Published in final edited form as:
Cancer. 2003 April 1; 97(7): 1746–1757. doi:10.1002/cncr.11227.

Physical activity levels before and after a diagnosis of breast cancer: The Health, Eating, Activity, and Lifestyle (HEAL) Study

Melinda L. Irwin, PhD[1], **Diane Crumley, PhD**[2], **Anne McTiernan, MD, PhD**[3], **Leslie Bernstein, PhD**[4], **Richard Baumgartner, PhD**[2], **Frank D. Gilliland, MD, PhD**[4], **Andrea Kriska, PhD**[5], and **Rachel Ballard-Barbash, MD, MPH**[6]

[1] Department of Epidemiology and Public Health, Yale School of Medicine, New Haven, CT [2] University of New Mexico, Albuquerque, New Mexico [3] The Fred Hutchinson Cancer Research Center, Seattle, WA [4] Department of Preventive Medicine University of Southern California, Los Angeles, CA [5] University of Pittsburgh, Pittsburgh, PA [6] Applied Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, Maryland

Abstract

Background—Increased body weight at breast cancer diagnosis has been associated with an increased risk of recurrence and reduced survival. Weight gain is also common following diagnosis. Increasing physical activity (PA) after diagnosis may minimize these adverse outcomes. This study investigated whether PA levels after diagnosis declined from pre-diagnosis levels, and whether any changes in PA varied by disease stage, treatment, age, and body mass index (BMI) in 812 incident population-based stage 0–3a breast cancer patients.

Methods—Types of sports and household activities and their frequency and duration for the year prior to diagnosis and for the month prior to the interview (i.e., 4–12 months post-diagnosis) were assessed during a baseline interview.

Results—Patients decreased their total PA by an estimated 2.0 hrs/week from pre- to post-diagnosis, an 11% decrease ($p < .05$). Greater decreases in sports PA were observed among women treated with radiation and chemotherapy (50% decrease) than women having surgery only (24% decrease) or treated with radiation only (23%) ($p < .05$). Greater decreases in sports PA were observed among obese patients (41% decrease) than normal weight (24% decrease) patients ($p < .05$).

Conclusions—PA levels were significantly reduced following breast cancer diagnosis. Greater decreases in PA observed among heavier patients implies a potential for greater weight gain among already overweight women. Randomized controlled trials are needed to evaluate how PA may improve breast cancer prognosis.

Keywords

exercise; prognosis; treatment; stage; body weight; obesity

DIRECT CORRESPONDENCE TO: Melinda L. Irwin, Ph.D., M.P.H., Department of Epidemiology and Public Health, Yale School of Medicine, P.O. Box 208034, New Haven, CT 06520-8034, PHONE: (203) 785-6392 FAX: (203) 785-6279, melinda.irwin@yale.edu.

Introduction

Weight gain is common during the first year after breast cancer diagnosis, especially among women receiving systemic adjuvant therapy.[1–6] In a study by Goodwin et al.[2,4], 84% of breast cancer patients gained weight in the first year after diagnosis with a mean weight gain of 2.5 kg among those receiving chemotherapy. Weight gain commonly ranges from 2.5 to 6.2 kg; however, greater gains are not unusual.[1,3,5] Increased body mass and body fat at breast cancer diagnosis have been associated with an increased risk of recurrence and reduced survival.[2] Less is known about the role of weight gain after diagnosis on breast cancer recurrence and survival.

Multiple reasons for post-breast cancer diagnosis weight gain have been suggested such as receiving adjuvant treatment, specifically chemotherapy, not taking tamoxifen, decreased physical activity, and an increase in caloric intake[1–6] although these theories have not been scientifically validated. Maintaining or increasing physical activity levels after breast cancer diagnosis with breast cancer may minimize post-diagnosis weight gain because physical activity is associated with weight maintenance in healthy women.[7,8]

Few epidemiologic studies have been conducted that describe physical activity levels among women who have been diagnosed and treated for breast cancer or any cancer. [9,10] In a study of stage I or II breast cancer, physical activity levels decreased significantly during chemotherapy treatment from pre-treatment levels.[10] Among colorectal cancer survivors, cancer treatment had a negative effect on exercise participation levels that was not completely recovered posttreatment.[9]

We have examined data collected in a population-based cohort of 1185 breast cancer patients – the Health, Eating, Activity, and Lifestyle (HEAL) Study to investigate changes in physical activity levels after breast cancer diagnosis relative to pre-diagnosis levels and to assess the influence of disease stage, cancer treatment, age, and body mass index (BMI) on these changes.

Methods

Study Setting and Subjects

The HEAL study is a population-based, multi-centered, multi-ethnic prospective cohort study that has enrolled 1185 breast cancer patients who are being followed to determine whether weight, physical activity, diet, sex hormones, and other exposures affect breast cancer prognosis. Patients were recruited to the HEAL study through Surveillance, Epidemiology, End Results (SEER) registries in New Mexico, Los Angeles County (CA), and Western Washington. Comparable data on pre- and post-breast cancer diagnosis physical activity levels are available only for New Mexico and Western Washington. Pre-diagnosis data were collected for Los Angeles County participants as part of a case-control study of risk factors for breast cancer and post-diagnosis data were not collected during the first follow-up year. Therefore, we limit these analyses to patients from New Mexico and Washington.

Recruitment and Eligibility

Patients were eligible for the study if they had been diagnosed with stages 0–3a breast cancer; were diagnosed at aged 18 years or older in New Mexico or between 40 and 64 years of age in Western Washington; were able to participate in an interview within a 4–12 month time period after diagnosis; were living in defined geographic areas (King, Pierce, or Snohomish Counties in Washington, and Bernalillo, Sante Fe, Sandoval, Valencia, or Taos Counties in New Mexico; and had been diagnosed between July 1996 and March 1999 (in

New Mexico) or September 1997 and September 1998 (in Western Washington). An additional criterion for Western Washington participants was their willingness to come to a clinic visit for measures.

