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CLINICAL TRIAL

Dietary intervention among breast cancer survivors increased adherence to a Mediterranean-style, anti-inflammatory dietary pattern: the Rx for Better Breast Health Randomized Controlled Trial

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Abstract

Purpose The goal of this education and culinary-based dietary intervention was to increase adherence to a Mediterranean-style, anti-inflammatory dietary pattern in breast cancer survivors (BCS) by promoting the consumption of anti-inflammatory foods, herbs, and spices.

Methods Overweight and obese, early-stage, BCS were randomized to the Intervention ($n=76$) or Control ($n=77$). The 6-month intervention included monthly nutrition and cooking workshops, Motivational Interviewing telephone calls, and individualized newsletters. Control participants received monthly informational brochures and no navigational services. Dietary intakes were collected via questionnaire and 3-day food records at baseline and 6 months.

Results One hundred twenty-five BCS ($n=60$ I; $n=65$ C) completed post-testing (81.7%) and were included in analyses. Adherence to Mediterranean diet guidelines significantly increased in the intervention group, but not in the control group (+22.5% vs. +2.7%, $P<0.001$). Upon further analysis of adherence to individual dietary guidelines, the intervention group significantly improved adherence to only three guidelines: consuming ≥ 3 servings of fish or shellfish/week, reducing red meat intake to < 1 serving/day, and limiting consumption of commercial sweets and baked goods to < 3 times/week. The intervention arm increased the use of spices and herbs compared to control (+146.2% vs. +33.3%, $P<0.001$), including significantly more frequent consumption of cinnamon, turmeric, garlic, ginger, black pepper, and rosemary.

Conclusion An education and culinary-based intervention in BCS successfully increased adherence to a more Mediterranean-style, anti-inflammatory dietary pattern by increasing the consumption of anti-inflammatory foods, spices, and herbs and decreasing the consumption of pro-inflammatory foods.

Keywords Diet · Breast cancer survivor · Anti-inflammatory · Survivorship · Mediterranean diet

Introduction

Breast cancer survivors (BCS) are the largest number of cancer survivors globally, and it is imperative to identify lifestyle interventions that reduce risk of recurrence and comorbidities in cancer survivorship [1]. Dietary interventions in BCS have primarily targeted weight loss because excess weight and body fat are risk factors for recurrence and comorbidities such as cardiovascular disease and diabetes [2, 3]; however, there is growing evidence that pro-inflammatory dietary patterns may also be a significant risk factor. As reviewed by Zahedi et al., several studies have demonstrated a relationship between a pro-inflammatory diet and an increased risk of breast cancer [4]. Additionally, a more anti-inflammatory diet post-breast cancer diagnosis was associated with a reduced

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risk of cardiovascular disease mortality [5]. Thus, dietary patterns may play an essential role in modifying inflammation and reducing the risk of comorbidities and recurrence in BCS.

An example of an anti-inflammatory dietary pattern is the Mediterranean diet which is characterized by high intakes of fruit and vegetables, whole grains, nuts, legumes, fish, monounsaturated fat (olive oil); moderate intakes of dairy products and alcohol; and low intakes of meat and meat products and saturated fat [6]. Adherence to a Mediterranean-type diet has been associated with a multitude of health benefits [7] including lower risk of all-cause mortality [8], cancer [9], type II diabetes [10], cardiovascular disease [11], and cognitive decline [12]. The Mediterranean dietary pattern is high in anti-inflammatory micronutrients and phytochemicals such as n-3 fatty acids, flavonoids, carotenoids, and vitamins C and E, and higher adherence to the Mediterranean has been associated with lower levels of inflammatory markers [13–15]. Thus, greater adherence to a Mediterranean dietary pattern may elicit health benefits through impacts on systemic inflammation [16]. Additionally, Mediterranean-style diets have been demonstrated to elicit cardiovascular benefits including improved endothelial function and reductions in serum cholesterol and triglycerides [17, 18]. In a 6-month randomized controlled trial, BCS who adhered to a Mediterranean-type diet had beneficial changes in body composition, cholesterol, and glucose levels compared to controls [19].

