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Dietary consumption patterns in breast cancer survivors: Pilot evaluation of diet, supplements and clinical factors

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ABSTRACT

Purpose: Adherence to dietary intake guidelines is recommended for optimal nutrition and outcomes in breast cancer survivors. The purpose of this study was to examine dietary quality in a cohort of breast cancer survivors related to current guidelines, guiding further education-based research.

Methods: This exploratory evaluation examined compliance with current dietary guidelines. Data collected included demographics, medical histories and repeated, three-day 24-h dietary recalls. Women with early-stage breast cancer (n = 97) who completed breast cancer treatment between 6 and 24 months were recruited. Descriptive statistics and frequencies were calculated for demographic and lifestyle characteristics, reported fish consumption, body mass index categories, supplement consumption, and adequacy of macronutrient and micronutrient consumption (classified as below, meeting, or exceeding needs).

Results: In this cohort, 28.9% were classified as overweight and 35% were obese. The mean dietary macronutrient consumption was 44.3% (±8.9%) carbohydrates, 36.6% (±7.3%) fat, and 17.3% (±4.7%) protein. Additionally, 32.3% participants consumed >45 g sugar/d. The mean n-6 to n-3 ratio was 8.0 (±3.3):1. Further, 38% of survivors reported consuming less than 1 serving of fish per week. Participants consumed between 0 and 1.03 servings of fish per day, with an average consumption of 0.16 (±0.26) servings per day and 61.5% (n = 59) consuming 0 servings per day. The mean daily combined dietary and supplement consumption of multiple micronutrients was below the Recommended Daily Allowance for Vitamin D (30%), Calcium (52.6%), Magnesium (42.1%), and Vitamin E (80%).

Conclusion: Breast cancer survivors 0.5–2 years post-treatment are not meeting recommended nutrition consumption guidelines for a number of nutrients. Findings suggested that nutrition therapy targeting weight loss through reduced sugar, total and saturated fat, while increasing foods rich in omega-3, and ensuring adequate micronutrient consumption would promote better nutritional consumption patterns and improve overall health during survivorship.

1. Introduction

Breast cancer (BCA) is the most commonly diagnosed cancer in the United States (DeSantis et al., 2014; Siegel et al., 2022). Increased screening mammography and an overall heightened awareness have promoted earlier BCA detection (Harding et al., 2015). This trend, along with improvement in therapy, correlates with the decline in BCA mortality rates, making breast cancer survivors (BCS) a substantially growing population (DeSantis et al., 2014). Since most women are relatively young at the time of diagnosis, the emphasis of care is on ensuring full recovery and maintenance of quality of life (QoL) in survivorship (DeSantis et al., 2014). A healthful diet is pivotal to improving health outcomes, maintaining QoL throughout survivorship and reducing morbidity and mortality, especially as nutritional needs change over time (Rock et al., 2012, 2022). Dietary composition, particularly fatty acid consumption profile, can regulate the inflammatory cascade

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(He et al., 2009). Diets that are low in omega-6 long-chain fatty acids (omega-6LC) and high in the beneficial omega-3 long-chain fatty acids (omega-3LC) create a more favorable omega-6 to omega-3 (n6:n3) ratio, closer to 4:1, that may have protective effects against cancer-related mortality and complications, i.e., depression and pain, and improve overall health (Freitas and Campos, 2019; Zhang et al., 2023). Since breast cancer and its treatments tend to be proinflammatory, improving the fatty acid profile in this population may promote better outcomes in survivorship (Alfano et al., 2012; Fabian et al., 2015; George et al., 2010).

Although the American Cancer Society's (ACS) Nutrition and Physical Activity Guidelines for Cancer Survivors (NPAGCS) makes no specific recommendation for fish consumption in survivorship, fish provides a rich source of omega-3LC, promoting optimal cardiovascular health and decreased mortality rates (Greenlee et al., 2016; Rock et al., 2012). In addition to being rich in omega-3LC, fish is notable for its high protein and low saturated fat content, further complying with the guidelines which advise adequate consumption of lean protein and limiting saturated fat consumption. Other ACS recommendations include consuming a diet that is high in vegetables, fruits, and whole grains, targeting optimal vitamin, mineral and fiber consumption. The use of supplements is not recommended in this population, unless deficiencies are apparent, or as advised by a practitioner (Rock et al., 2012). Thus, obtaining supplementary omega-3LC would not be as advisable or advantageous for BCS over increasing the consumption of omega-3LC rich foods. While there is ongoing research on the impact of nutritional supplements on health promotion, the results are inconclusive. Recent findings suggests that omega-3LC supplements are not beneficial; and maybe harmful in certain subgroups (Harvie, 2014). Although it is important to understand the behaviors of BCS around nutritional supplements, dietary interventions supporting dietary consumption, as opposed to supplements, are recommended to support sustained dietary change in BCS.

