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Diet quality of breast cancer survivors after a six-month weight management intervention: Improvements and association with weight loss

Danielle N. Christifano[1], **Tera L. Fazzino**[1], **Debra A. Sullivan**[2], and **Christie A. Befort**[1]

[1]Department of Preventive Medicine and Public Health, University of Kansas Medical Center, Kansas City, KS, USA

[2]Department of Nutrition and Dietetics, University of Kansas Medical Center, Kansas City, KS, USA

Abstract

Purpose—Obesity and diet quality are two distinct lifestyle factors associated with morbidity and mortality among breast cancer survivors. The purpose of this study was to examine diet quality changes during a weight loss intervention among breast cancer survivors, and whether diet quality change was an important factor related to weight loss.

Methods—Participants were overweight/obese breast cancer survivors (n=180) participating in a weight loss intervention. Diet quality scores were calculated using the Healthy Eating Index-2010. Paired sample t-tests were run to examine change in diet quality, and a latent difference model was constructed to examine whether change in diet quality was associated with weight change.

Results—Participants significantly improved diet quality (p=.001) and lost 13.2%± 5.8% (mean± SD) of their weight (p=.001). Six month HEI score was significantly associated with weight loss, controlling for baseline BMI (p=.003). Improvement in diet quality was also significantly associated with weight loss (p=.01).

Conclusion—Our findings indicate that a weight loss intervention can result in both clinically significant weight loss and improvement in diet quality, and that improved diet quality is predictive of weight loss. Both weight loss and diet quality are implicated in longevity and quality of life for breast cancer survivors.

Keywords

Diet quality; healthy eating index; weight loss; breast cancer survivorship

INTRODUCTION

The American Institute for Cancer Research estimates over one third of cancers could be prevented through adherence to weight, diet, and physical activity guidelines (1). A healthy

*Corresponding Author: Danielle Christifano, Ph.D., Department of Preventive Medicine and Public Health, University of Kansas Medical Center, 3901 Rainbow Boulevard Mail Stop 1008, Kansas City, KS 66160, USA, DChristifano@kumc.edu, 913-945-7890.

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diet has long been considered important to the well-being and longevity of breast cancer survivors (2–4). In the last decade, research exploring the relationship between nutrition and cancer has shifted its focus from single nutrients to more comprehensive assessment of overall diet quality (5). This is in part due to the fact that large-scale trials have reported contradictory findings regarding specific nutrients and breast cancer risk, and it has thus been difficult to create post-diagnosis recommendations regarding single nutrients for the growing number of breast cancer survivors (6). The National Cancer Institute has played an active role in the development and validation of the Healthy Eating Index (7), a standardized measure that assesses diet quality as it relates to conformance with the Dietary Guidelines for Americans (DGA). Recent research has emphasized the importance of post-diagnosis diet quality as measured by the HEI in the morbidity and mortality (8) and overall health of breast cancer survivors (9).

In addition to the quality of calories consumed, the quantity of calories consumed is implicated in breast cancer prognosis through its direct impact on the development and treatment of obesity (10–13). Several interventions have demonstrated that overweight and obese breast cancer survivors can successfully achieve clinically meaningful weight loss following evidence-based guidelines(14, 15) based on decreased caloric consumption and increased caloric expenditure (16–18), similar to the larger obese population (19). However, while weight loss and diet quality have both independently been associated with the overall health of breast cancer survivors, their interplay, e.g., the role of diet quality in promoting successful weight loss in this population, is largely unknown. A few small studies among obese and overweight men and women targeting diet and physical activity but not weight loss directly have reported modest improvements in diet quality indices following the interventions (20–23). In addition, one study of a heterogeneous group of older cancer survivors, diet quality improved following a diet and exercise based intervention (24). However, in the absence of clinically significant weight loss, the implications of these studies for simultaneously addressing diet quality and weight control are lacking. In a large observational study of the general U.S. adult population, weight gain was strongly associated with consumption of lower quality foods and weight loss was associated with consumption of higher quality foods (25), and in two intervention studies in the general population of obese adults, diet quality as measured at post-intervention only was associated with amount of weight loss (23, 26). To our knowledge, no studies in the literature have examined whether change in diet quality pre to post intervention is associated with change in weight during an intervention.