Selecting foods that are anti-inflammatory while avoiding pro-inflammatory foods may be health protective in BCS. Although many nutrients and foods are suggested to have anti-inflammatory potential, a variety of spices and herbs may also contribute to a diet's anti-inflammatory and overall health protective role. Culinary spices and herbs contain polyphenols and other anti-oxidants which are strong antagonists against tumorigenesis, carcinogen bioactivation, and inflammation [20–22]; however, these activities have primarily been demonstrated within in vitro and in vivo models, and more human clinical trials are needed.

There are several epidemiological studies associating health benefits with anti-inflammatory foods and dietary patterns in healthy populations, but limited dietary interventions have promoted this dietary pattern in BCS. Furthermore, even fewer have been conducted in diverse populations. The goal of this education and culinary-based dietary intervention was to improve adherence to an anti-inflammatory dietary pattern in BCS by promoting consumption of anti-inflammatory foods, herbs, and spices.

Methods

Study design and participants

The randomized controlled trial on which this analysis was based has been previously described [23]. Briefly, we recruited 153 overweight and obese (BMI $\geq$ 25 kg/m^2), early-stage (0–III), English-speaking breast cancer survivors who had completed treatment at least 2 months prior to study enrollment. Participants were randomized to an Intervention (I; $n = 76$) or Control (C; $n = 77$) arm (Fig. 1). Measures were obtained at baseline, and repeated at 6 months.

Intervention

The Intervention consisted of individualized anti-inflammatory dietary guidelines and behavior-change cues delivered during six months of monthly in-person Anti-inflammatory (AI) nutrition workshops; monthly Motivational Interviewing (MI) telephone calls by trained, patient navigators; and monthly newsletters tailored to individual change readiness.

The purpose of the AI nutrition workshops was to increase participant knowledge of the relationship between diet and cancer; describe AI foods and how they can help reduce risk for cancer recurrence; and promote behaviors aimed at increasing regular AI food intake. To optimize the intervention experience given limited space and culinary resources, women were grouped into 5 cohorts (10–20/cohort). Each cohort was asked to attend six monthly workshops beginning immediately following randomization. A total of 30 workshops were delivered during the study period.

Each nutrition workshop consisted of a didactic portion with PowerPoint slides, followed by a cooking demonstration with a chef skilled in AI food preparation, a tasting, and interactive discussion among participants, study investigators, and staff. Participants received paper copies of lecture slides, a description of the properties and benefit of featured AI foods, and recipes and supply lists for the food demonstration. Workshop attendance was tracked. Participants who missed a workshop session were contacted by a patient navigator and provided with electronic copies of all materials. Table 1 shows the themes and objectives, AI foods discussed and highlighted, and recipes demonstrated during each workshop.

At the end of each workshop, participants received a carbon copy sheet containing 4–6 goals related to workshop content. They were asked to select 1–2 goals to work on over the next month until the following workshop. The