Recent studies examining dietary consumptions in cancer survivors have found that adherence to a healthy diet was associated with a reduced risk for cancer recurrence (Kwan et al., 2009), lower all-cause mortality (Castro-Espin and Agudo, 2022; Castro-Espin et al., 2023; Spei et al., 2023) and better health-related quality of life (Kim et al., 2018). However, few studies have reported detailed dietary consumption patterns of BCS, specifically, current patterns of fish consumptions and supplement intakes are not well defined in the literature. The goal of this study was to expand understanding the dietary quality of nutrient consumption patterns, including fish consumption and dietary n-6:n-3 ratio, and nutritional supplement behavior in a BCS population. Our primary aims were to: 1) describe the macronutrient and micronutrient nutritional components of the BCS cohort, 2) identify and provide evidence of n-6:n-3 ratio, 3) determine the frequency of fish consumption and 4) describe the dietary supplement use behavior in this population. This investigation provides key information regarding the dietary macronutrient and micronutrient composition in a cohort of BCS to identify if specific nutritional deficits exist, providing evidence-based approach guiding educational and support efforts for BCS and with implications for survivors of other cancer types.

2. Materials and methods

2.1. Study design

Exploratory investigation of female early-stage (I-IIIA) BCS (n = 97) who had completed treatment within 6–24 months were evaluated for medical history, lifestyle characteristics and dietary nutritional composition as related to current guidelines for cancer survivors, the NPAGCS. This paper presents preliminary data from a larger randomized control trial examining the effect of a dietary fish intervention on nutrient consumption, inflammation and psychoneurological symptoms in BCS.

2.2. Sample

Participants were BCS recruited from a large cancer center in a metropolitan area in southern New England. All recruitment and investigational procedures were approved by the Investigational Review Board. Eligible participants were identified based upon the following criteria: 1) women, 2) post-treatment for early-stage BCA (stage I to IIIA), 3) completed treatment for BCA between 6 and 24 months prior to study enrollment, 4) completed chemotherapy and/or radiation (except tamoxifen/aromatase inhibitors), 5) age 35–75, and 6) able to comprehend English. Participants were excluded from participating if they had evidence of cancer recurrence or history of other cancer type, diagnosis of dementia or active psychosis. Informed consent was obtained prior to any data collection. Sample size was adequate for exploratory, descriptive data.

2.3. Procedures

Participants who received the mailing or flyer and self-determined that they met study criteria were arranged a study visit and informed consent was obtained prior to any data collection. Once consented, participants provided demographic data, medical and lifestyle histories and completed one of 3 of the repeated, 3 day 24-h dietary recalls (3-DR). The 2 remaining dietary recalls were collected via phone following the initial study visit for a total of three dietary recalls (one weekend day and two weekdays) to comprise the 3-DR. Recalls were collected under the oversight of a Registered Dietitian by individuals trained in NDSR procedures.

2.4. Measures

2.4.1. Demographic, lifestyle and clinical characteristics

Demographic and lifestyle characteristics were self-reported using an electronic medical history form. Lifestyle characteristics included self-reported physical activity, alcohol consumption, recreational drug and tobacco usage, and fish consumption patterns (frequency and type). Clinical characteristics included a self-report of height, weight, weight history, general medical history, psychiatric history, medication and nutritional supplement usage, BCA history (date of diagnosis, chemotherapy regimen, radiation treatment, surgical history), physical activity, typical fish/seafood consumption, and other lifestyle factors.

2.4.2. Body mass index (BMI)

BMI was calculated using self-reported weights and heights. BMIs were calculated and then categorized following Center for Disease Control and Prevention (CDC) guidelines: underweight (<18.5), healthy weight (18.5 to <25), overweight (25.0 to <30), class I obesity (30 to <35), class II obesity (35 to <40) and class III obesity (≥40).

2.4.3. Repeated, 3 day 24-hour dietary recalls (3-DR)

Dietary data were collected using the University of Minnesota's Nutrition Data System for Research (NDSR) (University of Minnesota, 2016). The NDSR was designed to collect and analyze 24-h dietary recalls and provides the nutrient composition of entered foods. Interested participants were asked to meet with research personnel, either in-person or virtually. The initial dietary recall was conducted at this visit via interview. As a component of the NDSR process for collecting dietary information and to assist participants in estimating food quantities consumed for various foods, food portion packets were also provided. Two additional recalls were conducted via telephone at times convenient to the participant. Participants provided information on all food, beverages and supplements consumed in the past 24-h period. Recalls were collected a total of three times: two weekdays and one weekend. Accuracy of dietary consumption information was assured through use of a systematic 3-pass system when collecting data through the NDSR. This 3-pass system involved: 1) asking participants about

everything they consumed in the past 24 h, 2) confirming their reported foods and mealtimes with details, and 3) verifying all details with participants. The records for the 3 respective 24-h dietary recalls were then averaged for analysis.

2.4.4. Fish consumption

As part of the Post BCA Medical History Form, participants were asked about their typical fish consumption. Participants first answered whether they ate fish, and if they did, they were asked how many times weekly they consume fish (ranging from less than one time per week to more than seven times weekly) and also to list the types of fish they typically consume. In addition, the NDSR software was used to calculate the average number of servings of fish that participants consumed using the 3-DR. Given the possibility of food aversions as a treatment side effect, analyses were also conducted to determine if differences exist in fish consumption based upon the type of breast cancer treatment BCS received (i.e. chemotherapy, radiation therapy vs. no therapy).

