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Postdiagnosis diet quality, the combination of diet quality and recreational physical activity, and prognosis after early-stage breast cancer

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Abstract

Objective—To investigate, among women with breast cancer, how postdiagnosis diet quality and the combination of diet quality and recreational physical activity are associated with prognosis.

Methods—This multiethnic, prospective observational cohort included 670 women diagnosed with local or regional breast cancer. Thirty months after diagnosis, women completed self-report assessments on diet and physical activity and were followed for 6 years. Cox proportional hazards models were used to estimate hazard ratios (HR) and 95% confidence intervals for death from any cause and breast cancer death.

Results—Women consuming better-quality diets, as defined by higher Healthy Eating Index-2005 scores, had a 60% reduced risk of death from any cause (HR_{Q4:Q1}: 0.40, 95% CI: 0.17, 0.94) and an 88% reduced risk of death from breast cancer (HR_{Q4:Q1}: 0.12, 95% CI: 0.02, 0.99). Compared with inactive survivors consuming poor-quality diets, survivors engaging in any recreational physical activity and consuming better-quality diets had an 89% reduced risk of death from any cause (HR: 0.11, 95% CI: 0.04, 0.36) and a 91% reduced risk of death from breast cancer (HR: 0.09, 95% CI: 0.01, 0.89). Associations observed were independent of obesity status.

Conclusion—Women diagnosed with localized or regional breast cancer may improve prognosis by adopting better-quality dietary patterns and regular recreational physical activity. Lifestyle interventions emphasizing postdiagnosis behavior changes are advisable in breast cancer survivors.

Keywords

Diet; Exercise; Breast neoplasm; Prognosis

Introduction

Even after accounting for stage, treatment, and comorbid diseases, long-term survival varies widely for women with breast cancer [1]. Over 2.5 million American women live with a personal history of breast cancer [2, 3]. It is important to understand how lifestyle health habits that women can change after diagnosis, such as diet and physical activity, improve prognosis.

Prior research on diet and prognosis focused on individual nutrients or dietary components, such as fat and fruits and vegetables, and results are conflicting. Given this inconsistency and that foods are not consumed in isolation, there has been growing interest in studying overall dietary patterns, an approach that takes into account the complexity of the diet and the potentially synergistic or antagonistic effects of all individual dietary components [4].

Few studies have evaluated dietary patterns in relation to outcomes after breast cancer [5, 6], and more research is needed in this area to inform guidance for survivors.

Evidence is accumulating in support of the benefit of regular recreational physical activity for reducing the risk of mortality after breast cancer [7–10]. Although healthier diets and regular physical activity, in many cases, cluster together, there is a lack of research on the combined association of these interrelated behaviors.

We proposed to build upon previously reported research in the Health, Eating, Activity, and Lifestyle (HEAL) Study, showing that among women with breast cancer, compared with inactive women, those engaging in any or at least the recommended amount of aerobic moderate to vigorous recreational physical activity had 64 and 67% lower risk of death from any cause, respectively, even after adjustment for body mass index (BMI) [9]. Among women with breast cancer in the HEAL Study, we examined whether a better-quality diet and a better-quality diet combined with recreational physical activity were related to death from any cause or to death from breast cancer.

Materials and methods

Study participants

The HEAL Study is a multiethnic prospective cohort study that has enrolled 1,183 women with first primary breast cancer drawn from Surveillance, Epidemiology, and End Results (SEER) population-based cancer registries in New Mexico, Los Angeles County, and Western Washington. The study was designed to determine whether lifestyle, hormones, and other exposures affect breast cancer prognosis. Details of the study have been published [11–13].

In New Mexico, we recruited 615 women aged 18 years or older, diagnosed with in situ to regional breast cancer between July 1996 and March 1999, and living in Bernalillo, Santa Fe, Sandoval, Valencia, or Taos counties. In Western Washington, we recruited 202 women between ages 40 and 64 years, diagnosed with in situ to regional breast cancer between September 1997 and September 1998, and living in King, Pierce, or Snohomish counties. The age range for the Washington patients was restricted due to other ongoing breast cancer studies. In Los Angeles County, we recruited 366 black women diagnosed with in situ to regional breast cancer between May 1995 and May 1998 who had participated in the Los Angeles portion of the Women's Contraceptive and Reproductive Experiences (CARE) Study or who had participated in a parallel case-control study of in situ breast cancer. The Women's CARE Study was designed to restrict eligibility to women ages 35–64 years at diagnosis.