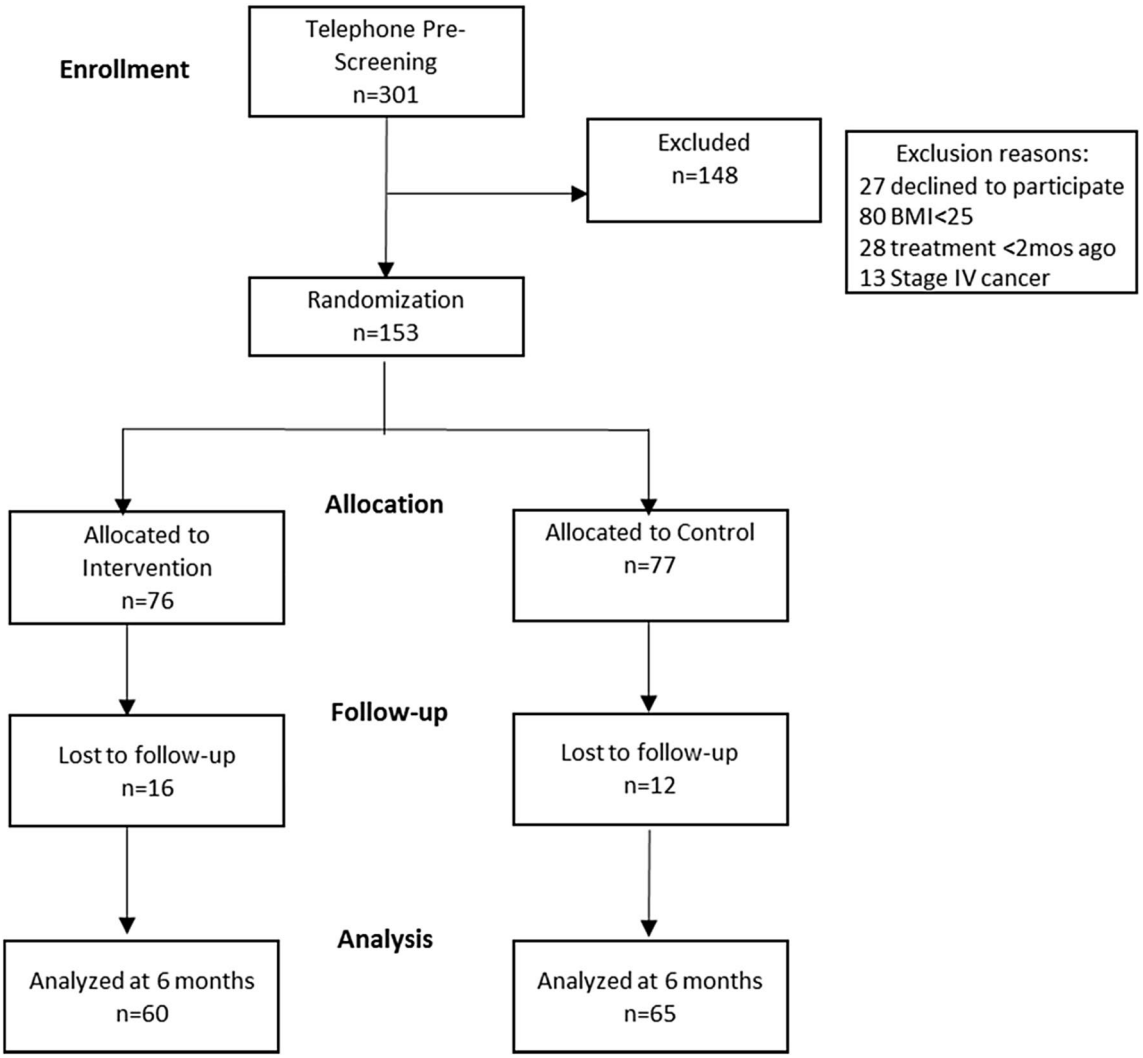

Fig. 1 CONSORT diagram for randomized controlled dietary intervention

sheet also contained importance and confidence scales based on stages of change (SOC) [24] and space to identify barriers to making changes as well as strategies to overcome these barriers. Participants turned in one copy to study staff and kept a copy with their other study materials. During follow-up MI telephone calls, patient navigators used the sheets to discuss progress, barriers, and strategies with participants, as well as assess their SOC. A new goal sheet was distributed at each workshop, and participants were encouraged to either work on the same goals or select new ones.

Control

Control participants received monthly American Institute for Cancer Research informational brochures, two telephone calls prior to each assessment appointment, and no navigational services.

Dietary intake

At baseline and 6 months, participants completed questionnaires to assess adherence to the Mediterranean diet [6] and spice and herb consumption [23]. The Mediterranean diet assessment tool consisted of 14 questions that were coded one for an answer in agreement with a Mediterranean diet and zero for non-adherence. Responses were added for a total value between 0 and 14, with higher scores indicating greater adherence. The spices and herbs questionnaire included questions about the frequency of use of 13 different spices and herbs that were the focus of the intervention. Use of the spice or herb 4 or more times per a week was coded as 1, while less than 4 times a week was scored a zero. The

