasm AND Survivors AND (Exercise OR Physical activity) AND Adult	31	265

The searches were subsequently limited to studies published in the English language. In addition, reference lists of the retrieved original and review articles were searched in order to identify any other relevant studies.

Exercise preferences of cancer survivors

Several cross-sectional studies have examined exercise preferences of cancer survivors across a range of cancer types.⁶⁷⁻⁷⁹ Although cancer survivors were aware of the many benefits of being physically active,^{73,76,79} their levels of physical activity decreased during cancer treatment and remained low following treatment.^{69,70,74-79}

Indeed, although 34–42% of survivors reported to engage in at least 150 minutes of moderate-to-vigorous activity before diagnosis,^{70,78} only 7–16% retained this level of activity during treatment,^{69,78} and 19–41% post-treatment.^{70,74,75,77,78} Furthermore, 31–54% of survivors reported to be sedentary and not to engage in any type of physical activities.^{67,70,74,75,77}

In female breast cancer survivors, this low participation in physical activities was due to soreness after surgery, lack of motivation, cost, work responsibilities, family commitments, health-related barriers (e.g., side effects from medication, other illness), psychological barriers (e.g., self-consciousness due to surgery), and uncertainty about which types of exercise were safe, and when it was safe to return to physical activity.^{73,76,79}

Despite this apparent lack of engagement in physical activity, most studies reported that an overwhelming majority of cancer survivors would have liked to receive exercise counselling or information about participating in an exercise programme at some stage during their cancer experience.^{67,69–72,74,75,77,78}

Furthermore, many cancer survivors felt that they should receive exercise counselling from either an exercise specialist or from a health professional such as a nurse, physician, or an oncologist,^{69,71,72,74–76,79} and that face-to-face counselling was the preferred mode of counselling.^{69,71,72,74,75} Moreover, most survivors indicated that they were interested in an exercise programme,^{67,71,72,74,75,77,78} were able to participate in such a programme,^{70–72,74,75,77,78} and most would have preferred to initiate an exercise programme after treatment.^{69–72,77,78}

A high proportion of cancer survivors, regardless of the type of cancer they had, indicated that they would have preferred to exercise in the morning,^{69,71,72,74,75,77,78} on weekdays,⁷⁵ at moderate intensity,^{69,71,72,74,75,78} unsupervised,^{69,72,74,75,78} in the company of friends, family or other cancer survivors,^{69–72,74,75,77–79} and at home.^{69–72,74,75,77} Walking was undoubtedly the most preferred type of exercise both in the summer and winter.^{69–72,74–78}

Many survivors were interested in physical activity programmes that were scheduled in terms of day and time,^{69,71,78} and many would have liked to perform the same type of activity each time they exercised.^{69,72,75} However, not all these findings were consistent across all studies. The majority of cancer survivors in some studies stated that they would have preferred to exercise alone,^{72,74,75} engage in unscheduled physical activity,^{72,75} and perform different activities each time they exercised.^{72,78}

Consistent with the literature in the general population,^{80,81} physical activity preferences appeared to be associated with a range of demographic, medical, and behavioural variables. Age,^{69,70,72,74,77} level of education,^{68,69,71,72,74,75,77,78} current exercise behaviour,^{69–72,75,77,78} body mass index (weight in kg divided by height in m²),^{68,71,72,78} type of treatment,^{68,70–72} and household income^{71,72,75,77} were the most commonly identified variables to moderate exercise programme and information preferences.

Adherence rates and predictors of adherence to exercise programmes among oncology patients and cancer survivors

Programmes—A number of randomised controlled trials have evaluated physical activity programmes offered to adults at any point of the cancer trajectory.^{23,44,82–86}

The programmes varied considerably in duration, ranging from 2 weeks⁴⁴ to 1 year,^{23,86} although most programmes lasted between 3 and 6 months.^{23,44,82–87}

The studies offered supervised exercise training,^{23,44,82,83} home-based training,^{23,44,85,86} or programmes including both supervised and home-based components.^{23,44,84} Many programmes recommended that participants engage in moderate-intensity physical activity that increased progressively to at least 5 days a week for at least 30 minutes per day (i.e., an equivalent of at least 7.5 MET-hours/week).^{23,44,82–86}