In the HEAL Study, women completed assessments approximately 6 months after diagnosis, and 30 months after diagnosis. At the 30-month postdiagnosis assessment, women from all study sites completed extensive diet and physical activity measures.

Nine hundred and forty-four participants completed the 30-month postdiagnosis assessment (Fig. 1). We excluded women who may have been receiving treatment for subsequent recurrences or new primaries that occurred before their 30-month assessment ($n = 57$), because active treatment may be associated with changes in diet and physical activity. We further excluded women who had an initial breast cancer diagnosis of in situ disease ($n = 197$), because they are at low risk for mortality [14]. We also excluded women missing data on physical activity ($n = 2$), diet ($n = 15$), or follow-up time ($n = 3$). Our final sample included 670 women. We obtained written informed consent from all study participants. The study was approved by the institutional review board at each participating center, in accord

with assurances filed with and approved by the US Department of Health and Human Services.

Data collection

Outcomes—Our primary and secondary outcomes were death from any cause and death from breast cancer. The mean follow-up time from the 30-month postdiagnosis assessment through 31 December 2006 was 6 years.

We used SEER cancer registry data from New Mexico, Los Angeles County, and Western Washington to determine vital status. We obtained data on underlying cause of death from state mortality files and the National Death Index.

Diet—At the 30-month postdiagnosis assessment, we measured diet using a 122-item self-administered food-frequency questionnaire (FFQ) developed and validated for the Women's Health Initiative (WHI) [15], adapted from the Health Habits and Lifestyle Questionnaire [16]. The WHI-FFQ was designed to capture foods relevant for multiethnic and geographically diverse population groups and has been shown to produce reliable ($r_{\text{all nutrients}} = 0.76$) and comparable estimates to 8 days of dietary intake from 24-h dietary recalls and 4-day food records ($r = 0.37, 0.62, 0.41, 0.36$, with energy, percent energy from fat, carbohydrate, and protein) [15]. New Mexico participants reported their usual dietary intake for the previous year, whereas participants at the other two centers reported usual intake for the previous month.

The nutrient database used to analyze the WHI-FFQ is derived from the Nutrition Data Systems for Research (NDS-R, version 2005, University of Minnesota, Minneapolis, MN) [17, 18]. NDS-R provides necessary estimates for energy, saturated fat, and sodium, but does not link to the MyPyramid Equivalents Database [19]. Thus, we established a customized link with the WHI-FFQ to calculate total fruit, whole fruit, total vegetables, dark green vegetables, orange vegetables, legumes, total grains, whole grains, milk, meat and beans, oils, solid fats, and added sugars. We also created variables for calories from alcohol, solid fat, and added sugar.

We measured diet quality with the Healthy Eating Index-2005 (HEI-2005) [20–23]. The HEI-2005, created by the US Department of Agriculture and the National Cancer Institute, aligns with the US Dietary Guidelines for Americans-2005 and uses an energy-adjusted density approach [24]. Table 1 lists the 12 HEI-2005 components and standards for scoring. For each participant, we scored each component and calculated a total score (100 possible points). We classified HEI-2005 scores into quartiles to best separate those with “better-quality” diets (Q4) and “poor-quality” diets (Q1).

Physical activity—At the 30-month postdiagnosis assessment, we collected information on postdiagnosis physical activity, including recreational, occupational, and household activities, using the interview-administered Modifiable Activity Questionnaire [25]. In this analysis, we focused on recreational physical activity, given its consistent association with mortality previously reported in our cohort and the literature [7–10]. The Modifiable Activity Questionnaire has high validity and reliability for measuring recreational physical activity ($r = 0.56$ with total energy expenditure assessed by doubly labeled water, and $r = 0.88$ for 3-week test-retest among 37–59-year-old women and men) [25].