2.4.5. Omega-6 to Omega-3 ratio

The average fatty acid consumption was calculated for individual Omega-6 and Omega-3 fatty acids and analyzed through the NDSR software output. Using this information, the omega-6 to omega-3 fatty acid (n6:n3) ratio was calculated as follows: (Linoleic acid + Arachidonic Acid)/(alpha-linolenic Acid + Eicosapentaenoic acid + Docosahexaenoic) or (LA + ARA)/(ALA + EPA + DHA).

2.4.6. Dietary composition

Macronutrient composition was analyzed utilizing the NDSR software. Ranges, means and standard deviations were determined for total energy (kilocalories [kcal], percent carbohydrate, protein, fat and saturated fat, as well as for total protein, cholesterol and fiber. Total protein was used to determine whether participants were meeting the minimum requirement for adult women of 46 g per day, as recommended by the National Institute of Health. Similarly, total fiber was analyzed to determine the number of participants meeting the age-dependent recommended daily consumption of 21–25 g.

Micronutrient composition was analyzed utilizing the NDSR software. Total micronutrient composition was obtained for vitamins A, C, D, E, K, thiamin, riboflavin, niacin, B6, folate, B12, pantothenic acid and choline, as well as the minerals calcium, copper, iron, magnesium, manganese, phosphorus, selenium, zinc, potassium and sodium. The Dietary Reference Intakes (DRI) and Recommended Dietary Allowances (RDA) were used to determine whether participants were meeting needs respective to their age. For nutrients in which tolerable upper intake levels (TUL) are established, it was additionally determined whether participants were exceeding the suggested limits. DRI, RDA and TUL were obtained from the National Institutes of Health Office of Dietary Supplements (National Institute of Health Office of Dietary Supplements).

2.4.7. Nutritional supplements

Information on nutritional supplements was collected using NDSR as a component of the 24-h dietary recalls. BCS were asked to share detailed information regarding brand and dose for all nutritional supplements they currently consume including multivitamins, individual or combined vitamin/mineral formulations, amino acids, fatty acids, prebiotics/probiotics, etc. Additionally, the medical history form captured supplements typically consumed. Supplement details from the 24-h recalls captured if the reported supplements were actually consumed at the time of the recall. Nutrient values were totaled with food consumption to determine total consumption of a given nutrient. Mean nutrient consumption was evaluated from the perspective of both adequate and excessive supplement consumption.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Investigational Review Board of Hartford Healthcare and University of Connecticut. Informed consent was obtained from all individual participants included in the study.

2.5. Statistical analyses

All analyses were conducted on the R software, Version 4.2.0 and SPSS, Version 27. The 3-DR data were averaged to generate a mean score for analysis. All data (participant characteristics and variables of interest) were analyzed with descriptive statistics. Frequencies were determined using SPSS (Version 27) for demographic and lifestyle characteristics, reported fish consumption, BMI category and adequacy of macronutrient and micronutrient consumption (below, meeting, or exceeding needs). Means and standard deviations were determined using SPSS (Version 27) for age, macronutrient and micronutrient compositions and total fish consumption. Differences in average weekly seafood consumption between the three groups were compared using one-way analysis of variance (ANOVA).

3. Results

3.1. Demographics and lifestyle factors

The demographic and lifestyle characteristics of the BCA cohort are reported in Table 1. The majority of the participants were Caucasian (86.6%), married (65.0%), had a college degree or above (74.2%), and with a mean age of 60.3 (±11.3) years old. According to the CDC classification, 28.9% of this cohort were overweight and 35% were obese. The majority had no history of smoking. Only 1 participant (1.0%) was an active smoker, while 23 participants (23.7%) had a history of smoking. About 10.5% (n = 10) partook in recreational/therapeutic marijuana use. Alcohol consumption varied, with 24.7% of BCS reported never drinking (n = 24), 23.7% reported drinking only occasionally (n = 24), and 30.9% (n = 30) and 20.6% (n = 20) reported low moderate (1–3 drinks/week) and high moderate (4–7 drinks/week) consumption respectively. Over half (54.2%) participants self-reported engaging in moderate or strenuous physical activities. Additionally, 12.5% (n = 12) reported being sedentary and 33.3% (n = 32) reported engaging mild physical activity. Data was collected from 2018 to 2022 with a 1-year period of suspension (2020–2021) due to the COVID-19 pandemic.

3.2. BCA history, treatment and clinical characteristics

Self-reported breast cancer stage and treatment are depicted in Table 2. Of note, one participant stated they were prescribed tamoxifen but reported stopping the medication due to severe side effects. In addition, one participant stated that she was on maintenance chemotherapy but did not provide any further details.

Among the 97 BCS, 22.4% self-reported a diagnosis of depression (n = 22), and 30.6% reported anxiety (n = 30). The majority, 58.2% (n = 57), reported no psychiatric history. A total of seven participants (7.2%) reported the usage of immunosuppressive medications. Aromatase inhibitor (AI) use was reported in 39.1% (n = 38), while 20.6% (n = 20) used selective estrogen receptor modulators (SERM). Fifteen (15.6%) participants reported a history of other cancers.

3.3. Fish consumption

The majority of the BCS self-reported that they consume fish (95.8%; n = 91), and 65.6% (n = 63) reported that they consume fish at least

Table 1
Demographic and lifestyle characteristics (n = 97).