Most programmes focused on aerobic exercise,^{23,44,84–86} some trials offered resistance training,^{23,44} and in some studies cancer survivors received a combination of aerobic and resistance training.^{23,44,82,83} The intensity of the aerobic training showed considerable variability with study participants required to exercise from at least 40% to no more than 85% of estimated maximum heart rate.^{23,44,82–84,86}

Adherence to physical activity programmes—Although the uptake of exercise programmes was varied with only 63% (range 12% to 100%) of the approached patients agreeing to undertake the exercise intervention,⁸⁷ adherence rates to exercise programmes were good, ranging from 68% to 98% for supervised programmes,^{23,44,82,83} 70% to 94% for home-based programmes,^{23,44,85,86} and 81% for programmes that included both supervised and home-based components.⁸⁴

The required level of intensity of aerobic training did not appear to affect adherence rates.^{23,82–84} In general, the programmes were effective in that the study participants increased their physical activity levels from 1.5–4.9 MET-hours/week at baseline^{84–86} to 6.2–16.8 MET-hours/week at the end of an exercise programme.^{84–86}

Predictors of adherence to physical activity programmes—Lower body mass index,^{82,84} a higher degree of readiness to change physical activity behaviour,⁸⁴ better self-efficacy scores at baseline,⁸⁶ higher physical activity levels before commencing an exercise programme,⁸⁶ higher aerobic fitness,⁸³ more advanced disease stage,⁸³ lower depression,⁸³ younger age,⁸² and more positive attitude towards exercise⁸² have been identified as predictors of better adherence to physical activity programmes. These findings, however, have not been observed consistently across studies.^{82–84,86}

Availability of physical activity counselling and programmes for oncology patients and cancer survivors

Despite the desire for the availability of exercise programming for cancer survivors, relatively little exercise programming is available specifically for this population, either within the cancer-care setting or elsewhere.⁸⁸

The limited programmes that have been developed for cancer survivors include written information such as the guidebook ‘Exercise for Health: an Exercise Guide for Breast Cancer Survivors’ in Canada,⁸⁹ as well as individualised or small-group structured programmes that are often subsidised such as the ‘Cancer Survivors Program’ in Australia⁹⁰ or ‘Pink Pilates’ in New Zealand.⁹¹

Recent surveys of oncologists⁹² and oncology nurses⁸⁸ found that although most oncologists had positive attitudes towards recommending exercise to patients with cancer during treatment, and most oncology nurses had positive attitudes towards providing exercise rehabilitation services for patients with cancer, only 42% of cancer survivors indicated that exercise was discussed at their treatment consultation with their oncologists, and only 28% of discussions were initiated by the oncologist.⁹³ Furthermore, an exercise programme was recommended to only 28% of patients,⁹² and few cancer-care hospitals provided an exercise programme for their patients.⁸⁸

This lack of exercise discussions and programme availability was due to a lack of awareness and familiarity with the exercise literature as well as scarce resources.⁸⁸ In fact, the majority of oncology nurses surveyed reported their familiarity with the exercise oncology literature as 'none' or 'low', and nearly a fifth of oncology nurses were unaware that a body of research in this area existed.⁸⁸

Discussion

Exercise during or after cancer treatment has been shown to improve the risk factors associated with cancer prognosis. Despite the known benefits of physical activity, exercise rates decrease drastically during cancer treatment and remain low even after treatment is completed.^{69,79,94-98} Furthermore, about half of cancer survivors are sedentary and do not engage in any type of physical activities.^{67,70,74,75,77}

Nevertheless, most patients with cancer and cancer survivors have been shown to be motivated to receive exercise advice, have interest in participating in an exercise programme, and have also indicated that they are interested in an exercise program designed specifically for them. Although, it appears that cancer survivors are unlikely to continue or initiate an exercise programme without a structured intervention.^{69,79,94-97}

Several exercise behaviour change interventions for adult patients with cancer and cancer survivors have been shown to effectively increase overall activity levels.^{23,44,82-86} Many study participants, however, remained inactive or did not achieve the recommended activity levels.^{84,85} Furthermore, nearly 40% of oncology patients or survivors who were approached to participate in an exercise programme declined to undertake it.⁸⁷