A total of 1,036 age-eligible women in Western Washington and 1,037 women in New Mexico living in the catchment areas were diagnosed with breast cancer during the specified recruitment periods. Patients were excluded from the HEAL Study for a variety of reasons: 834 women from Western Washington and 383 women from the targeted New Mexico counties were excluded due to doctor refusal (n = 59), patient refusal (n = 437), unable to locate physician or patient (n = 443), or being interviewed by other studies (n = 278). A total of 202 women from Washington and 654 women from New Mexico participated in the HEAL Study.

Among the 856 women enrolled, 38 women had a prior diagnosis of breast cancer, 3 women were diagnosed with Stage IV breast cancer, 1 woman had an undefined disease stage, and 2 women did not have complete physical activity data. These women were excluded and the remaining analyses are restricted to the 812 women. Written informed consent was obtained from each subject. The study was performed with the approval of the Institutional Review Boards of participating centers, in accord with an assurance filed with and approved by the U.S. Department of Health and Human Services.

Data Collection

In Western Washington, patients completed a mailed study questionnaire, which they brought to a baseline clinic visit (scheduled within 4–12 months after diagnosis) at the Fred Hutchinson Cancer Research Center Prevention Studies Clinic. Physical activity data were collected at an in-person interview. In-person interviews were conducted in New Mexico (scheduled within 4–12 months after diagnosis), and physical measurements were obtained at the University of New Mexico Aging and Genetic Epidemiology Program.

Physical Activity Assessment—We collected information on physical activity using an interview-administered physical activity questionnaire at the baseline clinic visit (i.e., 4–12 months after diagnosis). [14] The questionnaire was based on the Modifiable Activity Questionnaire developed by Kriska and colleagues,[14] which was designed to be easily modified for use with different populations, and which has been shown to be reliable and valid. The type, duration, and frequency of activities for the year prior to breast cancer diagnosis and for the month prior to the interview, corresponding to the period 4 to 12 months after diagnosis, were assessed. The sports/recreation and household activity section of the questionnaire addressed 29 popular activities, such as fast walking, jogging, aerobics, tennis, household cleaning, and yard work. The interviewer first read the list of activities to the participant and the participant identified all activities that she performed on at least ten different occasions over the past five years. For each activity performed, participants were further asked how often and for how long they performed the activity in the year prior to breast cancer diagnosis. We also recorded sedentary activities as the average number of hours per weekday and weekend spent watching television, sitting (not including watching television), and napping. After participation in each activity was determined for the year prior to diagnosis, the interviewer followed the exact same procedure to determine physical activity participation in the past month (i.e. post-diagnosis physical activity).

Stage of Disease and Cancer Treatment—We obtained data on stage of disease from the respective local SEER registries (the New Mexico Tumor Registry and the Cancer Surveillance System of Western Washington) and information on adjuvant therapy by medical record abstraction and SEER registry records. We abstracted the radiation and/or

chemotherapy sequence with surgery, type of chemotherapy agents given, and use of tamoxifen therapy. Participants also provided information on use of tamoxifen.

Anthropometrics—Trained staff measured height and weight in a standard manner at the baseline clinic visit. Weight was measured to the nearest 0.1 kg using a laboratory scale. Height was measured without shoes to the nearest 0.1 cm using a stadiometer. All measurements were performed and recorded twice in succession. The two measurements were averaged for a final value for analyses. Body mass index was computed as weight in kg divided by height in m^2. Three mutually exclusive BMI groups were then created: normal weight (BMI < 25 kg/m^2), overweight (25 $kg/m^2 \leq$ BMI < 30.0 kg/m^2), and obese (BMI ≥ 30.0 kg/m^2).[15]

Other Variables—Standardized questionnaire information was collected on medical history, health habits, history of benign breast disease, age at menopause, type of menopause, hysterectomy status, family history of breast and other specific cancers, self-reported physician diagnosed type 2 diabetes, smoking status, body weight one year prior to diagnosis, and selected demographic data (e.g., age, education, race, ethnicity, and marital status). These forms were self-administered in Washington, and interview-administered in New Mexico.

Data Analysis

Physical Activity Data—We estimated hours per week for each activity by multiplying the frequency and duration reported. Two mutually exclusive groups were created based on type of activity (sports/recreation including walking or household/gardening). Each activity was also categorized as light, moderate, or vigorous intensity based on Ainsworth et al's Compendium of Physical Activities.[16] Light-intensity physical activity was defined as less than 3 METs, moderate-intensity physical activity as 3–6 METs, and vigorous-intensity physical activity as greater than 6 METs.[17] A MET is defined as the ratio of the associated metabolic rate for a specific activity divided by the resting metabolic rate (e.g., a 2-MET activity requires two times the resting metabolic energy expenditure of sitting quietly). One MET is also defined as the energy expenditure for sitting quietly, which for the average adult is approximately 3.5 ml of oxygen per kg body weight per minute or 1 kcal per kg body weight per hour. [16]

Hours per week for sedentary activities were also determined by summing the duration reported for television watching, sitting, and napping by weekday (Monday – Friday) and weekend (Saturday and Sunday). Exceptions were made for participants whose schedule was different from the norm (e.g., participants who might work Tuesday – Saturday and have Sunday and Monday off from work). Weekday and weekend sedentary hours per day were summed separately and then weighted by 5/7 and 2/7 respectively to calculate total sedentary hours per week.

Stage of Disease and Cancer Treatment—Participants were classified as having *in situ* (stage 0), localized (Stage 1) or regional (Stage 2a–3a) breast cancer using the SEER stage of disease classification.[18] Adjuvant treatment was categorized into four mutually exclusive groups: surgery only, surgery + radiation, surgery + chemotherapy, or surgery + radiation + chemotherapy.

Statistical Analyses

Means and standard errors of physiological and demographic characteristics of the study sample were calculated separately for each stage of disease (*in situ*, localized, and regional).