	Number (n)	Percentage (%)
Race/Ethnicity		
Caucasian	84	86.6
African American	4	4.1
Latino	3	3.1
Other	6	6.2
Education[a]		
High school diploma[b]	25	25.8
College degree[c]	38	39.2
Master's level degree and above	34	35.0
BMI Category		
Under weight	1	1.0
Normal weight	34	35.1
Overweight	28	28.9
Obese Class I	20	20.6
Obese Class II-III	12	14.4
Relationship Status		
Married	63	65.0
Other	34	35.0
Smoking Status		
Smoker	1	1.0
Nonsmoker	96	99.0
Alcohol use		
Never	24	24.7
Occasionally	23	23.7
Low Moderate	30	30.9
High Moderate	20	20.6
Physical Activity		
Sedentary	12	12.5
Mild	32	33.3
Moderate	50	52.1
Strenuous	2	2.1
Recreational drug use		
Yes	10	10.5
No	85	89.5
Age (M±SD)	60.28 ± 11.32	

[a] Depicts highest level of education obtained;
[b] Includes those who attended some college, but did not obtain a degree;
[c] Includes those who attended some graduate school, but did not obtain a degree.

Table 2
Breast cancer (BCA) history (n = 97).

	Number (n)	Percentage (%)
BCA staging (patient-reported)		
Stage 1	56	57.7
Stage 2	31	32.0
Stage 3	10	10.3
Surgery Type		
Lumpectomy	13	13.4
Lumpectomy w/lymph node removal	41	42.3
Partial or total mastectomy	43	44.3
Treatment Type		
Radiation therapy	44	45.4
Chemotherapy	11	11.3
Radiation and chemotherapy	28	28.9
Neither	14	14.4
Hormone Treatment		
None	39	40.2
AI[a]	38	39.2
SERM[b]	20	20.6

[a] Aromatase Inhibitor;
[b] Selective estrogen receptor modulators.

once per week. Detailed results of self-reported fish consumption are available in Table 3. Upon analysis of the 3-DR, participants consumed 0–1.66 servings of seafood (fish and shellfish) daily, with an average 0.27 (±0.36) servings, of which, 49.0% (n = 47) consumed 0 servings. When excluding shellfish, participants consumed between 0 and 1.03 servings of fish per day, with an average 0.16 (±0.26) servings and

Table 3
Fish consumption patterns (n = 97).

Self-Reported[a]	Number	Percent
Fish Consumption		
Yes	91	95.8%
No	4	4.2%
Fish Consumption per Week		
<1	33	34.4%
1	31	32.3%
2	23	23.9%
≥3	9	9.4%
NDSR[b] (Servings)	Range	(M±SD)
Total Fish & Shellfish	0–1.66	0.27 ± 0.36
Fish Only (no Shellfish)	0–1.03	0.16 ± 0.26

[a] Self-reported data obtained from the Post BCA Medical History Form.
[b] NDSR data reflective of the 3-DR, aggregated by participant.

61.5% (n = 59) consuming 0 servings.

BCS were grouped based upon prior breast cancer treatment as follows: chemotherapy (n = 39); radiation therapy only (n = 44); no radiation or chemotherapy (n = 14) and compared based upon average fish consumption using 3-DR. Based upon 3-DR, average seafood (fish and shellfish) consumption was 0.22 (±0.4) servings/day in the chemotherapy group; 0.32 (±0.32) servings/day in the radiation therapy only; and 0.25 (±0.38) in the group that had received no chemotherapy or radiation. The differences in daily seafood consumption between the three groups were compared using one-way analysis of variance (ANOVA). These differences were not statistically significant (p = 0.5).

3.4. Omega-6LC and omega-3LC consumption

The items of the n-6:n-3 ratio included: linoleic acid (LA) (13.8g ± 6.4, ranged from 3.0 to 35.0), arachidonic acid (AA) (0.2g ± 0.1,ranged 0–0.6), docosahexaenoic acid (DHA) (0.2g ± 0.3, ranged 0–1.5), eicosapentaenoic acid (EPA) (0.1g ± 0.1, ranged 0–0.5), and linoleic acid (ALA) (1.8g ± 1.3, ranged 0.2–7.5). The n-6:n-3 ratio in this population ranged from 1.6 to 22.4, with a mean of 8.0 (±3.3):1.

3.5. Dietary macronutrient consumption

Energy consumption in kilocalories, total and percentage energy consumption of major macronutrient groupings are displayed in Table 4. The Dietary Reference Intake (DRI) values were used as the guideline for dietary reference ranges to assess the adequacy of nutrient intake with corresponding percentages of participants who met daily protein and fiber requirements. BCS consumed a range of 0.41–2.30 g protein/kg/day with mean daily consumption of.

0.98 ± 0.37 g/kg/d. Mean consumption of added sugar was 37.4 (±26.2) g per day with thirty-one (32.3%) participants exceeding the 45 g/day recommended limit. Mean energy percentage consumption of saturated fat was 11.8% ± 4.0%, which exceeds the recommended intake of 10%.