The low uptake of exercise interventions and low number of participants achieving the recommended activity levels might have been due to the fact that many programmes did not reflect the most frequently reported programme preferences among cancer survivors. The same physical activity can not be used across survivors of different tumour types, because cancer diagnosis, side effects associated with different treatments, different experiences of cancer survivors, cancer-site-specific barriers, patient position on the cancer spectrum, or patient demographics affect exercise behaviours and attitudes towards physical activity and therefore need to be taken into consideration when developing physical activity programmes specifically for oncology patients and cancer survivors.⁹⁹

Tailoring of exercise programmes to patient-specific and disease-specific needs is thus essential for optimising adherence, outcomes, and long-term behavioural changes in oncology patients and cancer survivors.¹⁰⁰

Application of behaviour change theories may be particularly useful during this process. Behaviour change theories may be used for understanding physical activity in various cancer survivor groups,^{75,76,82,83,101,102} identifying the main beliefs about physical activity in cancer survivors that are necessary for developing physical activity interventions for this population,^{75,76,82,83,101,102} and may be used for actually developing effective physical activity interventions for specific groups of cancer survivors.^{85,86}

In conclusion, research efforts are needed to develop physical activity programmes specifically for oncology patients and cancer survivors. Such programmes should take into account the programme preferences of the target population.

It is evident that a number of factors influence the exercise preferences of cancer survivors. Whether the needs of New Zealand oncology patients and cancer survivors in relation to continuation or initiation of physical activity are similar to those of North American or European survivors is uncertain and requires investigation. Furthermore, there is a need to examine whether tailoring of exercise programmes is associated with improved long-term adherence and exercise outcomes in New Zealand patients with cancer and cancer survivors.

Author information: Ewa A Szymlek-Gay, New Zealand Science and Technology Postdoctoral Fellow, Department of Clinical Sciences, Pediatrics, Umeå University, Umeå, Sweden; Rosalina Richards, Research Fellow, Cancer Society Social and Behavioural Research Unit, Department of Preventive and Social Medicine, University of Otago, Dunedin; Richard Egan, Research Fellow/Senior Teaching Fellow, Cancer Society Social and Behavioural Research Unit, Department of Preventive and Social Medicine, University of Otago, Dunedin.

Acknowledgements: Dr Szymlek-Gay is in receipt of a New Zealand Science and Technology Postdoctoral Fellowship from the Foundation for Research, Science and Technology (UMEA0901). Dr Richards, Dr Egan and the Cancer Society Social and Behavioural Research Unit receive support from the Cancer Society of New Zealand and the University of Otago. This project also received support from a research partnership between Curves Gymnasium and the Cancer Society of New Zealand.

Correspondence: Dr Ewa Szymlek-Gay, Department of Clinical Sciences, Pediatrics, Umeå University, SE-901 85 Umeå, Sweden. Fax: +46 (0)90 123728; email: ewa.szymlek-gay@pediatri.umu.se

References:

1. Ministry of Health. Cancer: New Registrations and Deaths 2005: Revised edition. Wellington: Ministry of Health; 2009.
2. Ministry of Health. Mortality and Demographic Data 2005. Wellington: Ministry of Health; 2009.
3. Ministry of Health. Cancer Patient Survival. Covering the Period 1994 to 2003. Wellington: Ministry of Health; 2006.
4. Dong C, Hemminki K. Second primary neoplasms in 633,964 cancer patients in Sweden, 1958-1996. *Int J Cancer*. 2001;93:155-61.
5. American Cancer Society. Cancer Facts & Figures 2009. Atlanta: American Cancer Society; 2009.
6. Fosså SD, Vassilopoulou-Sellin R, Dahl AA. Long term physical sequelae after adult-onset cancer. *J Cancer Surviv*. 2008;2:3-11.