Table 1 Monthly workshops

Workshop	Theme/objectives	AI foods featured in lecture	Recipes
1	Relationship between cancer, inflammation, and diet Become familiar with components of the AI diet Understand how AI foods can prevent cancer	Deep marine fish (wild) Bright multi-colored vegetables and fruit (red grapes and berries, pomegranate, citrus) Green tea, turmeric, ginger, black pepper, chilies, chives, garlic, onion	(1) Zesty citrus salad with ginger (2) Lemon grouper with fresh garden vegetables
2	Understand American Cancer Society recommendations to prevent cancer recurrence and spread Learn how to reduce risk of recurrence or spread by using key food groups in one's own kitchen	Alcohol Preserved/cooked meats Soy Turmeric and rosemary Green tea Cruciferous vegetables (collards, mustard greens)	(1) Oven roasted oatmeal crumble with cranberries (2) Sweet and spicy pepita snack mix
3	Exploring nature's anti-cancer cuisine Understand AI foods as chemoprevention–which foods when consumed regularly have an anti-inflammatory effect	Cruciferous vegetables (broccoli, watercress, cauliflower, Brussels sprouts, rapini, bok choy, kale, cabbage) Canola/rapeseed oil Wasabi, garlic	(1) Savory broccoli fritters (2) Asian slaw with serrano Chiles
4	Understand the value of anti-oxidants and how they fit into the AI diet, which foods when consumed daily have an anti-oxidant effect Learn how to reduce risk of recurrence or spread by consuming more anti-oxidant–rich foods	Black pepper Lemongrass Green tea	(1) Refreshing summer agua fresca (2) Green tea vinaigrette with garden basil
5	Understand regulations governing supplements and which products have been scientifically proven to work Understand that supplements may be unnecessary if the diet provides adequate nutrients Learn about Vitamin D and calcium, and why they are recommended as dietary supplements	Turmeric Smoked salmon/light tuna Whole eggs Vitamin D-fortified milk, yogurt Calcium-fortified bread, orange juice, cereal Spinach	(1) Frozen Watermelon and Greek Yogurt Popsicle with Black Pepper and Ginger (2) Breakfast Frittata with Fresh Vegetables and Cheeses
6	Understand how the objectives of workshops 1–5 work together to impact recurrence risk and prevention of future cancers Learn how the right type of chocolate can be beneficial in an anti-inflammatory diet	Chocolate (> 75% cacao)	(1) Cardamom Chicken Bites with Cracked Black Pepper (2) Black Bean Dip with Cocoa and Chipotle

questions were added for a total possible value of 0–13. Participants were also instructed to maintain a detailed 3-day food record (two weekdays and one weekend day) prior to each assessment. Food records were entered in Food Processor ® (ESHA Research, Salem, OR) for nutrient analysis. Missing or incomplete dietary questionnaires or food records were not included in the analyses.

Statistical analyses

Unadjusted comparisons between groups on baseline demographics measures were conducted using two-sample t tests for continuous variables and X^2-tests or Fisher's exacts tests for categorical variables. The main outcome was change over the intervention period, which was calculated as the 6-month value minus the baseline value. Differences in average change of Mediterranean diet score, spices, and herbs score, and nutrient intakes between groups were assessed using general linear models with adjustment for baseline values. McNemar's test was used for within-group comparisons of dichotomous variables including adherence to individual Mediterranean diet guidelines and use of individual herbs and spices. Statistical tests used $\alpha \leq 0.05$ and two-sided P values. All analyses were performed using SPSS v24.

Results

Demographics

Analyses are based on 125 breast cancer survivors ($n = 60$ intervention; $n = 65$ control) that completed 6-month analyses. There were no statistically significant differences in demographic or clinical characteristics between intervention and control groups (Table 2). The combined average age of the sample was 57.0 (SD 9.3). Over half of participants (54.4%) reported a college degree or higher, 45.6% reported working full time, and 74.2% reported a monthly household income of > $2000. Over half (51.2%) of study participants were Latina. The majority of participants were diagnosed with Stage II or lower (68.0%) and 24 or more months post treatment (63.2%).