3.6. Dietary Micronutrient Consumption

Based upon dietary consumption alone, the majority of participants were not meeting the Recommended Daily Allowance for vitamin D (96.8%; n = 92), vitamin E (80.0%; n = 76), folate (64.2%; n = 61), pantothenic acid (51.6%; n = 49), choline (86.3%; n = 82), calcium (84.2%; n = 80), magnesium (55.8%; n = 53) and potassium (60.0%; n = 57). In addition, 20% or more of participants were not meeting needs for vitamins A, C, K, B6, B12 and thiamin, and elements iron and zinc. The complete results for micronutrient consumption are summarized in Fig. 1.

Table 4
Energy and macronutrient composition (n = 96).

	Range	(M±SD)	DRI range	Below Range	Within Range	Exceeded Range
Energy (Kcal)	735–3588	1661 ± 484	1800–2000	65 (67.7%)	10 (10.4%)	21 (21.9%)
Carbohydrate(g)	39.0–512.0	188.9 ± 66.2	202.5–325	65 (67.7%)	28 (29.2%)	3 (3.1%)
Protein(g)	29.8–138.8	70.2 ± 22.4	45–175	10 (10.4%)	86 (89.6%)	0 (0%)
Fat(g)	25.5–161.2	70.9 ± 26.5	40–77.8	10 (10.4%)	52 (54.2%)	34 (35.4%)
Saturated Fat(g)	6.7–86.3	22.9 ± 11.9	0–20	0 (0%)	42 (43.8%)	54 (56.2%)
Cholesterol (mg)	23.9–634.0	255.4 ± 144.2	0–300	0 (0%)	63 (65.6%)	33 (34.4%)
Fiber (g)	7.0–62.4	21.0 ± 8.9	0-21/0-25	0 (0%)	58 (60.4%)	38 (39.6%)
Added Sugars (g)	0.9–181.4	37.4 ± 26.2	0–45	0 (0%)	65 (67.7%)	31(32.3%)

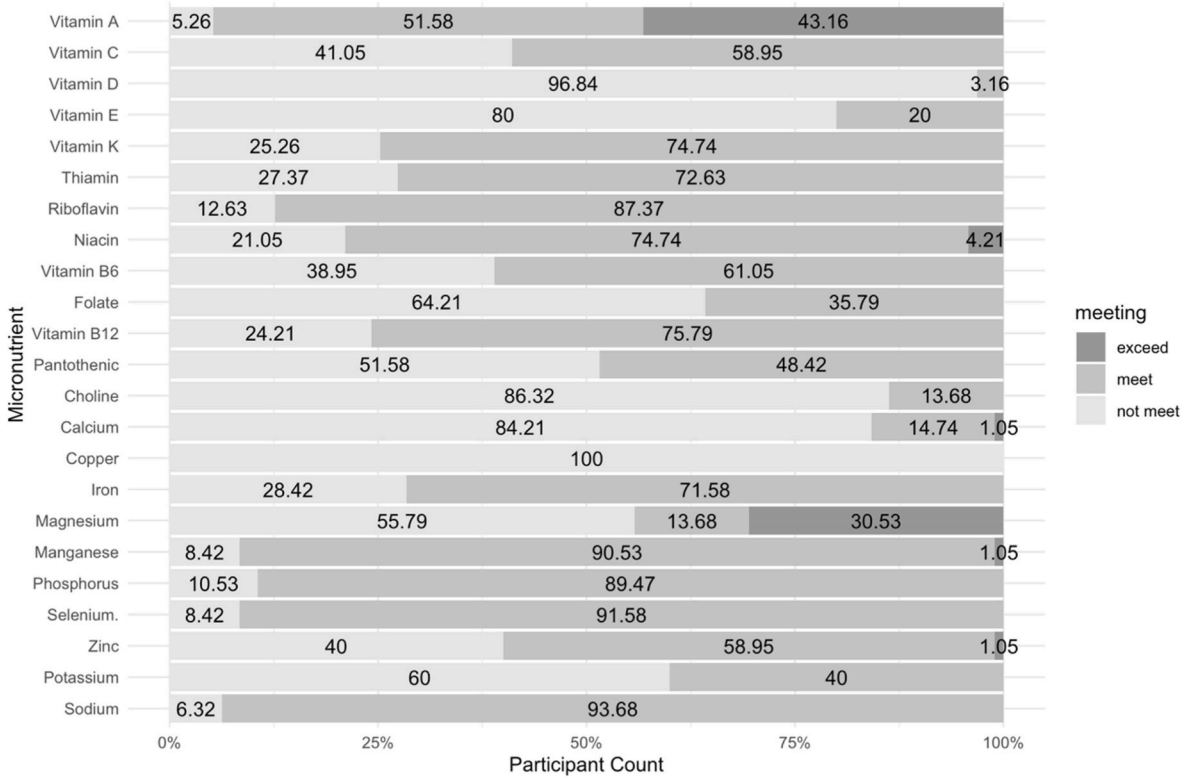

Fig. 1. Dietary Micronutrient Consumption (n = 95).
Bar-plot depicts the percentage of participants who were not meeting needs, meeting needs, or exceeding the total upper limit for each micronutrient.

3.6.1. Micronutrient and other supplements

3.6.1.1. Supplement intake and behaviors (compliance to supplements: vitamin D and fish oil). The most commonly consumed supplements in this cohort were vitamin D (n = 74, 77.9%), calcium (n = 58, 61.1%), biotin (n = 12, 12.6%), probiotics (n = 11, 11.6%), glucosamine (n = 10, 10.5%), and fish oil (n = 7, 7.4%).