The purpose of the current study was to examine the effect of a six-month weight management intervention on diet quality among obese breast cancer survivors, where the intervention primarily targeted caloric restriction through heavy emphasis on fruit and vegetable intake, pre-prepared meals, and protein shakes. In addition, we examined the association between change in diet quality and change in weight during the intervention to determine whether diet quality change is also important for weight loss among breast cancer survivors.

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METHODS

Study Sample

This study was completed during a non-randomized 6 month weight loss phase of a weight loss maintenance trial among rural breast cancer survivors (RO1 CA 155014)(27). Subsequent to successful weight loss, participants who successfully lost ≥ 5% of baseline weight continued on to a randomized Phase II targeting weight loss maintenance. Eligible participants (n=210 enrolled) were female breast cancer survivors age 75 or younger, with a BMI between 27–45 kg/m^2 who had been diagnosed with Stage 0–IIIc disease within the past 10 years, were at least 3 months out of treatment at the time of enrollment, had physician clearance to participate, and resided in rural areas (28). Participants who had two reliable and typical 24-hour dietary recalls at both baseline and 6 month assessments were included in this analysis (n=180). Of the 30 participants excluded from the analysis, 21 did not return for the 6 month assessment and 9 returned but did not have two reliable recalls at both time points. All procedures for this study were in accordance with the ethical standards of the Human Subjects Committee at the University of Kansas Medical Center.

Measures

Demographic and treatment information—Participant age, marital status, and employment status (full time, part time, not employed) were collected at baseline. Treatment-related information including cancer stage at diagnosis and time since treatment completion was reported by participants and verified by medical chart review.

Weight, height and BMI—A study nurse measured participant height with a stadiometer and weight with a calibrated digital scale (±0.1 lbs; Befour, Inc). Weight and height measures were taken in duplicate. BMI was calculated from height and weight measurements.

Dietary assessment—Diet intake measures included two 24-hour dietary recalls conducted by trained staff at baseline and 6 months. The recalls were conducted on one random weekday and one weekend day and used the USDA multiple-pass approach (29). The first recall was completed at the in-person baseline assessment with food models, containers, and charts to help participants estimate accurate portion sizes. The second recall was completed over the phone using a food amounts booklet containing food photos and charts to estimate accurate portion sizes. Interviewers asked participants if their reported intake was typical or considerably more/less than usual. If the recall was atypical, it was not included in the analysis. The 24-hour dietary recalls were entered into the Nutrition Data System for Research (NDSR) software and analyzed for total energy, food group, and nutrient intake.

Healthy Eating Index 2010—The Healthy Eating Index 2010 (HEI-2010) is a scoring metric commonly used to assess diet quality (30). HEI-2010 determines diet quality scores based on nutrient density (e.g. per 1000 calories) and provides a total score and 12 component scores: total fruit, whole fruit, total vegetables, greens and beans, whole grains; dairy, total protein foods, seafood and plant proteins, fatty acids (ratio of poly and

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monounsaturated fat to saturated fat); refined grains; sodium; and empty calories (solid fats, added sugars and alcohol beyond a moderate level) (7). The Healthy Eating Index scores range from 1–100, where a score 100 is indicative of a diet that is in perfect conformance with the Dietary Guidelines for Americans. For all component scores, higher scores are indicative of better diet quality. The population normed HEI total for women from the National Health and Nutrition Examination Survey (NHANES 2003–04) is 52.7 and the computed standard deviation is 43.28 (30)). HEI-2010 scores were calculated from NDSR data based on a method previously developed (31) and utilized three NDSR output files (Serving Count, Component/Ingredient, and Intake Properties) to calculate each of the 12 component scores that make up the HEI.

Intervention

All participants completed a six-month group phone-based weight loss intervention. Sixteen phone groups with 10–15 participants per group met weekly via conference call with an experienced group leader. Participants were asked to follow a 1200–1500 calorie per day diet consisting of 5 one-cup servings of fruits and vegetables, two pre-prepared entrees, and 2 whey-based protein shakes (120 kcal, 21 grams protein per serving). Participants were instructed to purchase and consume pre-prepared entrees from their local grocery store that were under 350 calories and 9 grams of fat per entrée. The whey-based protein shakes were provided to participants. The nutrition components of the group-based phone sessions were based on My Plate recommendations and focused on reducing calories, increasing fruit and vegetable intake, increasing fiber, limiting fat, and practicing portion control. Two sessions also focused on evidence- based nutrition recommendations for breast cancer survivors, specifically as they related to prevention of breast cancer recurrence and other co-morbidities. Other key program components included a gradual progression to 225 minutes per week of moderate to vigorous physical activity and regular self-monitoring of weight, dietary intake, daily steps, and exercise minutes.