Differences in means by stage of disease were compared using analysis of variance methods; we used Tukey's HSD test to identify statistically significant differences between groups.

We used analysis of covariance methods to compare pre- and post-diagnosis physical activity levels by disease stage, cancer treatment, age, and BMI with adjustments for age, ethnicity, menopausal status, education, study site, disease stage, adjuvant treatment, tamoxifen use, season, time from diagnosis to interview, pre-diagnosis physical activity levels, full-time employment, marital status, smoking status, self-reported physician-diagnosed type 2 diabetes, family history of breast cancer, and overall health. Least-squares mean values of hours of activity before and after diagnosis are presented in the tables. We used Tukey's HSD test to identify statistically significant differences between groups.

Lastly, to determine which factors predicted a decrease in physical activity levels from pre- to post-diagnosis (i.e., change in pre- to post-diagnosis in hours/week was used as the dependent variable), we used stepwise forward regression methods and considered the following factors as potential predictors: age, menopausal status, education, full-time employment, race, ethnicity, marital status, study site, disease stage, treatment, pre-diagnosis BMI, pre-diagnosis physical activity levels, smoking status, self-reported physician-diagnosed type 2 diabetes, family history of breast cancer, number of months from diagnosis to interview, overall health, and reported weight gain during treatment. Age, pre-diagnosis BMI, pre-diagnosis physical activity levels, and number of months from diagnosis to interview were analyzed as continuous variables; the other variables were categorical variables.

Results

Twenty-three percent of the women were diagnosed with *in situ* breast cancer, 59% with localized breast cancer, and 18% with regional breast cancer (Table 1). Patients with *in situ*, local, and regional disease were on average 55.5 ± 10.9 years of age, 59.2 ± 12.2 years of age, and 55.4 ± 10.9 years of age, respectively. No statistically significant differences in mean age were observed across disease stage for weight, BMI, race, ethnicity, and family history of breast cancer. Differences in cancer treatment were observed by disease stage. Fifty-eight percent of women diagnosed with regional breast cancer underwent radiation and chemotherapy treatment than 0% and 16% of women diagnosed with *in situ* and localized breast cancer.

We found statistically significant decreases in total, moderate-intensity, vigorous-intensity, and sports/recreational activity from pre- to post-diagnosis among patients with local and regional breast cancer ($p < .05$) (Table 2). Patients with localized and regional breast cancer decreased their total physical activity from pre- to post-diagnosis by 13.8% and 8.9%, respectively. Among patients diagnosed with *in situ* breast cancer, statistically significant decreases in vigorous-intensity and sports/recreational activity were observed from pre- to post-diagnosis ($p < .05$). Lastly, a total of 52%, 58%, and 62% of *in situ*, local, and regional breast cancer patients, respectively, decreased their total physical activity levels from pre- to post-diagnosis (data not shown).

Statistically significant decreases in physical activity were observed from pre- to post-diagnosis when comparing patients according to adjuvant treatment (Table 3). These decreases were observed overall and among subgroups defined by intensity of activity and type of activity. For example, patients treated with surgery+radiation+chemotherapy had statistically significantly greater decreases in pre- to post-diagnosis sports/recreational activity (50.0% decrease) than patients treated with surgery only (24.1% decrease) and surgery + radiation (23.3% decrease) ($p < .05$). Lastly, a total of 54%, 55%, 68%, and 65%

of patients treated with surgery only, surgery + radiation, surgery + chemotherapy, and surgery + radiation + chemotherapy, respectively, decreased their total physical activity levels from pre- to post-diagnosis (data not shown).

Statistically significant decreases in total, vigorous-intensity, and sports/recreational activity were observed from pre- to post-diagnosis by age group ($p < .05$) (Table 4). No statistically significant trends across age groups were observed in pre- to post-diagnosis changes in physical activity levels (p for trend > .05).

We observed decreases in total, moderate-intensity, vigorous-intensity, and sports/recreational activity from pre- to post-diagnosis for each BMI group ($p < .05$) (Table 5). Obese breast cancer patients had greater decreases in pre- to post-diagnosis sports/recreational activity (41.4% decrease) than the leanest patients (24.1% decrease) and overweight patients (35.7% decrease) patients (p for trend < .05).

Increases in sedentary activity (reading, napping, watching television) from pre- to post-diagnosis, in the range of 1.3 hours per week to 8.0 hours per week, were also observed across all stages of disease, all treatment groups, all ages, and all BMI groups ($p < .05$).

Statistically significant predictors of a decrease in total, sports/recreational, and vigorous-intensity physical activity levels were treatment with chemotherapy+radiation and no family history of breast cancer ($R^2 = 0.23$, $p < .05$); treatment with chemotherapy+radiation, BMI, and age ($R^2 = 0.39$, $p < .05$); and treatment with chemotherapy+radiation, advanced disease stage, and BMI ($R^2 = 0.44$, $p < .05$), respectively (data not shown).

Discussion

Breast cancer patients in this population-based cohort study decreased their estimated time spent in total physical activity on average by 2.0 hours per week from the year prior to diagnosis to within one year after diagnosis, an 11% decrease ($p < .05$). This decrease in physical activity most likely explains some of the weight gain observed after a cancer diagnosis. Statistically significantly larger decreases in physical activity were observed among women treated with radiation and chemotherapy than women having surgery only or treated with radiation only ($p < .05$). The decrease in physical activity levels from pre- to post-diagnosis was expected given the documented negative side effects of breast cancer treatment including fatigue, nausea, and pain.[10,19–22] In smaller, non-population-based studies, similar findings have been reported by Courneya and Friedenreich[9], Demark-Wahnefried et al.,[10] Cooper[19] and Mock et al.[20]

In a study of 130 colorectal cancer survivors, Courneya and colleagues[9] reported that treatment had a significant negative effect on physical activity participation level that was not completely recovered post-treatment. Similar findings have been reported by Mock[20] among 14 breast cancer survivors. These results indicate that within 1 to 4 years of diagnosis, persons treated for breast and colon cancer have still not fully returned to their pre-diagnosis level of physical activity.