7. 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;25:3991-4008.
8. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *J Clin Oncol*. 2005;23:5814-30.
9. Kintzel PE, Chase SL, Schultz LM, O'Rourke TJ. Increased risk of metabolic syndrome, diabetes mellitus, and cardiovascular disease in men receiving androgen deprivation therapy for prostate cancer. *Pharmacotherapy*. 2008;28:1511-22.
10. Stava CJ, Jimenez C, Hu MI, Vassilopoulou-Sellin R. Skeletal sequelae of cancer and cancer treatment. *J Cancer Surviv*. 2009;3:75-88.
11. Aziz NM. Cancer survivorship research: state of knowledge, challenges and opportunities. *Acta Oncol*. 2007;46:417-32.
12. Courneya KS. Exercise in cancer survivors: an overview of research. *Med Sci Sports Exerc*. 2003;35:1846-52.
13. Brewster AM, Hortobagyi GN, Broglio KR, et al. Residual risk of breast cancer recurrence 5 years after adjuvant therapy. *J Natl Cancer Inst*. 2008;100:1179-83.
14. Berman JM, Cheung RJ, Weinberg DS. Surveillance after colorectal cancer resection. *Lancet*. 2000;355:395-9.
15. Early Breast Cancer Trialists' Collaborative Group. Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of the randomised trials. *Lancet*. 2005;365:1687-717.
16. Reed VK, Krishnan S, Mansfield PF, et al. Incidence, natural history, and patterns of locoregional recurrence in gastric cancer patients treated with preoperative chemoradiotherapy. *Int J Radiat Oncol Biol Phys*. 2008;71:741-7.
17. Martini N, Bains MS, Burt ME, et al. Incidence of local recurrence and second primary tumors in resected stage I lung cancer. *J Thorac Cardiovasc Surg*. 1995;109:120-9.
18. Pound CR, Partin AW, Epstein JI, Walsh PC. Prostate-specific antigen after anatomic radical retropubic prostatectomy: patterns of recurrence and cancer control. *Urol Clin North Am*. 1997;24:395-406.
19. Aziz NM, Rowland JH. Trends and advances in cancer survivorship research: challenge and opportunity. *Semin Radiat Oncol*. 2003;13:248-66.
20. Ganz PA. Late effects of cancer and its treatment. *Semin Oncol Nurs*. 2001;17:241-8.
21. Travis LB, Rabkin CS, Brown LM, et al. Cancer survivorship - genetic susceptibility and second primary cancers: research strategies and recommendations. *J Natl Cancer Inst*. 2006;98:15-25.
22. Schmitz KH, Holtzman J, Courneya KS, et al. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. *Cancer Epidemiol Biomarkers Prev*. 2005;14:1588-95.
23. McNeely ML, Campbell KL, Rowe BH, et al. Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. *CMAJ*. 2006;175:34-41.
24. Kim CJ, Kang DH, Park JW. A meta-analysis of aerobic exercise interventions for women with breast cancer. *West J Nurs Res*. 2009;31:437-61.
25. Jones LW, Demark-Wahnefried W. Diet, exercise, and complementary therapies after primary treatment for cancer. *Lancet Oncol*. 2006;7:1017-26.
26. Adamsen L, Quist M, Andersen C, et al. Effect of a multimodal high intensity exercise intervention in cancer patients undergoing chemotherapy: randomised controlled trial. *BMJ*. 2009;339:b3410.
27. Kirshbaum MN. A review of the benefits of whole body exercise during and after treatment for breast cancer. *J Clin Nurs*. 2007;16:104-21.
28. Conn VS, Hafdahl AR, Porock DC, et al. A meta-analysis of exercise interventions among people treated for cancer. *Support Care Cancer*. 2006;14:699-712.