Data Analysis

We conducted paired samples t-tests to determine whether mean HEI total score and component scores significantly changed from baseline to 6 months. To determine whether HEI score and weight loss were correlated at 6 months, we constructed a linear regression model with 6 month HEI total score predicting weight loss at 6 months, while controlling for baseline BMI. These analyses were conducted using SPSS Version 22(32).

To determine whether *change* in HEI score from baseline to 6 months was significantly associated with weight loss from baseline to six months, we constructed a latent difference model using MPLUS statistical software (33). This model takes into account the correlation in repeated measures within individuals and avoids spurious effects that are inherent in simple correlations of change scores. Baseline BMI was included as a control variable. Five standard goodness of fit indices were used to evaluate model fit chi-square (χ^2), Tucker-Lewis index (TLI), Comparative Fit Index (CFI), standardized root mean residuals (SRMR), and the root mean square error of approximation (RMSEA) (34). Finally, we constructed an exploratory latent difference model that estimated the association between change in both diet quality and energy intake with weight loss.

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RESULTS

Participant demographics and treatment-related information is presented in Table 1. Participants had a mean BMI of 34.0 (SD = 4.5) and were a mean of 3.5 years (SD=2.4) beyond cancer treatment. Weight, energy intake, and macronutrient profile at baseline and 6 months are shown in Table 2. Participants lost a mean of 13.2% (SD= 5.8%) of their body weight during the 6 month intervention (p= .001). Total mean kcal intake significantly decreased by 453 kcal per day (p = .001) with participants consuming a mean of 26% fewer kcal at 6 months. Total dietary fat decreased by 49% (39 g) (p = .001) and total carbohydrate intake decreased by 11% (23 g) (p= .001). Percent kcal from protein significantly increased by 5.8% (p = .001); however total grams of protein intake did not change (p = .5).

Baseline and 6 month HEI scores are shown in Table 3. Compared to population estimates, participants in the current study had comparable diet quality at baseline (total score: 51.9 ± 11.9 vs. 52.7 ± 43.3 for representative sample of U.S. female population(30)). From baseline to 6 months, total HEI score significantly increased (mean total HEI score change = 12.1 ± 10.52; p=.01). HEI scores for total fruit, whole fruit, total vegetables, green and beans, dairy, and empty calories all increased over the 6-month period (all ps<0.001; Table 3) while total protein HEI score decreased (p=.001). There was no significant change in refined grains, seafood and plant proteins, fatty acids, and sodium.

Our linear regression model indicated that HEI score at 6 months was significantly associated with weight loss at 6 months, while controlling for baseline BMI (b= −.25, SE = .08, p = .003), indicating that better diet quality at 6 months was associated with more weight loss at 6 months. Results from the latent difference model examining the association between change in HEI total score and weight loss indicated strong model fit as all fit indices were within recommended limits (chi-square: ($\chi^2(2)$= 2.04, p=.36); TLI= 0.992; SRMR= .029, CFI= 0.997 and RMSEA = 0.011, 90%, CI = 0.00–0.148; p=.84). Results indicated that change in HEI total score was significantly associated with change in weight (unstandardized r = −24.74, SE = 9.56, p = .01), indicating that greater improvement in diet quality from baseline to 6 months was associated with more weight loss at 6 months.

Results from our an exploratory model simultaneously examining the associations between change in HEI total score and change in energy intake on weight loss had poorer model fit on some indices (chi-square: $\chi^2(2)$= 60.39, p=.001; TLI= 0.390; SRMR= .055; CFI= 0.782; RMSEA = 0.106, 90% CI = 0.047–0.169; p=.06). Results indicated that change in energy intake was significantly associated with change in HEI total score (r = −25, p = .001), change in HEI total score remained significantly associated with weight loss (r= −.15, p = .003), however change in energy intake was not significantly associated with weight loss (r = .04, p = .332).