Decreases in physical activity with a diagnosis of breast cancer may lead to increases in body weight and body fat, which, in turn, may lead to a poorer breast cancer prognosis.[1,2] Furthermore, as observed in the present study, greater decreases in physical activity from pre- to post-diagnosis were observed among obese breast cancer patients than normal weight and overweight patients ($p < .05$) implying a potential for greater weight gain among already obese women. The negative influence of increased body weight or BMI on prognosis of breast cancer patients has been reported in the vast majority of studies over the past 25 years, with many analyses controlled for recognized prognostic variables such as

comorbidities and breast cancer screening.[13] Differential variation in sex hormones (e.g., estrogens) by body mass and body fat may be one explanation for the poor survival experienced by overweight breast cancer patients.[23–25] Specifically, overweight and obese postmenopausal women with[26] and without breast cancer[23–25] have been observed to have higher estrogen levels compared with lighter-weight women. High levels of estrogens have been associated with increased risk for incident breast cancer in several cohort studies,[27] suggesting that these hormones may be breast tumor promoters.[13] High estrogen levels likely represent conversion of androgens to estrogens by the enzyme aromatase, which is abundant in adipose tissue.[23–25] High estrogen levels promote breast cancer cell growth; [27] thus, explaining, in part, the poorer prognosis of overweight or obese postmenopausal breast cancer patients.

The present study has several limitations that should be considered when interpreting the findings and planning future research. In regards to the physical activity assessment, pre- and post-diagnosis physical activity levels were assessed in the same interview, which may result in “cross-contamination” of responses. Change in occupational physical activity from before to after breast cancer diagnosis was not assessed. Information on whether on not the patient continued to work during treatment and if so, if her occupational activity level changed with diagnosis would provide a more detailed description of physical activity patterns across the cancer experience. The physical activity questionnaire, while based on another validated questionnaire,[14] was not internally validated in the HEAL study. Although our analyses were limited to within-cohort comparisons, we cannot be sure that these associations pertain to all breast cancer patients.

The study has several strengths: this study is one of a handful that has examined physical activity levels across the cancer experience, and the only study reporting detailed physical activity information by disease stage, cancer treatment, age, and BMI, with household and sports/recreational physical activity being assessed. Our large, population-based sample of 812 breast cancer patients increases the generalizability of the results to other breast cancer survivors.

Overall, in the present study, physical activity levels were significantly reduced following diagnosis; this was particularly evident for those activities requiring greater energy expenditure. A 60% decline in vigorous-intensity physical activity was observed among women receiving the most intensive treatment (chemotherapy and radiation therapy), the group most likely to gain the most weight after diagnosis, than a 33% decline among women receiving surgery only. The implications of decreased physical activity on breast cancer prognosis are not yet known. However, higher body mass and body fat at breast cancer diagnosis have been associated with increased risk of breast cancer recurrence and poorer survival.[13] Work by Courneya[9] and others[20–22] has demonstrated that women undergoing more intensive treatment are able to be physically active so it should be feasible to avoid this decline in physical activity. These data on physical activity levels among breast cancer patients provide valuable information for planning larger observational and intervention studies designed to evaluate how physical activity levels may improve prognosis and prolong survival.

Acknowledgments

This study was supported through NCI contracts N01-CN-75036-20, NO1-CN-05228, NO1-PC-67010, and training grant T32 CA09661. A portion of this work was conducted through the Clinical Research Center at the University of Washington and supported by the National Institutes of Health, Grant M01-RR-00037.

References

1. Demark-Wahnefried W, Rimer B, Winer E. Weight gain in women diagnosed with breast cancer. J Am Diet Assoc 1997;97:519–526. [PubMed: 9145091]
2. Goodwin P, Esplen M, Butler K, et al. Multidisciplinary weight management in locoregional breast cancer: results of a phase II study. Breast Cancer Research and Treatment 1998;48:53–64. [PubMed: 9541189]
3. Demark-Wahnefried W, Peterson BL, Winer EP, et al. Changes in weight, body composition, and factors influencing energy balance among premenopausal breast cancer patients receiveing adjuvant chemotherapy. J Clin Oncol 2001;19 (9):2381–9. [PubMed: 11331316]
4. Goodwin PJ, Ennis M, Pritchard KI, et al. Adjuvant treatment and onset of menopause predict weight gain after breast cancer diagnosis. J Clin Oncol 1999;17 (1):120–9. [PubMed: 10458225]
5. McInnes JA, Knobf MT. Weight gain and quality of life in women treated with adjuvant chemotherapy for early-stage breast cancer. Oncol Nurs Forum 2001;28 (4):675–84. [PubMed: 11383182]
6. Rock C, Flatt S, Newman V, et al. Factors associated with weight gain in women after diagnosis of breast cancer. J Am Diet Assoc 1999;99:1212–1218. [PubMed: 10524383]
7. Votruba S, Horvitz M, Schoeller D. The role of exercise in the treatment of obesity. Nutrition 2000;16:179–188. [PubMed: 10705072]
8. Van Loan M, Keim N, Barbieri T, et al. The effects of endurance exercise with and without a reduction of energy intake on fat-free mass and the composition of fat-free mass in obese women. Eur J Clin Nutr 1994;48:408. [PubMed: 7925223]
9. Courneya K, Friedenreich C. Relationship between exercise pattern across the cancer experience and current quality of life in colorectal cancer survivors. J Alternative and Complementary Medicine 1997;3(3):215–226.
10. Demark-Wahnefried W, Hars V, Conaway M, Havlin K, Rimer B, McElveen G, Winer E. Reduced rates of metabolism and decreased physical activity in breast cancer patients receiving adjuvant chemotherapy. Am J Clin Nutr 1997;65:1495–501. [PubMed: 9129482]
11. Kaye S, Folsom A, Soler J, Prineas R, Potter J. Associations of body mass and fat distribution with sex hormone concentrations in postmenopausal women. Int J Epidemiol 1991;20:151–156. [PubMed: 2066214]
12. Bernstein L, Ross R. Endogenous hormones and breast cancer risk. Epi Rev 1993;15:48–65.
13. Chlebowski R, Aiello E, McTiernan A. Weight loss in breast cancer patient management. J Clin Oncology 2002;20:1128–43.
14. Kriska A, et al. Modifiable activity questionnaire. Med Sci Sports Exer 1997;29 (6):S73–78.
15. National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults – the evidence report. Obes Res 1998;6 (Suppl 2):51S–209S. [PubMed: 9813653]
16. Ainsworth B, Haskell W, Whitt M, Irwin M, Swartz A, Strath S, O'Brien W, Bassett D, Schmitz K, Emplaincourt P, Jacobs D, Leon A. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exer 2000;32 (9):S498–516.
17. Pate R, Pratt M, Blair S, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273:402–407. [PubMed: 7823386]
18. NIH publication No. 92–1999. Cancer Statistics Branch, Surveillance Program, Division of Cancer Prevention and Control, National Cancer Institute, U.S. Department of Health and Human Services, Public Health Service, National Institute of Health; Jun. 1992 The SEER Program Code Manual.
19. Cooper H. The role of physical activity in the recovery from breast cancer. Melpomene J 1995;14:18–20.
20. Mock V, Burke M, Sheehan P, et al. A nursing rehabilitation program for women with breast cancer receiving adjuvant chemotherapy. Oncology Nursing Forum 1994;21:899–907. [PubMed: 7937251]