Participants reported the type, duration, and frequency of recreational physical activities (e.g., brisk walking, biking, dancing, swimming, jogging) in the previous year. We classified each activity according to its corresponding metabolic equivalent of task (MET) value in the “Compendium of Physical Activities” [26]. For all activities with MET values ≥ 3 , we

summed the products of activity MET values and hours spent in each activity to arrive at MET-hours/week spent in moderate/vigorous-intensity activity for each participant. In the HEAL Study, postdiagnosis, but not prediagnosis, activity was inversely associated with death from any cause [9], supporting our choice to focus on the former.

Similar to Irwin et al. [9], we classified recreational physical activity into three categories (inactive: 0; somewhat active: >0 to <9; active: ≥ 9 MET-hours/week), with 9 MET-hours/week approximately equal to 150 min/week of moderate-intensity physical activity, and meeting the general population guidelines for health promotion [27]. Results were similar when classifying activity as done by Holmes et al. [8]. For combined association analyses, we classified women into two groups: none (0 MET-hours/week) versus any (>0 MET-hours/week), given the benefit observed in HEAL for doing any postdiagnosis activity [9].

BMI—Height was measured postdiagnosis at the baseline assessment. For participants missing measured height ($n = 217$), self-reported height at age 18 was used ($r = 0.93$ among 466 participants with both measures). Trained staff measured weight at the 30-month assessment. Measurements of weight were made to the nearest 0.1 kg with women wearing light indoor clothing and no shoes. All measurements were performed twice and averaged for a final value. BMI was calculated as weight (kg)/height (m^2) and was categorized into the World Health Organization's (WHO) BMI categories (underweight <18.5; normal: ≥ 18.5 to <25; overweight: ≥ 25 to <30; obese: ≥ 30 to <40; very obese: ≥ 40 kg/ m^2).

Additional risk factors—For participants' breast cancer diagnoses, disease stage and estrogen receptor status were obtained from cancer registry records, and detailed information on treatment and surgical procedures were obtained from cancer registry, physician, and hospital records. At baseline, information was collected on recruitment site, date of birth, race, education level, and prediagnosis physical activity. We calculated age at 30-month assessment and age at exit using date of birth. At the 30-month assessment, we collected information on tamoxifen use and current smoking status via questionnaire. We determined participants' menopausal status at the 30-month assessment from medical records, hormone levels, and questionnaires. We considered each of these risk factors in model development.

Statistical analyses

Means, standard deviations, and frequencies of demographic, clinical, and lifestyle characteristics of the study sample were calculated by quartiles of HEI-2005 scores. Participant characteristics by physical activity level were previously reported [9].

Cox proportional hazards models were fit to our data using age as the underlying time metric. We estimated multivariate hazard ratios (HR) and 95% confidence intervals (CI) for death from any cause and death from breast cancer associated with diet quality and the combination of diet quality and recreational physical activity.

The comparison of interest in our diet quality analysis was Q4:Q1, because the HEI-2005 distinguishes those scoring well on virtually all of the components (Q4) versus those scoring poorly on virtually all the components (Q1). Scores in the middle quartiles (Q2–Q3) are more likely to reflect “mixed-quality” diets, thus including individuals with somewhat similar total scores, but more widely varying component scores.

All models were adjusted for energy to reduce measurement error [28]. Then, we included variables that improved model fit and changed the magnitude of hazard ratios by at least 10% and/or allowed comparison to the published literature. To assess confounding by BMI, we created models with and without BMI. For diet quality models, we adjusted for energy,

physical activity, race, stage, and tamoxifen use. In models for our combined diet quality and physical activity measure, we adjusted for energy, race, stage, and tamoxifen use.

To see whether any one component was driving associations for diet quality, we ran models for each of the 12 HEI-2005 components, adjusting for all other components and the covariates above. To rule out reverse causation, we ran analyses restricted to women who did not have an event during the first year of follow-up. To determine whether associations differed across the WHO's BMI categories, we examined likelihood ratio tests for both the interaction of diet quality with BMI ($\alpha = 0.05$) and the difference in model fit of full and reduced models.

All statistical analyses were conducted using SAS (version 9.1.3, Cary, NC).

Results

Compared with women with poor-quality diets (Q1), survivors with better-quality diets (Q4) were, on average, older, more likely to be non-Hispanic white and college educated and less likely to be current smokers (Table 2). They also engaged in more physical activity before and after diagnosis, and, in particular, consumed a lower percent of calories from solid fat, added sugar, and alcohol, or from saturated fat.