Mediterranean diet adherence

Adherence to Mediterranean dietary guidelines at baseline and 6 months is shown in Table 4. Overall at baseline, there was low adherence to Mediterranean dietary guidelines in both groups. Adherence to Mediterranean diet guidelines significantly increased in the intervention group, but not in the control group (+1.6 vs. +0.2, $P < 0.001$). When further examining adherence to individual guidelines, the intervention group significantly improved adherence to three

Table 2 Sample characteristics

	Intervention *n* (%)	Control *n* (%)	*P* value
Age (Mean ± SD)	55.3 ± 10.3	58.4 ± 8.2	0.083
BMI (Mean ± SD)	31.2 ± 4.1	32.7 ± 5.2	0.066
Ethnicity			0.984
Anglo	25 (41.7)	28 (43.1)	
Latino	31 (51.7)	33 (50.8)	
Other	4 (6.7)	4 (6.2)	
Education			0.127
High school graduate or less	9 (15.0)	7 (10.8)	
Some college/Assoc. degree	24 (40.0)	17 (26.2)	
College graduate or higher	27 (45.0)	41 (63.1)	
Employment status			
Full time	30 (50.0)	27 (41.5)	
Part time	5 (8.3)	8 (12.3)	
Unemployed	21 (35.0)	30 (46.2)	
Student	4 (6.7)	0(0.0)	
Marital status			0.577
Married/Cohabitating	43 (71.7)	42 (64.6)	
Divorced/widowed/separated	11 (18.3)	17 (26.2)	
Single	6 (10.0)	6 (9.2)	
Household monthly income			0.752
Under $1500	4 (6.7)	6 (9.4)	
$1500–$2000	7 (11.7)	11 (17.2)	
Over $2000	48 (78.3)	45 (70.3)	
Time since last treatment			0.948
Less than 6 months	8 (13.3)	8 (12.3)	
6 months	4 (6.7)	4 (6.2)	
12 months	5 (8.3)	6 (9.2)	
18 months	4 (6.7)	7 (10.8)	
≥ 24 months	40 (65.0)	40 (61.5)	
Stage of cancer			0.824
Stage 0	5 (8.3)	7 (10.8)	
Stage 1	18 (30.0)	17 (26.2)	
Stage 2	20 (33.3)	18 (27.7)	
Stage 3	8 (13.3)	13 (20.0)	
Don't know	9 (15.0)	10 (15.4)	
Treatment type			
Surgery	57 (95.0)	60 (92.3)	0.539
Chemotherapy	37 (61.7)	45 (69.2)	0.374
Radiation	38 (63.3)	39 (60.0)	0.702
Hormonal therapy	16 (26.7)	26 (40.0)	0.115
Antibody therapy	6 (10.0)	7 (10.8)	0.888
Reconstruction	23 (38.3)	25 (38.5)	0.988

Totals may not equal 100% due to missing/refused

Table 3 Adherence to individual mediterranean diet guidelines

	Intervention			Control		
	Baseline (%)	6 months (%)	Within-group difference, *P*	Baseline (%)	6 months (%)	Within-group difference, *P*
Do you use olive oil or canola oil as a main culinary fat? (yes)	94.9	100.0	0.25	87.7	86.2	1.00
How much olive oil or canola oil do you consume in a given day? (≥ 4T/day)	13.8	19.0	0.61	15.4	15.4	1.00
How many vegetable servings do you consume per day? (≥ 2 servings/day)	54.2	64.4	0.21	52.3	64.6	0.12
How many fruit units do you consume per day? (≥ 3 servings/day)	30.5	40.7	0.18	25.0	31.3	0.42
How many servings of red meat, hamburger, or meat products do you consume per day? (< 1 serving/day)	64.4	86.4	0.002	78.1	78.1	1.00
How many servings of butter, margarine, or cream do you consume per day? (< 1 serving/day)	59.3	74.6	0.07	76.2	63.5	0.08
How many sweet or carbonated beverages do you drink per day? (< 1/day)	74.6	86.4	0.07	68.8	76.6	0.23
How many glasses of wine do you drink per week? (≥ 7 glasses/week)	5.1	0.0	0.25	7.9	11.1	0.69
How many servings of legumes do you consume per week? (≥ 3 servings/week)	33.9	45.8	0.17	23.4	34.4	0.12
How many servings of fish or shellfish do you consume per week? (≥ 3 servings/week)	13.6	35.6	0.002	25.0	21.9	0.75
How many times per week do you consume commercial sweets or pastries (not homemade), such as cakes, cookies, biscuits, or custard? (< 3 times/week)	69.5	86.4	0.01	69.8	76.2	0.22
How many servings of nuts do you consume per week? (≥ 3 servings/week)	44.8	56.9	0.17	53.1	50.0	0.82
Do you preferentially consume chicken or turkey meat instead of pork, hamburgers, or sausage? (yes)	86.4	93.2	0.13	85.9	87.5	1.00
How many times per week do you consume vegetables, pasta, rice, or other dishes seasoned with tomato, onion, leek, garlic, and simmered with olive oil? (≥ 2 times/week)	61.0	78.0	0.06	64.1	60.9	0.83