21. Dimeo FC, Stieglitz RD, Novelli-Fischer U, Fetscher S, Keul J. Effects of physical activity on the fatigue and psychologic status of cancer patients during chemotherapy. Cancer 1999;85:2273–7. [PubMed: 10326708]

22. Schwartz A. Daily fatigue patterns and effect of exercise in women with breast cancer. Cancer Practice 2000;8 (1):16–24. [PubMed: 10732535]

23. Cauley J, Gutai J, Kuller L, LeDonne D, Powell J. The epidemiology of serum sex hormones in postmenopausal women. Am J Epidemiol 1989;129:1120–31. [PubMed: 2729251]

24. Hankinson S, Willett W, Manson J, et al. Alcohol, height, and adiposity in relation to estrogen and prolactin levels in postmenopausal women. JNCI 1995;87:1297–1302. [PubMed: 7658481]

25. Verkasalo P, Thomas H, Appleby P, Davey G, Key T. Circulating levels of sex hormones and their relation to risk factors for breast cancer: a cross-sectional study in 1092 pre- and postmenopausal women (United Kingdom). Cancer Causes Control 2001;12:47–59. [PubMed: 11227925]

26. McTiernan A, Irwin M, Baumgartner R, Bernstein L, Ballard-Barbash R. Body mass and sex hormones in postmenopausal breast cancer patients.(abstract). Am J Epidemiology. 2001

27. Endogenous Hormones and Breast Cancer Collaborative Group. Endogenous sex hormones and breast cancer in postmenopausal women: Reanalysis of nine prospective studies. JNCI 2002;94:606–616. [PubMed: 11959894]

Table 1

Physiological and demographic characteristics of H.E.A.L. breast cancer survivors (N = 812).

	In Situ Mean ± SE (n = 185)	Localized Mean ± SE (n = 479)	Regional Mean ± SE (n = 148)
Age (years)	55.5 ± 10.9	59.2 ± 12.2[a]	55.4 ± 10.9[b]
Education (% H.S. graduate)	96%	94%	94%
Weight (kg)	71.4 ± 15.6	69.1 ± 14.9	71.4 ± 16.5
Height (cm)	163.2 ± 6.9	162.2 ± 7.0	162.3 ± 6.9
BMI (wt/ht^2)	26.9 ± 5.8	26.3 ± 5.6	27.1 ± 5.9
Time from Diagnosis to Interview (months)	6.3 ± 2.3	6.0 ± 1.8	6.4 ± 1.7
Race			
White	96%	97%	97%
African American	1%	0%	0%
American Indian	1%	1%	2%
Asian	2%	1%	1%
Other	0%	1%	0%
Ethnicity			
Non-Hispanic White	84%	81%	77%
Hispanic	16%	19%	23%
Treatment			
Surgery only (%)	56%	30% [a]	14% [a b]
Radiation (%)	44%	48%	11% [a b]
Chemotherapy (%)	0%	6%	17% [a b]
Radiation + Chemotherapy (%)	0%	16% [a]	58% [a b]
Tamoxifen Users (%)	16%	54% [a]	64% [a]
Family History of Breast Cancer [c]	24%	25%	17%

[a] significantly different from in situ ($p < .05$);

[b] significantly different from local ($p < .05$);

[c] First Degree Relative

Table 2

Adjusted[1] physical activity levels (hrs/week) before and after a diagnosis of breast cancer by disease stage (N = 812).