In fully adjusted models, breast cancer survivors with better-quality diets as defined by higher HEI-2005 scores (Q4 vs. Q1) had a 60% reduced risk of death from any cause (HR: 0.40, 95% CI: 0.17, 0.94) and an 88% reduced risk of breast cancer death (HR: 0.12, 95% CI: 0.02, 0.99; Table 3). We did not find evidence of associations with individual HEI-2005 components (data not shown).

Compared with inactive survivors with poor-quality diets, active survivors with better-quality diets had an 89% reduced risk of death from any cause (HR: 0.11, 95% CI: 0.04, 0.36) and a 91% reduced risk of death from breast cancer (HR: 0.09; 95% CI: 0.01, 0.89; Table 4).

We did not find evidence of effect modification of diet quality associations by WHO BMI categories. Associations were strengthened after control for confounding by BMI. When we excluded women who had events in the first year of follow-up, the magnitude of HRs were similar (data not shown).

Discussion

This study suggests that better-quality diet alone and in combination with participation in regular recreational physical activity might be beneficial for reducing risks of overall and breast cancer specific mortality, regardless of BMI. The observed inverse association between better-quality diet and death from any cause is consistent with previous research [6] and remained even after control for recreational physical activity. Our study provided evidence of a reduced risk of death from breast cancer associated with a better-quality diet, and this warrants future research. Previous work with dietary patterns has not shown similar findings for breast cancer mortality [5, 6], but it should be noted that past work used data-driven methods, and this analysis used a recommendation-driven method, the HEI-2005. To our knowledge, our study is also the first to report on the potential prognostic benefit associated with overall better diet quality combined with regular recreational activity.

A summary diet quality score is most instructive when scores are very high or low. In this study, we were able to accurately separate those individuals with better-quality diets (Q4) compared to those with poor-quality diets (Q1). In these quartiles, we can most

appropriately capture those who are scoring well on virtually all of the components compared with those who are not. Although women with mixed diet quality (Q2) also appeared to have a reduced risk of death from any cause, these findings in the middle quartiles are more difficult to interpret because these scores include some individuals with the same score but very different diets.

Advantages of this study include use of the multidimensional HEI-2005, which is able to capture the potentially synergistic nature of multiple important dietary components [29] and allowed us to distinguish survivors with better- versus poor-quality diets (Q4 vs. Q1). Our detailed postdiagnosis assessment of physical activity allowed us to categorize women by their recreational physical activity level [9]. For covariate purposes, we had high-quality extensive data on clinical characteristics and treatment abstracted from physician and hospital records in addition to cancer registry records and objective measurement of weight at 30 month postdiagnosis. Last, the women in our study were representative of American women seen in routine clinical practice versus tertiary cancer hospitals.

Our study also had several limitations. The self-report nature of our diet and physical activity assessments may have resulted in exposure misclassification. The response timeframe (last month vs. last year) for the FFQ differed by study site, but it is reasonable to assume that women did not differentially make diet changes across sites during that time in the absence of an intervention. Age eligibility criteria were not uniform among study sites; however, study site did not confound results observed, and age was used as the underlying time metric. Our results are only generalizable to women who have survived at least 30 months after diagnoses of breast cancer. However, as our interest was in predictors of long-term survival, measuring exposures 30 months postdiagnosis allowed us to separate out treatment effects.

Although we had detailed data allowing us to carefully control for the major confounders and to show that associations were unlikely to be artifacts of reverse causation, given the observational nature of this study, it remains possible that those who chose a better-quality diet or more extensive physical activity routine had better prognoses for reasons that we did not examine.

With the limited number of deaths observed, we did not have the statistical power to test whether the survival benefit of having both healthy behaviors (diet and physical activity) versus neither was different than the benefit of having one or the other, irrespective of the other health behavior. Among populations of breast cancer patients as a whole and clinically important subpopulations (i.e., by race, ER/PR status, stage, and BMI), the extent of the potential prognostic benefit of having a better-quality diet and being physically active should be addressed in future larger cohort studies, pooled analyses of existing breast cancer patient cohort studies with relevant measures, and in clinical trials of lifestyle interventions [30]. Future studies could also explore the influence of these interrelated health behaviors on risk of recurrence and new breast cancer primaries.