29. Cramp F, Daniel J. Exercise for the management of cancer-related fatigue in adults. *Cochrane Database Syst Rev.* 2008;CD006145.
30. Thorsen L, Courneya KS, Stevinson C, Fosså SD. A systematic review of physical activity in prostate cancer survivors: outcomes, prevalence, and determinants. *Support Care Cancer.* 2008;16:987-97.
31. Bicego D, Brown K, Ruddick M, et al. Effects of exercise on quality of life in women living with breast cancer: a systematic review. *Breast J.* 2009;15:45-51.
32. Morey MC, Snyder DC, Sloane R, et al. Effects of home-based diet and exercise on functional outcomes among older, overweight long-term cancer survivors: RENEW: a randomized controlled trial. *JAMA.* 2009;301:1883-9.
33. Fairey AS, Courneya KS, Field CJ, Mackey JR. Physical exercise and immune system function in cancer survivors: a comprehensive review and future directions. *Cancer.* 2002;94:539-51.
34. Irwin ML, Alvarez-Reeves M, Cadmus L, et al. Exercise improves body fat, lean mass, and bone mass in breast cancer survivors. *Obesity.* 2009;17:1534-41.
35. Schwartz AL, Winters-Stone K, Gallucci B. Exercise effects on bone mineral density in women with breast cancer receiving adjuvant chemotherapy. *Oncol Nurs Forum.* 2007;34:627-33.
36. Holick CN, Newcomb PA, Trentham-Dietz A, et al. Physical activity and survival after diagnosis of invasive breast cancer. *Cancer Epidemiol Biomarkers Prev.* 2008;17:379-86.
37. Holmes MD, Chen WY, Feskanich D, et al. Physical activity and survival after breast cancer diagnosis. *JAMA.* 2005;293:2479-86.
38. Pierce JP, Stefanick ML, Flatt SW, et al. Greater survival after breast cancer in physically active women with high vegetable-fruit intake regardless of obesity. *J Clin Oncol.* 2007;25:2345-51.
39. Irwin ML, Smith AW, McTiernan A, et al. Influence of pre- and postdiagnosis physical activity on mortality in breast cancer survivors: the health, eating, activity, and lifestyle study. *J Clin Oncol.* 2008;26:3958-64.
40. Sternfeld B, Weltzien E, Quesenberry CP, Jr., et al. Physical activity and risk of recurrence and mortality in breast cancer survivors: findings from the LACE study. *Cancer Epidemiol Biomarkers Prev.* 2009;18:87-95.
41. Meyerhardt JA, Giovannucci EL, Holmes MD, et al. Physical activity and survival after colorectal cancer diagnosis. *J Clin Oncol.* 2006;24:3527-34.
42. 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;24:3535-41.
43. World Cancer Research Fund / American Institute for Cancer Research. *Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective.* Washington, DC: AICR; 2007.
44. Pinto BM, Floyd A. Methodologic issues in exercise intervention research in oncology. *Semin Oncol Nurs.* 2007;23:297-304.
45. Stevens RJ, Roddam AW, Spencer EA, et al. Factors associated with incident and fatal pancreatic cancer in a cohort of middle-aged women. *Int J Cancer.* 2009;124:2400-5.
46. Ma J, Li H, Giovannucci E, et al. Prediagnostic body-mass index, plasma C-peptide concentration, and prostate cancer-specific mortality in men with prostate cancer: a long-term survival analysis. *Lancet Oncol.* 2008;9:1039-47.
47. Rock CL, Demark-Wahnefried W. Nutrition and survival after the diagnosis of breast cancer: a review of the evidence. *J Clin Oncol.* 2002;20:3302-16.
48. Reeves GK, Pirie K, Beral V, et al. Cancer incidence and mortality in relation to body mass index in the Million Women Study: cohort study. *BMJ.* 2007;335:1134-9.

49. Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. Adults. *N Engl J Med.* 2003;348:1625-38.
50. Nichols HB, Trentham-Dietz A, Egan KM, et al. Body mass index before and after breast cancer diagnosis: associations with all-cause, breast cancer, and cardiovascular disease mortality. *Cancer Epidemiol Biomarkers Prev.* 2009;18:1403-9.
51. Carmichael AR. Obesity and prognosis of breast cancer. *Obes Rev.* 2006;7:333-40.
52. Kroenke CH, Chen WY, Rosner B, Holmes MD. Weight, weight gain, and survival after breast cancer diagnosis. *J Clin Oncol.* 2005;23:1370-8.
53. Caan BJ, Kwan ML, Hartzell G, et al. Pre-diagnosis body mass index, post-diagnosis weight change, and prognosis among women with early stage breast cancer. *Cancer Causes Control.* 2008;19:1319-28.
54. Demark-Wahnefried W, Rimer BK, Winer EP. Weight gain in women diagnosed with breast cancer. *J Am Diet Assoc.* 1997;97:519-26.
55. 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;23:774-82.
56. Saquib N, Flatt SW, Natarajan L, et al. Weight gain and recovery of pre-cancer weight after breast cancer treatments: evidence from the women's healthy eating and living (WHEL) study. *Breast Cancer Res Treat.* 2007;105:177-86.
57. 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;56:323-53.
58. Ardies CM. Exercise, cachexia, and cancer therapy: a molecular rationale. *Nutr Cancer.* 2002;42:143-57.
59. Fearon KC, Voss AC, Hustead DS. Definition of cancer cachexia: effect of weight loss, reduced food intake, and systemic inflammation on functional status and prognosis. *Am J Clin Nutr.* 2006;83:1345-50.
60. Evans WJ, Morley JE, Argiles J, et al. Cachexia: a new definition. *Clin Nutr.* 2008;27:793-9.
61. Zinna EM, Yarasheski KE. Exercise treatment to counteract protein wasting of chronic diseases. *Curr Opin Clin Nutr Metab Care.* 2003;6:87-93.
62. Fearon KCH. Cancer cachexia: developing multimodal therapy for a multidimensional problem. *Eur J Cancer.* 2008;44:1124-32.
63. Al-Majid S, Waters H. The biological mechanisms of cancer-related skeletal muscle wasting: the role of progressive resistance exercise. *Biol Res Nurs.* 2008;10:7-20.
64. McTiernan A. Mechanisms linking physical activity with cancer. *Nat Rev Cancer.* 2008;8:205-11.
65. Kellen E, Vansant G, Christiaens M-R, et al. Lifestyle changes and breast cancer prognosis: a review. *Breast Cancer Res Treat.* 2009;114:13-22.
66. Fair AM, Montgomery K. Energy balance, physical activity, and cancer risk. *Methods Mol Biol.* 2009;472:57-88.
67. Demark-Wahnefried W, Peterson B, McBride C, et al. Current health behaviors and readiness to pursue life-style changes among men and women diagnosed with early stage prostate and breast carcinomas. *Cancer.* 2000;88:674-84.
68. Hong S, Bardwell WA, Natarajan L, et al. Correlates of physical activity level in breast cancer survivors participating in the Women's Healthy Eating and Living (WHEL) Study. *Breast Cancer Res Treat.* 2007;101:225-32.
69. Jones LW, Courneya KS. Exercise counseling and programming preferences of cancer survivors. *Cancer Pract.* 2002;10:208-15.
70. Jones LW, Guill B, Keir ST, et al. Exercise interest and preferences among patients diagnosed with primary brain cancer. *Support Care Cancer.* 2007;15:47-55.