Table 4 Comparison of mediterranean diet and spices and herbs scores between intervention and control

	Baseline	6 months	Change	*P* value[a]
Mediterranean diet score				< 0.001
Intervention	7.1 (0.3)	8.7 (0.3)	+ 1.6 (0.2)	
Control	7.4 (0.3)	7.6 (0.3)	+ 0.2 (0.2)	
Spices and herbs score				< 0.001
Intervention	1.3 (0.2)	3.2 (0.3)	+ 1.9 (0.3)	
Control	1.2 (0.1)	1.6 (0.3)	+ 0.4 (0.2)	

Values are estimated marginal means ± SE

[a]*P* value for the difference between groups in change in intake controlling for baseline

guidelines (Table 3). At 6 months, 86.4% of the intervention group reported consuming less than one serving of red meat a day, which was significantly higher than the 64.4% adherence at baseline ($P = 0.002$). At baseline, 13.6% of the intervention group reported consuming 3 or more servings of fish or shellfish week, which increased to 35.6% at 6 months ($P = 0.002$). Additionally, 86.4% reported limiting consumption of commercial sweets and pastries to less than 3 times a week compared to only 69.5% at baseline ($P = 0.01$).

Spices and herbs intake

At month 6, the intervention arm compared to controls reported an increase in the use of spices and herbs (+ 1.9 vs. + 0.4, $P < 0.001$) (Table 4). Compared to baseline, the intervention arm significantly increased the use of cinnamon, turmeric, garlic, ginger, black pepper, and rosemary; however, no significant increase in the use of cardamom, black cumin, cloves, oregano, lemongrass, chives, and thyme

was observed (Table 6). The control arm only significantly increased the use of cinnamon.

Nutrient analysis

Compared to the control group, the intervention group reported a significant reduction in Calorie intake (−195.5 vs. +34.8, $P=0.045$) (Table 5). Changes from baseline in percent Calories from fat, percent Calories from carbohydrates, percent Calories from protein, percent Calories from saturated fat, sodium, fiber, fruit servings, and vegetable (Table 6) servings were not statistically significant between groups.

Discussion

The dietary intervention increased adherence to an anti-inflammatory dietary pattern as demonstrated by increased adherence to Mediterranean diet guidelines and increased use of anti-inflammatory spices and herbs. The Mediterranean diet has shown protection against diseases associated with low-grade inflammation, including cancer, diabetes, obesity, atherosclerosis, metabolic syndrome, and cognitive disorders [7, 9–12]. At baseline, both groups had low adherence to Mediterranean dietary guidelines. The Mediterranean diet score significantly increased in the intervention group, but further examination suggested this was largely due to significant increases in adherence to only three specific guidelines: increase of fish consumption, reduction of red meat intake, and limiting consumption of commercial sweets and baked goods. Adherence to a new dietary pattern requires multiple dietary behavior changes compared to interventions that target a specific food group or nutrient. Six months may not be sufficient time for participants to make an impactful change on multiple components. The dietary behaviors that did significantly change were all goals introduced to the intervention group at the beginning of the study, suggesting that these dietary changes required significant time and support.