DISCUSSION

The purpose of the current study was to evaluate changes in diet quality following a weight loss intervention among rural, overweight and obese breast cancer survivors, and to examine whether change in diet quality was associated with change in weight. The structured weight

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loss intervention produced substantial improvements in diet quality, along with clinically significant weight loss. Prior studies have demonstrated diet quality improvements from lifestyle interventions targeting diet and physical activity behaviors, but not weight loss specifically, in cancer survivors (35, 36). Further, the diet was based on prepackaged entrees, whey protein shakes, and fruit and vegetable consumption. Prepackaged entrees are advantageous to use in weight loss interventions because the structured portion control leads to more weight loss than home-prepared meals (37–40). This may be particularly important for breast cancer survivors because ≥10% weight loss appears to be necessary to impact some important biomarker mediators between obesity and breast cancer recurrence, e.g. adiponectin (41, 42). Although this weight loss approach is often anecdotally criticized as sacrificing diet quality, our results suggest that using prepackaged entrees combined with an emphasis on increasing fruit and vegetable intake leads not only to substantial weight loss but also improvements in diet quality.

Results also indicated that larger improvements in diet quality were associated with greater weight loss. Higher quality foods as defined by the HEI tend to have higher fiber content and lower energy density (i.e. fewer calories per gram) than lower quality foods. Because satiety is more driven by volume of food consumed rather than the caloric content, one might expect that a person who aims to improve the quality of her diet will still consume the same volume of food and will therefore consume fewer calories (43). However, it is well-documented that interventions that target diet quality alone, most commonly through increased fruit and vegetable consumption, in the absence of targeting reduced calories do not produce meaningful weight loss (44). In contrast, our findings indicate that the reverse is possible, i.e, that targeting calorie reduction primarily, with recommendations for unlimited fruit and vegetable consumption combined with elimination of snack foods and sweetened beverages and reductions in eating out, can lead to improvements in diet quality. Likewise, Webber et al. found that women who achieved > 5% weight loss during a 16 week web-based intervention had significantly greater improvements in HEI-2005 scores compared to women who had < 5% weight loss (26). O-Brien et al. recently found that weight loss at 12 weeks was associated with diet quality at 12 weeks after participation in an on-line weight loss program (23). Taken together, our findings and the broader literature suggest that it may be easier to target diet quality through calorie reduction than to target calorie reduction through diet quality modification.

While the benefits of both weight loss and diet quality for breast cancer prognosis are supported by large respective literatures(1, 45), the relative importance of weight and diet quality for cancer survivors is an ongoing area of debate. Recently, a panel of researchers debated the question, “Energy balance versus dietary quality for cancer prevention: As long as I stay lean, does it matter what I eat?”(46). While our data do not end this debate, it does offer an encouraging and relevant viewpoint to the two-thirds of breast cancer survivors who are overweight or obese- targeting weight loss directly can also improve diet quality. Furthermore, the American Institute for Cancer Research and the National Cancer Institute state that improving diet quality by increasing fruit and vegetable intake, limiting red and processed meats, and eliminating sugar sweetened beverages are key strategies for cancer prevention(1). The strategies used in this intervention align with the AICR and NCI

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guidelines and are one approach that may be used by clinicians to promote weight loss while simultaneously improving diet quality among breast cancer survivors.

We used 24 hour dietary recalls as the gold-standard measure of estimating energy intake and diet quality (47); however, they still have limitations because they rely on accurate recall and reporting. Some findings suggest that individuals are better at reporting *what* (quality) they are eating rather than *how much* (quantity) they are eating (48). In addition, under-reporting of quantity is more common among women and overweight/ obese individuals(49). The issue of under-reporting energy (quantity or portion size) more than misreporting types of foods (quality) may explain why only change in diet quality and not change in energy intake was associated with weight loss in our sample. It is also likely that participants were more accurate in reporting quantity at 6 months compared to baseline as they learned to measure portions and track calories throughout the intervention (50, 51).

The study had several limitations. First, we did not experimentally control diet quality thus inferences about changes in diet quality causing weight loss should be confirmed with a randomized controlled trial designed to address this question. Second, the sample was comprised of rural, overweight and obese breast cancer survivors enrolled in a structured weight loss intervention, and it is unknown to what extent the degree of diet changes we observed would generalize to other populations or other interventions. Finally, although the Healthy Eating Index is a gold-standard tool for assessing diet quality (52), its usefulness in measuring diet quality in the context of calorie restriction is still under investigation. The HEI is scored as a proportion of calories such that total caloric intake is not considered as a component of quality. In other words, a person could have excellent diet quality, but still be consuming excess calories (53). This highlights some of the limitations for the HEI in the context of dietary change. In addition, the HEI protein component score may not fully capture all high quality proteins. For example, our finding that total protein component scores worsened over the intervention is likely due to the fact that the protein component score does not include protein from whey-based protein shakes, which participants in this study consumed regularly.