3.6.1.2. Nutritional supplements combined with dietary consumption. The consumption of vitamin D and calcium supplements, both individually and in combination with dietary intake, is detailed in Table 6. The average calcium intake for this cohort was 1272.33 mg (±631.87), while the average vitamin D intake was 56.87 IU (±145.06). It is worth noting that although these values fall within the RDA, 30.5% of the cohort was not meeting the RDA for vitamin D and 52.6% were not meeting the RDA for calcium with supplementation. Additional nutrients where consumption was below the RDA included magnesium (42.1%), Vitamin E (80%), folate (35.8%). In contrast, 53.7% of the cohort exceeded the tolerable upper limit for Vitamin A with diet and supplements combined.

4. Discussion

The majority of participants in this study were overweight (28.9%) or obese (35%) which aligns with findings from Zhang et al. (2015). using the National Health and Nutrition Examination Survey (NHANES) in which 36% of surveyed cancer survivors were overweight and 35.3% were obese (Zhang et al., 2015). Obesity (BMI ≥30 kg/m^2), both pre- and post-cancer diagnosis, has been associated with higher risks of cancer recurrence, progression and overall mortality in women with cancer (Jackson et al., 2017; Nechuta et al., 2016). The NPAGCS in 2012 and 2022 emphasized the importance of weight control in this population (Rock et al., 2022). Our results are consistent with previous findings and suggest an urgent need for effective weight loss intervention and support throughout survivorship. Further, we observed sub-optimal lifestyle behaviors among a significant percentage of BCS, including sub-optimal nutritional choices, moderate alcohol intake and sedentary-mild physical activity level, all have been reported as risk factors for obesity. Although current evidence is limited and inconsistent on the association of alcohol intake and breast cancer recurrence and mortality, there is sufficient and consistent evidence pointing out that engaging in regular physical activity and healthier dietary behavior is

associated with lower risk of mortality and morbidity (Rock et al., 2012, 2022). Our findings highlight the necessity for emphasizing nutritional and lifestyle education and support when planning and implementing weight reduction intervention. It is worth noting that a considerable number of BCS reported a history of depression and/or anxiety, which can have a significant impact on lifestyle and dietary choices (Galiano-Castillo et al., 2014; Phillips and McAuley, 2015; Zainal et al., 2013). This underscores the importance of addressing psychological factors and providing comprehensive support to promote healthy behaviors in this population.

Omega-3 fatty acid, specifically long chain forms of omega-3 including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) have great potential in reducing inflammatory load thereby reducing risks for cardiac vascular events, cancer re-occurrence and persistent psychoneurological symptoms (Fabian et al., 2015; Rock et al., 2012). Given that omega-6LC and omega-3LC share the same biosynthetic pathway and compete for the same enzymes, an excess of omega-6LC can lead to a deficiency of omega-3LC. Thus, maintaining a balanced ratio of n6: n3 ratio is essential for reducing anti-inflammatory load and achieving optimal health. While an n6:n3 ratio of 4:1 or less is ideal, currently the typical Western diet is laden with omega-6LC, with ratios upwards of 20:1 or higher (Simopoulos, 2002). In this cohort, the average ratio was 8.0 ± 3.3. Although not as high as previously reported, this ratio remains above ideal and reflects an excess of proinflammatory omega-6LC coupled with insufficient omega-3LC consumption. Therefore, to improve this ratio, nutritional education for BCS should promote increased fish consumption and other foods containing omega-3 fatty acids.

In this study, both self-report and dietary recall revealed that the fish consumption for the majority of BCS was less than one serving of fish and/or shellfish per week. Contrasting the fish consumption amounts we report, the Food and Drug Administration recently released guidance for women of childbearing age to consume 2–3 servings (4oz uncooked portion = 1 serving) of fish weekly for optimal health outcomes (U.S. Food and Drug Administration, 2017a). Given cancer treatments and associated inflammation, fish consumption at or above these guidelines would be necessary for an anti-inflammatory effect (Calder, 2002). Concerns about methylmercury and polychlorinated biphenyl contamination in fish have led to misconceptions and negatively affected receptivity to fish consumption. Information regarding safe fish consumption is a necessary component of the educational plan while also encouraging minimum vs. maximum fish consumption (Administration, 2021). The "Best Choices" list for low-mercury fish options are listed in Table 5, providing an overview of fish choices with lower levels of contaminants for BCS to consider (Hayward et al., 2007; U.S. Department of Agriculture, 2016; U.S. Food and Drug Administration, 2017b; U.S. Food and Drug Administration, 2019). Careful consideration of barriers to fish consumption is crucial when planning education to BCS. In particular, financial, logistical, and clinical barriers may interfere with adherence to fish recommendations (Jahns et al., 2014). Furthermore, it is important to consider that side effects from cancer treatment may also contribute to low consumption of fish among BCS. Taste aversion to meat and other high protein foods, caused by a metallic or chemical taste sensation, is a side effect of BCA chemotherapy (American Society of Clinical Oncology, 2020). Taste alteration may extend beyond treatment into survivorship (Lee et al., 2016). We report that BCS in this cohort who had received chemotherapy consumed 0.1 servings fewer average daily servings of seafood (fish and shellfish) compared to BCS who had received radiation therapy alone or neither chemotherapy nor radiation therapy. Although not significant, from a clinical perspective, a difference of ½ serving of seafood weekly, especially at a low consumption level (≤1 serving weekly) presents a clinical concern of low omega-3LC consumption. There is a need for further research with a larger sample size to assess differences in seafood consumption among BCS by BCA treatment modality for further exploration of clinical symptom clustering and other key outcomes.