Table 5 Dietary changes between baseline and 6 months

	Baseline	6 months	Change	*P* value[a]
Calories				0.045
Intervention	1779.3 (92.2)	1578.3 (85.6)	−195.5 (83.0)	
Control	1765.8 (85.0)	1805.3 (79.0)	+34.8 (76.6)	
% Calories from fat				0.815
Intervention	34.5 (1.1)	35.7 (1.2)	+0.6	
Control	36.6 (1.0)	36.3 (1.1)	+0.3	
% Calories from saturated fat				0.164
Intervention	10.3 (0.5)	11.2 (0.5)	+0.6	
Control	11.5 (0.5)	10.9 (0.5)	−0.4	
% Calories from protein				0.634
Intervention	17.3 (0.6)	18.8 (0.8)	+1.4 (0.8)	
Control	17.3 (0.6)	18.2 (0.7)	+0.9 (0.7)	
% Calories from carbohydrates				0.954
Intervention	48.2 (1.4)	45.7 (1.4)	−1.5 (1.4)	
Control	45.5 (1.3)	44.9 (1.3)	−1.4 (1.3)	
Fiber (g)				0.616
Intervention	10.2 (1.8)	9.1 (1.7)	−1.8 (1.3)	
Control	13.5 (1.6)	11.9 (1.6)	−0.9 (1.2)	
Sodium (mg)				0.674
Intervention	2464.3 (142.7)	2370.7 (133.4)	−105.0 (131.3)	
Control	2490.6 (131.6)	2451.3 (123.1)	−29.6 (121.1)	
Fruit (cups)				0.601
Intervention	1.1 (0.2)	1.0 (0.1)	−0.2 (0.1)	
Control	1.2 (0.2)	0.9 (0.1)	−0.3 (0.1)	
Vegetable (cups)				0.768
Intervention	1.6 (0.1)	1.6 (0.2)	−0.1 (0.2)	
Control	1.8 (0.1)	1.7 (0.2)	−0.1 (0.2)	

Values are estimated marginal means ± SE

[a]*P* value for difference between groups in change in intake controlling for baseline

Table 6 Change in use of individual spices and herb

Used spice ≥ 4 times/week	Intervention			Control		
	Baseline (%)	6 months (%)	Within-group difference, *P*	Baseline (%)	6 months (%)	Within-group difference, *P*
Cinnamon	15.2	35.6	0.002	9.5	2.6	0.039
Cardamom	1.7	6.8	0.375	1.6	0.0	1.00
Turmeric	8.5	22.0	0.021	6.3	4.8	1.00
Garlic	39.0	69.5	< 0.001	32.8	42.2	0.180
Ginger	0.0	31.6	< 0.001	3.1	6.3	0.625
Black pepper	54.2	84.7	< 0.001	54.7	65.6	0.167
Cumin	1.7	11.9	0.070	3.1	4.7	1.00
Rosemary	1.7	16.9	0.004	0.0	1.6	1.00
Cloves	0.0	3.4	0.500	0.0	1.6	1.00
Oregano	1.7	8.5	0.219	1.6	3.1	1.00
Lemongrass	0.0	1.7	1.00	3.1	3.1	1.00
Chives	0.0	6.8	0.125	4.7	6.3	1.00
Thyme	0.0	8.5	0.063	0.0	4.7	0.250

Although adherence to only three of fourteen guidelines significantly increased, these dietary changes can have significant long-term impacts on health. Most fish are a good source of the omega-3 polyunsaturated fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which have been demonstrated to have anti-inflammatory and anti-carcinogenic properties [25, 26]. Red meat was classified as "probably carcinogenic to humans" by the International Agency for Research on Cancer in 2015 [27], and the American Institute for Cancer Research cancer prevention guidelines recommend limiting consumption of red meat [28]. Limiting the intake of sweets and baked goods not prepared at home suggests BCS in the intervention group reduced intake of processed and packaged foods that are typically high in added sugar, sodium, and fat. Even though calorie reduction was not a focus of this study, the intervention arm significantly reduced calorie intake. This may have been due to an overall increased adherence to a Mediterranean-type diet consisting of less frequent consumption of higher calorie red meat, sweets, and baked goods. However, this reduction in caloric intake did not result in significantly greater weight changes compared to the control group (−0.43 vs. +0.14 lbs, $P = 0.619$).