	In Situ Mean ± SE (n = 185)	Localized Mean ± SE (n = 479)	Regional Mean ± SE (n = 148)	P for Trend
Total PA[2]				
Before Diagnosis	18.5 ± 0.3	18.9 ± 0.1	19.2 ± 0.3	.07
After Diagnosis	17.8 ± 0.8	16.3 ± 0.4	17.5 ± 0.9	.9
Absolute Difference	−0.7 ± 0.8	−2.6 ± 0.4 *a c*	−1.7 ± 0.9 *c*	.5
% Difference	−3.8%	−13.8%	−8.9%	.5
Light-Intensity PA[3]				
Before Diagnosis	11.2 ± 0.5	11.5 ± 0.3	12.1 ± 0.5	.2
After Diagnosis	11.1 ± 0.6	10.1 ± 0.4	12.0 ± 0.7*b*	.4
Absolute Difference	−0.1 ± 0.6	−1.3 ± 0.3 *c*	−0.2 ± 0.7	.9
% Difference	−0.9%	−11.3%	−1.7%	.9
Moderate-Intensity PA[4]				
Before Diagnosis	6.7 ± 0.4	6.8 ± 0.2	6.6 ± 0.4	.9
After Diagnosis	6.2 ± 0.5	5.8 ± 0.3	5.1 ± 0.6	.2
Absolute Difference	−0.5 ± 0.5	−1.0 ± 0.3 *c*	−1.5 ± 0.6 *c*	.3
% Difference	−7.5%	−14.7%	−22.7%	.3
Vigorous-Intensity PA[5]				
Before Diagnosis	0.6 ± 0.1	0.7 ± 0.1	0.5 ± 0.1	.4
After Diagnosis	0.4 ± 0.1	0.4 ± 0.1	0.2 ± 0.1 *a b*	.1
Absolute Difference	−0.2 ± 0.1*c*	−0.3 ± 0.1 *c*	−0.3 ± 0.1 *c*	.5
% Difference	−33.3%	−42.9%	−60.0%	.5

	In Situ Mean ± SE (n = 183)	Localized Mean ± SE (n = 482)	Regional Mean ± SE (n = 151)	P for Trend
Sports/Recreational PA				
Before Diagnosis	2.9 ± 0.3	2.8 ± 0.2	3.0 ± 0.4	.5
After Diagnosis	2.2 ± 0.2	2.0 ± 0.1	1.8 ± 0.2	.3
Absolute Difference	−0.7 ± 0.2 *c*	−0.9 ± 0.1*c*	−1.1 ± 0.2 *c*	.3
% Difference	−24.1%	−32.1%	−36.7%	.3
Household PA				
Before Diagnosis	14.6 ± 1.1	14.4 ± 0.6	14.5 ± 1.2	.6
After Diagnosis	14.5 ± 0.8	13.0 ± 0.4 *a*	13.9 ± 0.9	.7
Absolute Difference	−0.1 ± 0.8	−1.4 ± 0.4 *c*	−0.6 ± 0.9	.7
% Difference	−0.7%	−9.7%	−4.1%	.4
Sedentary[6]				
Before Diagnosis	39.7 ± 1.7	40.0 ± 0.9	40.9 ± 1.9	.6

	In Situ	Localized	Regional	P for Trend
	Mean ± SE (n = 183)	Mean ± SE (n = 482)	Mean ± SE (n = 151)	
After Diagnosis	43.4 ± 1.7	42.9 ± 0.9	45.7 ± 1.9	.4
Absolute Difference	3.7 ± 1.3[c]	3.0 ± 0.7[c]	4.8 ± 1.4[c]	.6
% Difference	9.3%	7.5%	11.7%	.4

[1] Least square means adjusted for age, menopausal status, education, race, ethnicity, study site, season, time from diagnosis to interview, before diagnosis physical activity level, adjuvant treatment, radiation, tamoxifen therapy, family history of breast cancer, full-time employment, smoking status, marital status, self-reported physician-diagnosed type 2 diabetes, and overall health.

[2] Total physical activity is the sum of light, moderate, and vigorous intensity physical activity. Total physical activity is also the sum of sports and household activity.

[3] Light intensity: < 3 METs

[4] Moderate intensity: 3 – 6 METs

[5] Vigorous intensity: > 6 METs

[6] Sedentary activity includes watching television, reading, and sitting.

[a] significantly different from *in situ* ($p < .05$).

[b] significantly different from localized ($p < .05$).

[c] significantly different from before diagnosis PA levels ($p < .05$).

Table 3

Adjusted[1] physical activity levels (hrs/week) before and after a diagnosis of breast cancer by adjuvant treatment (N = 812).

	Surgery Mean ± SE (n = 266)	Surgery+Radiation Mean ± SE (n = 329)	Surgery+Chemotherapy Mean ± SE (n = 52)	Surgery+Rad + Chemo Mean ± SE (n = 165)
Total PA[2]				
Before Diagnosis	18.9 ± 0.2	18.7 ± 0.2	19.7 ± 0.4	18.9 ± 0.3
After Diagnosis	17.3 ± 0.6	17.4 ± 0.5	16.1 ± 1.4	15.3 ± 0.9
Absolute Difference	−1.6 ± 0.6 *c*	−1.3 ± 0.5	−3.6 ± 1.4*bc*	−3.5 ± 0.9 *bc*
% Difference	−8.5%	−7.0%	−18.3%*b*	−18.5%*b*
Light-Intensity PA[3]				
Before Diagnosis	11.7 ± 0.4	11.5 ± 0.3	12.1 ± 0.8	11.2 ± 0.5
After Diagnosis	11.1 ± 0.5	10.9 ± 0.4	10.2 ± 1.1	9.8 ± 0.7
Absolute Difference	−0.7 ± 0.5	−0.5 ± 0.4	−1.8 ± 1.1*c*	−1.4 ± 0.7
% Difference	−6.0%	−4.3%	−14.9%	−12.5%
Moderate-Intensity PA[4]				
Before Diagnosis	6.6 ± 0.3	6.5 ± 0.3	7.1 ± 0.7	7.1 ± 0.4
After Diagnosis	5.8 ± 0.4	6.0 ± 0.3	6.1 ± 0.9	4.9 ± 0.6
Absolute Difference	−0.8± 0.4*c*	−0.5 ± 0.4	−1.1 ± 0.9	−2.2 ± 0.6*abc*
% Difference	−12.1%	−7.7%	−15.5%	−31.0%*ab*
Vigorous-Intensity PA[5]				
Before Diagnosis	0.6 ± 0.1	0.7 ± 0.1	0.5 ± 0.2	0.5 ± 0.1
After Diagnosis	0.3 ± 0.1	0.5 ± 0.1	0.1 ± 0.2	0.3 ± 0.1
Absolute Difference	−0.2 ± 0.1*c*	−0.3 ± 0.1*c*	−0.3 ± 0.2*c*	−0.3 ± 0.1*c*
% Difference	−33.3%	−42.9%	−60.0%	−60.0%