71. Karvinen KH, Courneya KS, Campbell KL, et al. Exercise preferences of endometrial cancer survivors: a population-based study. *Cancer Nurs.* 2006;29:259-65.
72. Karvinen KH, Courneya KS, Venner P, North S. Exercise programming and counseling preferences in bladder cancer survivors: a population-based study. *J Cancer Surviv.* 2007;1:27-34.
73. Larsson IL, Jönsson C, Olsson AC, et al. Women's experience of physical activity following breast cancer treatment. *Scand J Caring Sci.* 2008;22:422-9.
74. Rogers LQ, Courneya KS, Verhulst S, et al. Factors associated with exercise counseling and program preferences among breast cancer survivors. *J Phys Act Health.* 2008;5:688-705.
75. Rogers LQ, Markwell SJ, Verhulst S, et al. Rural breast cancer survivors: exercise preferences and their determinants. *Psychooncology.* 2009;18:412-21.
76. Rogers LQ, Matevey C, Hopkins-Price P, et al. Exploring social cognitive theory constructs for promoting exercise among breast cancer patients. *Cancer Nurs.* 2004;27:462-73.
77. Stevinson C, Capstick V, Schepansky A, et al. Physical activity preferences of ovarian cancer survivors. *Psychooncology.* 2009;18:422-8.
78. Vallance JK, Courneya KS, Jones LW, Reiman T. Exercise preferences among a population-based sample of non-Hodgkin's lymphoma survivors. *Eur J Cancer Care (Engl).* 2006;15:34-43.
79. Whitehead S, Lavelle K. Older breast cancer survivors' views and preferences for physical activity. *Qual Health Res.* 2009;19:894-906.
80. Booth ML, Bauman A, Owen N, Gore CJ. Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Prev Med.* 1997;26:131-7.
81. Cohen-Mansfield J, Marx MS, Biddison JR, Guralnik JM. Socio-environmental exercise preferences among older adults. *Prev Med.* 2004;38:804-11.
82. Courneya KS, Friedenreich CM, Reid RD, et al. Predictors of follow-up exercise behavior 6 months after a randomized trial of exercise training during breast cancer chemotherapy. *Breast Cancer Res Treat.* 2009;114:179-87.
83. Courneya KS, Segal RJ, Gelmon K, et al. Predictors of supervised exercise adherence during breast cancer chemotherapy. *Med Sci Sports Exerc.* 2008;40:1180-7.
84. Latka RN, Alvarez-Reeves M, Cadmus L, Irwin ML. Adherence to a randomized controlled trial of aerobic exercise in breast cancer survivors: the Yale exercise and survivorship study. *J Cancer Surviv.* 2009;3:148-57.
85. Matthews CE, Wilcox S, Hanby CL, et al. Evaluation of a 12-week home-based walking intervention for breast cancer survivors. *Support Care Cancer.* 2007;15:203-11.
86. Pinto BM, Rabin C, Dunsiger S. Home-based exercise among cancer survivors: adherence and its predictors. *Psychooncology.* 2009;18:369-76.
87. Maddocks M, Mockett S, Wilcock A. Is exercise an acceptable and practical therapy for people with or cured of cancer? A systematic review. *Cancer Treat Rev.* 2009;35:383-90.
88. Stevinson C, Fox KR. Role of exercise for cancer rehabilitation in UK hospitals: a survey of oncology nurses. *Eur J Cancer Care (Engl).* 2005;14:63-9.
89. Vallance JK, Courneya KS, Taylor LM, et al. Development and evaluation of a theory-based physical activity guidebook for breast cancer survivors. *Health Educ Behav.* 2008;35:174-89.
90. Edith Cowan University, Health and Wellness Institute. Our Programs - Overview. Cancer Survivors Program. [Internet]. 2011 [updated 2011 January 19; cited 2011 May 30]. Available from: <http://www.variowellness.org/programs/index.php>
91. Pink Pilates. [Internet] 2011 [cited 2011 May 30]. Available from: <http://www.pinkpilates.org.nz/home>.
92. 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;13:929-37.

93. Jones LW, Courneya KS. Exercise discussions during cancer treatment consultations. *Cancer Pract.* 2002;10:66-74.
94. Vallance JK, Courneya KS, Jones LW, Reiman T. Differences in quality of life between non-Hodgkin's lymphoma survivors meeting and not meeting public health exercise guidelines. *Psychooncology.* 2005;14:979-91.
95. Courneya KS, Friedenreich CM. Determinants of exercise during colorectal cancer treatment: an application of the theory of planned behavior. *Oncol Nurs Forum.* 1997;24:1715-23.
96. Courneya KS, Friedenreich CM. Relationship between exercise during treatment and current quality of life among survivors of breast cancer. *J Psychosoc Oncol.* 1997;15:35-57.
97. 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;97:1746-57.
98. Blanchard CM, Denniston MM, Baker F, et al. Do adults change their lifestyle behaviors after a cancer diagnosis? *Am J Health Behav.* 2003;27:246-56.
99. Craike MJ, Livingston PM, Botti M. How much do we know about the determinants of physical activity among prostate cancer survivors? Directions for future research to inform interventions. *Aust N Z J Public Health.* 2009;33:193-4.
100. Stull VB, Snyder DC, Demark-Wahnefried W. Lifestyle interventions in cancer survivors: designing programs that meet the needs of this vulnerable and growing population. *J Nutr.* 2007;137:243S-8S.
101. Keogh J, Shepherd D, Krägeloh C, et al. Predictors of physical activity and quality of life in New Zealand prostate cancer survivors undergoing androgen-deprivation therapy. *N Z Med J.* 2010;123:20-9.
102. Rogers LQ, McAuley E, Courneya KS, Verhulst SJ. Correlates of physical activity self-efficacy among breast cancer survivors. *Am J Health Behav.* 2008;32:594-603.