Interestingly, despite the discussion of fruits and vegetables at every workshop, intakes of these food groups did not significantly change. Across groups, average consumption of fruits and vegetables was less than 3 servings a day at both baseline and 6 months. This supports a previous report that only 14–19% of most cancer survivors meet the recommendation of consuming 5 or more servings of fruits and vegetables per day [29]. Also of note is that at 6 months, none of the participants in the intervention group reported consuming seven or more glasses of wine a week. The Mediterranean diet includes wine consumption, and research suggests moderate wine consumption is associated with health benefits such as lower inflammation and reduced risk of cardiovascular disease [30–32]. Although wine is an abundant source of polyphenols that have anti-oxidant functions [32], alcohol intake may not be appropriate to include as a dietary goal for BCS. Due to the growing research that alcohol consumption is a risk factor for multiple cancers including breast cancer [28], cancer survivors may choose to limit their overall alcohol intake. Future dietary interventions should consider promoting non-alcoholic beverages that are abundant in anti-inflammatory polyphenols such as tea and coffee.

All spices and herbs recommended in this study were chosen for the beneficial health compounds they contained. For example, cinnamon contains multiple bioactive compounds, including polyphenols and cinnamaldehyde, which have been demonstrated to have anti-tumor properties and anti-inflammatory effects [33]. Aside from anti-inflammatory, anti-carcinogenic, antimicrobial, and anti-oxidant properties, some spices and herbs may impact lipid metabolism, stimulate digestion, and have anti-diabetic functions [20–22]. The intervention promoted the incorporation of spices and herbs in cooking, and resulted in significant increases in the use of cinnamon, garlic, ginger, black pepper, and rosemary. Further investigation is needed to identify potential barriers to increasing consumption of the other herbs and spices such as cost, availability, or taste preferences.

Several interventions in BCS have successfully changed dietary behaviors such as increasing fruit and vegetable intake and reducing fat intake [34–38]. Effective interventions incorporated individualized counseling from a registered dietitian or health counselor, individualized progress reports, personalized workbooks, nutritional education, and group support, supporting the need to provide

education in combination with personalized support and follow-up. Our intervention utilized multiple strategies including detailed workshops with goal setting, culinary instruction and recipe booklets to improve cooking skills, and follow-up monthly newsletters and motivational interviewing. Educational group workshops in combination with individual counseling requires significant time and money. Before implementation and dissemination of the dietary intervention in larger samples, further research is needed to identify the components of the intervention that led to successful dietary changes.

The study had several strengths including a moderate sample size with low attrition rates (18.3% lost to follow-up). Additionally, the sample was diverse, consisting of over 50% Latinas. Disparities between non-Latina Whites and Latina breast cancer survivors are evidenced by the lower 5-year survival rates and greater likelihood of risk of recurrence in Latinas [39, 40]. The two largest dietary intervention studies conducted in breast cancer survivors, Women's Healthy Eating and Living (WHEL), and Women's Intervention Nutrition Study (WINS) [35, 36], included less than 6% Hispanics in the study, which is not representative of the large and growing population of Latina breast cancer survivors. To our knowledge, only one dietary intervention has been conducted in a Latina breast cancer sample [34, 41]; therefore, our successful dietary intervention in this population addresses an important gap in the current literature.

A limitation of the study was that all assessments of dietary intake were based on self-report. Additionally, there was high incidence of missing data in the food records, reducing the ability to identify changes in individual nutrients. Future studies should consider using nutrient biomarkers to objectively measure changes in dietary intakes. The intervention was only 6 months; therefore, it is unknown if the educational workshops resulted in long-term dietary changes. Finally, the biological impact of dietary changes were not evaluated. Further research is warranted to evaluate the longitudinal and biological effects of anti-inflammatory dietary changes in BCS, especially among diverse populations.

Overall, the study demonstrated that an education and culinary-based intervention in BCS was successful at increasing adherence to a more anti-inflammatory dietary pattern by increasing consumption of anti-inflammatory foods, spices, and herbs and decreasing consumption of pro-inflammatory foods. Dietary patterns are multidimensional, and nutrients and phytochemicals from a variety of foods, spices, and herbs can reduce inflammation through additive or synergistic interactions. Promoting a dietary pattern rather than a specific food group or nutrient may have greater health benefits, but future interventions must identify strategies that enable individuals to successfully change multiple dietary behaviors.

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Data availability The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

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