	Surgery Mean ± SE (n = 266)	Surgery+Radiation Mean ± SE (n = 329)	Surgery+Chemo Mean ± SE (n = 52)	S+Rad + Chemo Mean ± SE (n = 165)
Sports/Recreational PA				
Before Diagnosis	2.9 ± 0.7	3.0 ±0.2	2.9 ± 0.5	3.0 ± 0.4
After Diagnosis	2.2 ± 0.1	2.2 ± 0.1	1.8 ± 0.3	1.4 ± 0.2*a b*
Absolute Difference	−0.7 ± 0.1*c*	−0.7 ± 0.1*c*	−1.0 ± 0.3*c*	−1.5 ± 0.2*abc*
% Difference	−24.1%	−23.3%	−34.5%	−50.0%*ab*
Household PA				
Before Diagnosis	14.1 ± 0.8	14.5 ± 0.8	14.5 ± 1.7	14.5 ± 1.4
After Diagnosis	13.7 ± 0.6	13.9 ± 0.5	13.1 ± 1.4	12.7 ± 0.8
Absolute Difference	−0.8 ± 0.6	−0.6 ± 0.5	−1.4 ± 1.3*c*	−1.8 ± 0.8*c*
% Difference	−5.7%	−4.1%	−9.7%	−12.4%
Sedentary[6]				
Before Diagnosis	41.3 ± 1.3	39.7 ± 1.1	43.4 ± 2.9	37.8 ± 1.8

	Surgery	**Surgery+Radiation**	**Surgery+Chemo**	**S+Rad + Chemo**
	Mean ± SE (n = 266)	**Mean ± SE (n = 329)**	**Mean ± SE (n = 52)**	**Mean ± SE (n = 165)**
After Diagnosis	44.1 ± 1.3	41.0 ± 1.1	49.4 ± 2.9*b*	45.9 ± 1.8*b*
Absolute Difference	2.8 ± 1.0*c*	1.3 ± 0.8*c*	6.0 ± 2.2*c*	8.0 ± 1.4*abc*
% Difference	6.8%	3.3%	13.8%	21.2%*ab*

*1*Least square means adjusted for age, menopausal status, education, race, ethnicity, study site, disease stage, season, time from diagnosis to interview, before diagnosis physical activity level, tamoxifen therapy, family history of breast cancer, full-time employment, smoking status, marital status, self-reported physician-diagnosed type 2 diabetes, and overall health.

*2*Total physical activity is the sum of light, moderate, and vigorous intensity physical activity. Total physical activity is also the sum of sports and household activity.

*3*Light intensity: < 3 METs

*4*Moderate intensity: 3 – 6 METs

*5*Vigorous intensity: > 6 METs

*6*Sedentary activity includes watching television, reading, and sitting.

*a*significantly different from surgery ($p < .05$).

*b*significantly different from surgery+radiation ($p < .05$).

*c*significantly different from before diagnosis PA levels ($p < .05$).

Table 4

Adjusted[1] physical activity levels (hrs/week) before and after a diagnosis of breast cancer by age (N = 812).

	40–49 years Mean ± SE (n = 218)	50–59 years Mean ± SE (n = 274)	60+ Mean ± SE (n = 320)	P for Trend
Total PA[2]				
Before Diagnosis	18.7 ± 0.2	18.9 ± 0.2	19.0 ± 0.2	.5
After Diagnosis	16.8 ± 0.8	17.1 ± 0.6	16.7 ± 0.6	.9
Absolute Difference	−1.9 ± 0.8 *c*	−1.8 ± 0.6 *c*	−2.2 ± 0.6 *c*	.8
% Difference	−10.2%	−9.5%	−11.6%	.8
Light-Intensity PA[3]				
Before Diagnosis	11.1 ± 0.5	11.8 ± 0.3	11.6 ± 0.4	.4
After Diagnosis	10.1 ± 0.6	10.6 ± 0.5	11.2 ± 0.5	.3
Absolute Difference	−1.0 ± 0.6	−1.2 ± 0.5 *c*	−0.4 ± 0.5	.5
% Difference	−9.0%	−10.2%	−3.4%	.5
Moderate-Intensity PA[4]				
Before Diagnosis	6.7 ± 0.4	6.5 ± 0.3	6.9 ± 0.3	.8
After Diagnosis	6.2 ± 0.5	6.1 ± 0.4	5.1 ± 0.4	.2
Absolute Difference	−0.6 ± 0.5 *c*	−0.4 ± 0.4	−1.8 ± 0.4 *bc*	.1
% Difference	−9.0%	−6.2%	−26.1%*b*	.1
Vigorous-Intensity PA[5]				
Before Diagnosis	0.8 ± 0.1	0.7 ± 0.1	0.5 ± 0.1 *a*	.02
After Diagnosis	0.4 ± 0.1	0.5 ± 0.1	0.2 ± 0.1*b*	.2
Absolute Difference	−0.4 ± 0.1*c*	−0.2 ± 0.1 *c*	−0.2 ± 0.1 *c*	.1
% Difference	−50.0%	−28.6%	−40.0%	.1
Sports/Recreational PA				
Before Diagnosis	2.9 ± 0.3	2.9± 0.2	3.0 ± 0.4	.4
After Diagnosis	2.2 ± 0.2	2.1 ± 0.1	1.8 ± 0.1	.2
Absolute Difference	−0.7 ± 0.2 *c*	−0.8± 0.1*c*	−1.1 ± 0.1 *c*	.2
% Difference	−24.1%	−27.6%	−36.7%	.2
Household PA				
Before Diagnosis	14.5 ± 1.1	14.4 ± 0.6	14.5 ± 1.2	.3
After Diagnosis	13.2 ± 0.7	13.8 ± 0.6	13.5 ± 0.6	.8
Absolute Difference	−1.3 ± 0.7	−0.7 ± 0.6	−1.0 ± 0.6	.8
% Difference	−9.0%	−4.9%	−6.9%	.8
Sedentary[6]				
Before Diagnosis	39.4 ± 1.6	40.8 ± 1.2	39.9 ± 1.3	.8
After Diagnosis	40.9 ± 1.6	45.4 ± 1.2*a*	43.8 ± 1.3	.2
Absolute Difference	1.5 ± 1.2*c*	4.6 ± 0.9*ac*	3.8 ± 1.0*c*	.2
% Difference	3.8%	11.3%*a*	9.5%	.2