Table 5
Fish choices with lower levels of contaminants.

Fish Species	Long Chain Omega-3 Content (DHA) (mg/3-oz cooked portion)
Best choices (2–3 servings weekly):	
Salmon chinook	618
Salmon pink (canned in oil)[a]	569
Salmon sockeye	476
Sea bass	473
Sardines (canned in oil)[a]	433
Pollock	360
Salmon pink	339
Cod (Atlantic)	277
Chunk light tuna (canned in water)[a]	167
Shrimp	120
Tilapia	113
Haddock	93
Good choices (1 serving weekly):	
Blue fin tuna	970
Grouper	181
Halibut	132

Adapted from (Judge, 2018), compiled from the Food Composition Databases, by the U.S. Department of Agriculture, 2016. Retrieved from https://ndb.nal.usda.gov/ndb.

[a] Lower-cost options.

Table 6
Dietary, Supplementary and Total consumption of Calcium and Vitamin D (n = 95).

	Calcium (mg)	Vitamin D (mcg)
Diet Consumption	831.5 ± 372.8	440.9 ± 542.7
Supplement Consumption	440.9 ± 542.7	51.7 ± 145.4
Supplements (Frequency)	58 (61.1%)	74 (77.9%)
Total Consumption	1272.3 ± 631.9	56.9 ± 145.1
N (%) below DRI*	51 (52.6%)	30 (30.5%)
N (%) within DRI**	34 (34.7%)	59 (61.1%)
N (%) exceed DRI**	12 (12.6%)	8 (8.4%)

Notably, mean energy consumption in our cohort was 1661 ± 484 kcal/day, a relatively low-calorie level which is not congruent with the weight status we observed, suggesting low reporting of intake across the 3-DR data. Underreporting energy consumption in dietary recalls among women has been reported previously in the literature (Novotny et al., 2003). Carbohydrate consumption fell within the acceptable macronutrient distribution range (AMDR) of 45–65% of energy for the majority of participants(National Institute of Health Office of Dietary Supplements). Dietary planning for weight loss in BCS should be carefully designed to encourage optimal protein consumption. BCS in this study met the recommended nutritional oncology guidelines for protein consumption, a "minimum" of 1.0 g protein/kg/d, for preserving skeletal muscle mass. However, it is important to note that the target consumption of 1.2–2.0 g/kg/d to promote anabolism was not achieved by this cohort (Arends et al., 2017; Berryman et al., 2018; Ford et al., 2022). Amongst participants with BCA in the Nurses' Health Study (n = 6348), Holmes and colleagues found that higher protein consumption was associated with a reduced risk of cancer recurrence (Holmes et al., 2017).

Inclusive of omega-3LC, total fat consumption accounted for a significant amount of energy and exceeded the AMDR of 20–35% in this BCS cohort. Saturated fat consumption was only slightly higher than the 10% maximum suggested by the 2015–2020 dietary guidelines for Americans (DGA) (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). The most recent DGA no longer specifies a limitation on daily cholesterol consumption, however, it does note that there is approximately 100–300 mg in the Healthy U.S.-Style

Eating Pattern, dependent upon the calorie level (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). The participants in this study, on average, fell within these numbers. However, daily consumption ranged from 23.9 to 634 mg per day, suggesting high variability in cholesterol consumption among participants.

Upon analysis of NHANES data, McGill, Fulgoni and Devareddy found that the U.S. population over age 19 consumed, on average, 17 g of fiber per day, far below the age and sex-dependent recommendation of 21–38 g (McGill et al., 2015). In this current study, 60.4% of BCS study participants did not meet fiber recommendations, however, their average consumption (21.0 g) was slightly higher than what was reported nationally. The recommendation for fiber is 25 g a day for women between 18 and 50 years old, and 21 g a day for women 51 years and older (McGill et al., 2015). In line with this recommendation and the NPAGCS, continued education on increased fruit, vegetable and whole grain consumption should be encouraged in BCS.

Although 60% of the participants didn't meet potassium needs, this finding was consistent with other reports, as NHANES data reveals that the average American only consumes approximately half of the recommended daily intake for this nutrient (Whelton, 2018). Other nutrients in which over half of participants were not meeting needs included vitamin E, folate, choline and magnesium. Although the TUL for sodium is 2300 mg (mg) per day, many Americans far exceed these recommendations. According to the United States Department of Agriculture (USDA), the average U.S. diet consists of 3440 mg per day, with women consuming slightly lower amounts of 2980 mg per day (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Thus, our data was consistent with existing literature in the general population where 50% of participants in this investigation exceeded existing sodium consumption limits.