In addition to their association with reduced mortality observed in our study, diet quality and physical activity have been shown to have broad-based benefits for morbidity among older cancer survivors. One study showed that among older long-term breast, prostate, and colorectal cancer survivors, a diet and exercise intervention reduced self-reported functional decline [31], and having higher levels of physical activity and healthier diets was positively associated with better physical health and quality of life [32]. In the HEAL Study, better diet quality after diagnosis was associated with increased mental and physical functioning [13] and lower levels of chronic inflammation [33], and greater postdiagnosis recreational physical activity was associated with reduced fatigue [34], improved physical functioning

[34], and improved psychosocial quality of life [35]. Preserving functionality and quality of life in addition to length of life of older adults will be important as the number of elderly US adults increases and the population of older survivors grows.

Women diagnosed with localized or regional breast cancer may improve prognosis by adopting and maintaining better-quality dietary patterns and regular recreational physical activity. Future research examining the associations of specific diet, physical activity, and weight control practices with prognosis will provide more evidence for informed guidance.

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Fig. 1. Participant recruitment and timing of data collection

Table 1
Components of the Healthy Eating Index-2005 [36]

Component ^a	Maximum points	Standard for maximum score	Standard for minimum score of zero
Total fruit (includes 100% juice)	5	≥0.8 cup equiv. per 1,000 kcal	No fruit
Whole fruit (not juice)	5	≥0.4 cup equiv. per 1,000 kcal	No whole fruit
Total vegetables	5	≥1.1 cup equiv. per 1,000 kcal	No vegetables
Dark green and orange vegetables and legumes ^b	5	≥0.4 cup equiv. per 1,000 kcal	No dark green and orange vegetables or legumes
Total grains	5	≥3.0 oz equiv. per 1,000 kcal	No grains
Whole grains	5	≥1.5 oz equiv. per 1,000 kcal	No whole grains
Milk ^c	10	≥1.3 cup equiv. per 1,000 kcal	No milk
Meat and beans	10	≥2.5 oz equiv. per 1,000 kcal	No meat or beans
Oils ^d	10	≥12 grams per 1,000 kcal	No oil
Saturated fat	10	≤7% of energy ^e	≥15% of energy
Sodium	10	≤0.7 gram per 1,000 kcal ^e	≥2.0 grams per 1,000 kcal
Calories from solid fats, alcoholic beverages, and added sugars	20	≤20% of energy	≥50% of energy

^aIntakes between the minimum and maximum levels are scored proportionately, except for saturated fat and sodium (see footnote 'e')

^bLegumes counted as vegetables only after meat and beans standard is met

^cIncludes all milk products, such as fluid milk, yogurt, and cheese, and soy beverages

^dIncludes non-hydrogenated vegetable oils and oils in fish, nuts, and seeds

^eSaturated fat and sodium get a score of 8 for the intake levels that reflect the 2005 Dietary Guidelines, <10% of calories from saturated fat and 1.1 grams of sodium/1,000 kcal, respectively

Table 2
Demographic, clinical, and lifestyle characteristics of women in the Health, Eating, Activity, and Lifestyle Study ($n = 670$) by quartiles of HEI-2005 scores

	Poor-quality diet		Mixed-quality diet		Better-quality diet		<i>p</i> value ^e		
	Healthy Eating Index-2005 score quartile 1		Healthy Eating Index-2005 score quartile 2		Healthy Eating Index-2005 score quartile 3			Healthy Eating Index-2005 score quartile 4	
	No.	%	No.	%	No.	%		No.	%
Number of participants									
Age ^d	167		168		168		167		
Mean (SE)		55.4 (0.8)		58.0 (0.9)		58.0 (0.8)		60.0 (0.8)	
Race/ethnicity									
White, non-Hispanic	79	47	93	55	101	60	113	68	
Hispanic	25	15	22	13	21	13	9	5	
Black, non-Hispanic	60	36	49	29	41	24	39	23	
American Indian, Asian, other	3	2	4	2	5	3	6	4	
College graduate or beyond	38	23	52	31	69	41	78	47	
Menopausal status ^a									
Premenopausal	64	38	61	36	54	32	48	29	
Postmenopausal	90	54	97	58	106	63	115	69	
Unknown	13	8	10	6	8	5	4	2	
Treatment									
Surgery only	39	23	40	24	38	23	43	26	
+ radiation	66	40	57	34	59	35	58	35	
+ chemotherapy	23	14	19	11	17	10	23	14	
+ radiation and chemotherapy	39	23	52	31	54	32	43	26	
Stage									
Localized	122	73	122	73	116	69	118	71	
Regional	45	27	46	27	52	31	49	29	
Current tamoxifen use									
No	91	54	83	49	79	47	72	43	
Yes	76	46	85	51	89	53	95	57	
0.038									