[1] Least square means adjusted for age, menopausal status, education, race, ethnicity, study site, season, time from diagnosis to interview, before diagnosis physical activity level, adjuvant treatment, radiation, tamoxifen therapy, family history of breast cancer, full-time employment, smoking status, marital status, self-reported physician-diagnosed type 2 diabetes, and overall health.

[2] Total physical activity is the sum of light, moderate, and vigorous intensity physical activity. Total physical activity is also the sum of sports and household activity.

[3] Light intensity: < 3 METs

[4] Moderate intensity: 3 – 6 METs

[5] Vigorous intensity: > 6 METs

[6] Sedentary activity includes watching television, reading, and sitting.

[a] significantly different from 40–49 year olds ($p < .05$).

[b] significantly different from 50–59 year olds ($p < .05$).

[c] significantly different from before diagnosis PA levels ($p < .05$).

Table 5

Adjusted[1] physical activity levels (hrs/week) before and after a diagnosis of breast cancer by BMI (N = 812).

	BMI < 25 Mean ± SE (n = 401)	BMI: 25–29.9 Mean ± SE (n = 246)	BMI > 29.9 Mean ± SE (n = 165)	P for Trend
Total PA[2]				
Before Diagnosis	18.8 ± 0.2	19.0 ± 0.2	18.9 ± 0.2	.7
After Diagnosis	17.1 ± 0.5	17.0 ± 0.6	16.1 ± 0.8	.3
Absolute Difference	−1.7 ± 0.5 [c]	−2.0 ± 0.6 [c]	−2.8 ± 0.8 [c]	.2
% Difference	−9.0%	−10.5%	−14.8%	.2
Light-Intensity PA[3]				
Before Diagnosis	11.4 ± 0.3	11.4 ± 0.4	11.8 ± 0.4	.5
After Diagnosis	10.8 ± 0.4	10.7 ± 0.5	10.5 ± 0.6	.6
Absolute Difference	−0.7 ± 0.4	−0.8 ± 0.5	−1.4 ± 0.6	.3
% Difference	−6.1%	−7.0%	−11.9%	.3
Moderate-Intensity PA[4]				
Before Diagnosis	6.6 ± 0.2	7.0 ± 0.3	6.5 ± 0.4	.9
After Diagnosis	5.7 ± 0.3	6.0 ± 0.4	5.4 ± 0.5	.6
Absolute Difference	−0.9 ± 0.3 [c]	−1.0 ± 0.4 [c]	−1.1 ± 0.5 [c]	.7
% Difference	−13.6%	−14.3%	−16.9%	.7
Vigorous-Intensity PA[5]				
Before Diagnosis	0.7 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	.1
After Diagnosis	0.5 ± 0.1	0.3 ± 0.1[a]	0.2 ± 0.1[a]	.01
Absolute Difference	−0.2 ± 0.1[c]	−0.3 ± 0.1 [c]	−0.3 ± 0.1 [c]	.5
% Difference	−28.6%	−60.0%	−60.0%	.5
Sports/Recreational PA				
Before Diagnosis	2.9 ± 0.3	2.8 ± 0.2	2.9 ± 0.4	.4
After Diagnosis	2.2 ± 0.1	1.9 ± 0.1	1.7 ± 0.2 [a]	.01
Absolute Difference	−0.7 ± 0.1 [c]	−1.0± 0.1[c]	−1.2 ± 0.2 [c]	.01
% Difference	−24.1%	−35.7%	−41.4%	.01
Household PA				
Before Diagnosis	14.4 ± 1.1	14.5 ± 0.6	14.3 ± 1.2	.5
After Diagnosis	13.4 ± 0.5	13.8 ± 0.6	13.3 ± 0.7	.9
Absolute Difference	−1.0 ± 0.5	−0.6 ± 0.6	−1.1 ± 0.7	.9
% Difference	−6.9%	−4.1%	−7.7%	.9
Sedentary[6]				
Before Diagnosis	38.9 ± 1.0	38.8 ± 1.3	45.2 ± 1.6	.006
After Diagnosis	41.8 ± 1.0	41.4 ± 1.3	51.1 ± 1.6	.0001
Absolute Difference	3.0 ± 0.8[c]	2.6 ± 1.0[c]	5.9 ± 1.2[abc]	.04
% Difference	7.7%	6.7%	13.1%[ab]	.04

[1] Least square means adjusted for age, menopausal status, education, race, ethnicity, study site, season, time from diagnosis to interview, before diagnosis physical activity level, adjuvant treatment, tamoxifen therapy, family history of breast cancer, full-time employment, smoking status, marital status, self-reported physician-diagnosed type 2 diabetes, and overall health.

[2] Total physical activity is the sum of light, moderate, and vigorous intensity physical activity. Total physical activity is also the sum of sports and household activity.

[3] Light intensity: < 3 METs

[4] Moderate intensity: 3 – 6 METs

[5] Vigorous intensity: > 6 METs

[6] Sedentary activity includes watching television, reading, and sitting.

[a] significantly different from BMI < 25 ($p < .05$).

[b] significantly different from BMI: 25–29.9 ($p < .05$).

[c] significantly different from before diagnosis PA levels ($p < .05$).