In summary, this is one of the first studies to determine the association between change in diet quality and weight loss within the context of a large-scale trial that produced clinically significant weight loss for breast cancer survivors. Our findings indicate that a weight loss intervention with dietary recommendations emphasizing both diet quality and caloric restriction through prepackaged or other structured portion-controlled meals may be recommended for survivors considering weight loss approaches; however future interventions are needed to elucidate the relationship between diet quality change and long term weight loss maintenance. It is possible that a weight loss intervention may impact survivors' prognosis both through the reduction in fat mass, as well as providing benefits from increased fruit and vegetable consumption and enhanced diet quality (8, 9). For this reason, achieving and maintaining a healthy weight should remain a primary recommendation among breast cancer survivors, and diet quality may be simultaneously improved as a result.

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Table 1

Participant baseline characteristics (n=180)

	Mean ± SD or n (%)	Range
Age (years)	59.0 ± 7.7	36.9–75.4
BMI (kg/m^2)	34.0 ± 4.5	27.0–45.2
Weight (kg)	91.1 ± 14.1	65.1–137.6
Time since treatment end (years)	3.5 ± 2.4	0.25–9.9
Cancer stage		
Stage 0	16 (8.9%)	
Stage I	74 (41.1%)	
Stage II	64 (35.6%)	
Stage III	26 (14.4%)	
Race		
African American	1 (0.6%)	
White	179 (99.4%)	
Employment Status		
Full Time/Part Time	128 (71.1%)	
Unemployed/Retired	52 (28.9%)	
Marital Status		
Married/Cohabitating	154 (85.6%)	
Single/Widowed/Divorced	26 (14.4%)	

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Table 2

Change in total energy, macronutrients, and weight from baseline to six months

	Baseline (n=180)		6 month (n=180)		Difference	P-value	Effect size[a]
Macronutrient	**Mean**	**SD**	**Mean**	**SD**	**Mean**		
Total Energy (kcal)	1795.7	533.4	1342.5	288.5	−453.3	.001	1.0
Total Fat (g)	75.2	29.4	38.2	18.2	−37.0	.001	1.4
Total Carbohydrates (g)	209.0	64.7	186.0	44.4	−23.0	.001	0.4
Total Protein (g)	72.7	23.4	74.1	19.0	1.4	.5	−0.1
% Kcal from Fat	36.1	7.1	24.1	8.3	−12.0	.001	1.2
% Kcal from Carbohydrates	45.9	7.7	53.0	8.5	7.2	.001	−0.7
% Kcal from Protein	16.8	3.9	22.6	5.4	5.8	.001	−1.0
Weight (kg)	91.1	14.1	79.1	13.9	5.5	.001	2.2

[a]Cohen’s d for paired t-test

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Table 3

Change in HEI score from baseline to six months

	Baseline (n=180)		6 month (n=180)		Difference		P-value
Component (maximum score)	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Total Fruit (5)	1.78	1.48	4.11	1.28	2.33	1.81	.001
Whole Fruit (5)	2.32	1.64	4.49	1.04	2.17	1.84	.001
Total Vegetables (5)	2.89	1.31	4.12	1.07	1.23	1.53	.001
Greens and Beans (5)	0.93	1.19	1.79	1.68	0.86	1.93	.001
Refined Grains (10)	6.68	2.68	7.21	2.59	0.52	3.66	.06
Whole Grains (10)	4.05	2.59	3.30	2.86	−0.75	3.84	.01
Dairy (10)	4.66	2.83	7.77	2.57	3.11	3.66	.001
Total Protein Foods (5)	4.08	1.04	3.44	1.25	−0.64	1.55	.001
Seafood and Plant Proteins (5)	1.50	1.60	1.39	1.50	−0.11	2.09	.49
Fatty Acids (10)	5.26	2.64	4.83	2.83	−0.43	3.57	.11
Sodium (10)	3.36	2.65	3.85	2.62	0.49	3.51	.07
Empty Calories (20)	14.42	4.76	17.74	3.60	3.33	5.64	.001
Total Score (100)	51.93	11.19	64.04	10.52	12.11	14.46	.001

Note: higher scores are indicative of better diet quality