	Poor-quality diet			Mixed-quality diet			Better-quality diet			<i>p</i> value ^e			
	Healthy Eating Index-2005 score quartile 1			Healthy Eating Index-2005 score quartile 2			Healthy Eating Index-2005 score quartile 3				Healthy Eating Index-2005 score quartile 4		
	No.	%		No.	%		No.	%			No.	%	
Estrogen receptor status ^b													
Positive	112	67		113	67		117	70	124	74			0.254
Negative	35	21		40	24		32	19	27	16			
# of months from diagnosis to 30- month assessment													
Mean (SE)		30.6 (0.3)			30.2 (0.3)			29.7 (0.3)		30.1 (0.3)			0.31
HEI-2005 score (100 points possible)													
Mean (SE)		50.1 (0.5)			62.9 (0.2)			70.8 (0.2)		79.0 (0.2)			<0.0001
Energy/day (kcal)													
Mean (SE)		1,826 (98)			1,426 (50)			1,394 (47)		1,259 (38)			<0.0001
Fruit (c eq/1,000 kcal)													
Mean (SE)		0.5 (0.03)			1.0 (0.05)			1.2 (0.06)		1.7 (0.07)			<0.0001
Whole fruit (c eq/1,000 kcal)													
Mean (SE)		0.3 (0.03)			0.6 (0.04)			0.9 (0.06)		1.2 (0.06)			<0.0001
Vegetables (c eq/1,000 kcal) ^c													
Mean (SE)		0.8 (0.03)			1.0 (0.03)			1.1 (0.04)		1.3 (0.04)			<0.0001
Dark green vegetables, orange vegetables, and legumes (c eq/1,000 kcal) ^c													
Mean (SE)		0.1 (0.01)			0.2 (0.01)			0.2 (0.01)		0.3 (0.01)			<0.0001
Total grains (oz eq/1,000 kcal)													
Mean (SE)		2.5 (0.08)			2.7 (0.08)			2.8 (0.07)		2.8 (0.07)			0.002
Whole grains (oz eq/1,000 kcal)													
Mean (SE)		0.4 (0.03)			0.6 (0.04)			0.8 (0.05)		0.9 (0.04)			<0.0001
Meat and beans (oz eq/1,000 kcal) ^d													
Mean (SE)		2.9 (0.09)			3.0 (0.09)			3.0 (0.08)		2.9 (0.07)			0.800
Oils (g/1,000 kcal)													
Mean (SE)		9.8 (0.4)			10.8 (0.4)			11.1 (0.4)		11.0 (0.4)			0.026
Milk (c eq/1,000 kcal)													

	Poor-quality diet		Mixed-quality diet		Better-quality diet		<i>p</i> value ^e
	Healthy Eating Index-2005 score quartile 1		Healthy Eating Index-2005 score quartile 2		Healthy Eating Index-2005 score quartile 3		
	No.	%	No.	%	No.	%	
Mean (SE)		0.7 (0.04)		0.9 (0.04)		0.9 (0.05)	<0.0001
Sodium (g/1,000 kcal)							
Mean (SE)		1.5 (0.03)		1.6 (0.02)		1.7 (0.02)	<0.0001
Percent calories from saturated fat							
Mean (SE)		14 (0.3)		12 (0.2)		11 (0.2)	<0.0001
Percent discretionary calories from solid fat, alcoholic beverages, and added sugars							
Mean (SE)		41 (0.6)		32 (0.4)		27 (0.4)	<0.0001
MET-hours/week of postdiagnosis recreational physical activity							
Mean (SE)		9.9 (1.4)		10.7 (1.1)		12.3 (1.2)	<0.0001
MET-hours/week of prediagnosis recreational physical activity							
Mean (SE)		7.3 (1.0)		11.9 (1.4)		13.0 (1.4)	0.001
BMI ^a							
Mean (SE)		28.6 (0.5)		28.4 (0.5)		27.5 (0.5)	0.081
Current smoker ^d	33	20	21	13	23	14	5