Nearly all the participants in this study were not meeting their needs for vitamin D based on dietary data. Trukova et al. (2012) found a similar pattern when measuring serum 25-hydroxy vitamin D levels in BCS, of which 77% of participants (76 of 99) exhibited insufficient vitamin D levels (Trukova et al., 2012). When compared to an analysis of 2010 NHANES data by Liu et al., these deficiency levels are even higher than the national average of 41.4% (Liu et al., 2018). Likewise, Calcium consumption was also insufficient in 84.2% of participants in this study. Considering the lower bone mass and increased risk of osteoporosis in this population, adequate calcium and vitamin D consumption should be recommended to aid in the preservation of remaining bone density (Bruyere et al., 2017). It is worth noting that 78% of the BCS in our cohort took vitamin D supplements and over 60% regularly supplemented with calcium supplements, which significantly increased the overall vitamin and calcium consumption. However, despite the supplementation, there were still a considerable number of participants who did not meet the recommended intake.

Other supplement consumption behaviors were in line with common concerns among biotin related to hair loss, glucosamine for joint health related to estrogen modulating therapies, probiotics for gut health and fish oil for anti-inflammatory action, and is consistent with previous findings (Du et al., 2020; Silver et al., 2022). While supplements can provide essential nutrients, many contains ingredients that may interact with medication, and lead to adverse health consequences (Chen et al., 2019). In this study, we observed a small portion of participants vitamin D and calcium exceeding the total upper limit due to supplement. Excessive nutrient intake by supplements have been repeatedly reported in previous literature. For example, one study using NHANES data reported that intakes of calcium exceeding total upper limit are associated with an increased risk of cancer mortality (Chen et al., 2019). Therefore, it is important for BCS to work with healthcare professionals or registered dietitians to determine the optimal dosage and ensure that the supplements align with medical and nutritional considerations. Additionally, it is crucial to note that supplements cannot replace the nutritional benefits provided by whole foods (Du et al., 2020; Rock et al., 2012). Well-balanced diet that includes food sources rich in protein, omega 3LC fatty acid, vitamin D and calcium is beneficial for overall health in this population.

Survivorship guidelines, including the NPAGCS from the ACS, contain valuable but often complex information that may overwhelm cancer survivors. American College of Surgeons' Commission on Cancer (CoC) emphasize the importance of a robust survivorship program involving multidisciplinary team (*Cancer Program Standards 2012, Version 1.1: Ensuring Patient-Centered Care*). Further, the survivorship program should offer the full spectrum of care services such as providing survivorship care plans, rehabilitation services, nutrition services, psychological services, physical activity programs or financial support services. Research has demonstrated the value that BCS place on survivorship care plan and communication with their provider and other members of the healthcare team as the most important component to guide them in engaging in healthier behaviors (Krok-Schoen et al., 2020).

The findings of this study have important implications for practice as they underscore the importance of targeted nutritional interventions for BCS. Oncology nurses are in a unique position to capitalize on this receptivity through the promotion of dietary and lifestyle change and by providing referrals to registered dietitians/nutritionists, with expertise and time allocation to support for optimal alignment with current recommendations and ongoing support. Nurses also play a pivotal role in promoting adherence to dietary guidelines, particularly by educating BCS on the benefits of dietary approach (i.e., omega-3 fatty acid) in reducing inflammatory load and improving overall health in survivorship. Additionally, the frequent occurrence of nutrient deficiencies, such as in vitamin D and calcium, highlights the need for nurses to advocate for regular dietary assessments and appropriate supplementation.

4.1. Limitations

The limitations of this preliminary exploration of dietary consumption in a cohort of BCS include lack of generalizability due to small sample size. Additionally, the sample was 80% white, further limiting the findings to the more diverse BCS population. There is a lack of comprehensive nutritional guideline for BCS, so analysis drew from multiple sources to examine the overall nutritional adequacy within this sample. Despite the limitations outlined, this study provides important information in understanding dietary consumption patterns in BCS and thus building evidence toward programmatic planning for improved dietary and associated outcomes in BCS.

5. Conclusions

In this study, BCS 0.5–2 years post-treatment were not closely adhering to NPAGCS for several nutrients and low-fat protein consumption. Our data support a need for further research targeting lifestyle interventions focused on personalized dietary planning to reduce risk of nutrient deficiencies as outlined. This BCS cohort also self-reported psychoneurological symptomatology including depression and anxiety, adding another level of complexity to efforts targeting lifestyle modification. Given that our cohort ranged from 0.5 to 2 years post-treatment, these findings underscore a need for continued, long-term support in dealing with this complex combination of symptoms and lifestyle factors that place them at risk for additional comorbidities. Dietary guidelines for cancer survivors are vague in nature, and there is a need for a more targeted and multidisciplinary approach to maintaining quality of life in survivorship. Given its potential to down-regulate inflammation, future research should examine BCA treatment-related barriers to fish consumption and the implications of the n6:n3 ratio in psychoneurological symptom cluster burden in order to establish more specific dietary guidelines targeting symptom self-management and relief in the BCS population.

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CRediT authorship contribution statement

Wanli Xu: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Aolan Li:** Formal analysis, Data curation. **Hayley D. Yackel:** Writing – review & editing, Formal analysis, Data curation. **Michelle L. Sarta:** Writing – original draft, Formal analysis, Data curation. **Andrew Salner:** Writing – review & editing, Supervision, Conceptualization. **Michelle P. Judge:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

No competing interests.

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