^a At 30-month assessment

^b Confirmed positive/negative status for 600 participants

^c Includes legumes only after meat and beans standard has been met

^d Includes legumes only if meat and beans standard is otherwise not met

^e *p* values are for likelihood ratio chi-square tests contrasting means (continuous variables) and percentages (categorical variables) for the better-quality diet group compared with the poor-quality diet group

Table 3
Diet quality, risk of death from any cause, and risk of death from breast cancer among 670 breast cancer survivors in the Health, Eating, Activity, and Lifestyle Study

	Poor-quality diet	Mixed-quality diet		Better-quality diet
	Healthy Eating Index-2005 score quartile 1 (35–58)	Healthy Eating Index-2005 score quartile 2 (58–67)	Healthy Eating Index-2005 score quartile 3 (67–74)	Healthy Eating Index-2005 score quartile 4 (74–87)
<i>n</i>	167	168	168	167
<i>Death from any cause (n)</i>	22	14	17	9
Multivariate-adjusted HR without BMI (95% CI) ^a	1.00	0.49 (0.23, 1.02)	1.00 (0.50, 2.01)	0.46 (0.20, 1.08)
Full multivariate-adjusted HR (95% CI) ^b	1.00	0.39 (0.18, 0.85)	0.85 (0.43, 1.71)	0.40 (0.17, 0.94)
<i>Death from breast cancer (n)</i>	11	6	6	1
Multivariate-adjusted HR without BMI (95% CI) ^a	1.00	0.67 (0.24, 1.85)	0.78 (0.27, 2.27)	0.14 (0.02, 1.12)
Full multivariate-adjusted HR (95% CI) ^b	1.00	0.65 (0.23, 1.86)	0.70 (0.24, 2.06)	0.12 (0.02, 0.99)

^a Adjusted for energy intake, physical activity, race, stage, tamoxifen use

^b Additionally adjusted for body mass index

Table 4
Joint associations of diet quality and recreational physical activity on risk of death from any cause and death from breast cancer among 670 breast cancer survivors in the Health, Eating, Activity, and Lifestyle study

	No regular recreational physical activity after diagnosis (0 MET-hours/week)			Any regular recreational physical activity after diagnosis (>0 MET-hours/week) ^a		
	Poor-quality diet	Mixed-quality diet	Better-quality diet	Poor-quality diet	Mixed-quality diet	Better-quality diet
<i>n</i>	37	59	14	130	277	153
<i>Death from any cause (n)</i>	10	15	4	12	16	5
Multivariate HR without BMI (95% CI) ^b	1.00	1.09 (0.46, 2.59)	1.17 (0.34, 4.01)	0.72 (0.29, 1.81)	0.32 (0.14, 0.75)	0.16 (0.05, 0.51)
Full multivariate HR (95% CI) ^c	1.00	0.80 (0.32, 1.99)	1.07 (0.30, 3.84)	0.53 (0.21, 1.34)	0.24 (0.10, 0.58)	0.11 (0.04, 0.36)
<i>Death from breast cancer</i>	3	6	0	8	6	1
Multivariate HR without BMI (95% CI) ^b	1.00	1.93 (0.46, 8.15)	0	1.22 (0.30, 5.03)	0.46 (0.11, 1.97)	0.13 (0.01, 1.29)
Full multivariate HR (95% CI) ^c	1.00	1.88 (0.41, 8.65)	0	1.05 (0.25, 4.45)	0.37 (0.08, 1.70)	0.09 (0.01, 0.89)

Poor-quality diet (Q1 of HEI-2005 scores); mixed-quality diet (Q2-Q3 of HEI-2005 scores); better-quality diet (Q4 of HEI-2005 scores)

^aThe mean MET-hours/week among women engaging in any postdiagnosis recreational physical activity was 15.5

^b Adjusted for energy intake, race, stage, and tamoxifen use

^c Additionally adjusted for body mass index