January 2014

Post-Diagnosis Changes In Dietary Patterns And Body Weight Among Breast Cancer Survivors

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POST-DIAGNOSIS CHANGES IN DIETARY PATTERNS AND BODY WEIGHT AMONG BREAST CANCER SURVIVORS

by

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A Thesis Submitted in
Partial Fulfillment of the
Requirements for the Degree of
Master of Public Health

Yale School of Public Health
May 2014

ABSTRACT

Background

Weight gain is common after a breast cancer diagnosis and is known to be a risk factor for breast cancer recurrence and mortality independent of weight and BMI at diagnosis. Determining the factors associated with post-diagnosis weight gain will provide insight into improving weight management and ultimately improving breast cancer outcomes.

Purpose

This study examined dietary patterns of breast cancer survivors and whether weight gain after a diagnosis of breast cancer was associated with post-diagnosis dietary changes among breast cancer survivors.

Methods

The study sample consisted of 100 breast cancer survivors diagnosed an average of 3.3 ± 2.1 years prior to enrollment in the Lifestyle Exercise and Nutrition (LEAN) Study. Participants' weight, height, and dietary patterns were self-reported at diagnosis and at enrollment into the LEAN study. Food frequency questionnaires were also completed at LEAN enrollment. Generalized linear models were performed to examine associations between changes in weight and dietary patterns, overall and stratified by BMI at diagnosis.

Results

Average weight change from diagnosis to LEAN enrollment was 2.3 ± 7.0 kg. A greater percent of women with a BMI ≤ 25 kg/m^2 gained weight than women with a BMI > 25 kg/m^2 (93% and 41%, respectively; $p<0.001$). At LEAN enrollment, 47% and 63% of participants met the Dietary Guidelines for Americans (DGA) recommended fruit and vegetable intake, respectively. However, 55% of participants were surpassing the DGA recommended total caloric intake and 99% were surpassing the DGA recommended fat intake. After adjusting for age, ethnicity, race, education, cancer stage at diagnosis, treatment type, endocrine therapy, menopausal status, and time between diagnosis and LEAN enrollment, weight changes differed significantly ($p<0.05$) among participants who changed total caloric intake, sugar intake, and fast food consumption. Significant weight change differences were seen between those who increased versus decreased their total caloric intake (5.1 ± 1.6 kg vs. -0.8 ± 1.7 kg), sugar intake (7.2 ± 2.1 kg vs. -1.0 ± 1.5 kg), and fast food consumption (11.4 ± 3.0 vs. 0.9 ± 1.3), all $p<0.05$.

Conclusions

The results suggested that weight gain commonly seen in the first few years after a breast cancer diagnosis is, at least in part, associated with unfavorable post-diagnosis changes in diet composition. Dietary interventions aimed at decreasing unhealthy dietary patterns, such as high intake of total calories, fat, sugar, and fast food may be particularly effective in preventing weight gain among breast cancer survivors.

INTRODUCTION

Both obesity and breast cancer are major public health issues.[1-3] Breast cancer is the most common cancer among women in the United States, with approximately 232,340 new diagnoses of invasive disease and 39,620 deaths annually.[3] Obesity, defined as a body mass index (BMI) of 30 kg/m^2 or greater in adults, affects over 30% of adult women in the United States.[4-6] Obesity is associated with increased morbidity and mortality compared to normal weight (BMI < 25 kg/m^2) due to a range of obesity-associated diseases.[5,6]

Beyond their individual impacts, obesity and breast cancer have been shown to directly interact.[7,8] Obesity is associated with an increased breast cancer risk as well as an increased risk for recurrence and breast cancer mortality in women diagnosed with breast cancer.[7-13] Furthermore, breast cancer treatment commonly results in weight gain, which is a risk factor for breast cancer recurrence and mortality independent of BMI at diagnosis.[7-19] Overweight, defined as having a BMI of 25 kg/m^2 or greater, is thought to pose similar increased risks for breast cancer survivors.[12] Several studies have shown improved diet, increased exercise, and weight loss as protective factors against breast cancer incidence, recurrence, and mortality while others draw more variable conclusions, demonstrating the need for further research.[4,12,20-22]

Developing effective weight loss and weight management programs for breast cancer survivors could have significant positive health impacts on this population.[8,11,23] A better understanding of factors that contributing to post-diagnosis weight gain will assist in designing weight management programs for breast cancer survivors. There is strong evidence that endocrine therapy,[16,18] chemotherapy,[30,33,34] changes in physical activity,[19,24,25] and changes in menopausal status[14,16,19] contribute to weight gain after breast cancer diagnosis, but diet-related weight changes have been less thoroughly studied.

Thus, the purpose of this study was to examine dietary patterns and changes in weight and dietary patterns of breast cancer survivors between breast cancer diagnosis and enrollment into the Lifestyle, Exercise, and Nutrition (LEAN) Study. Because women may alter their dietary patterns as a result of receiving a diagnosis of breast cancer, even before any intervention is conducted, the present analysis aimed to determine whether diet and weight changes occur between diagnosis and at the baseline LEAN study visit.[1] It was hypothesized that favorable changes in diet, as outlined in the Dietary Guidelines for Americans[26], would be associated with weight maintenance or weight loss while unfavorable changes in diet would be associated with weight gain.

METHODS

This study was an observational study examining associations between changes in weight and dietary patterns between a diagnosis of breast cancer and enrollment into LEAN. All LEAN study procedures, including written informed consent, were reviewed and approved by the Yale University School of Medicine Human Investigation Committee.

Study Participants and Recruitment

Participants were overweight (BMI $\geq$ 25 kg/m^2) women diagnosed with Stage 0-III breast cancer who had undergone breast cancer surgery. Women were recruited between May 2011 and June 2013 through the Rapid Case Ascertainment (RCA) Shared Resource of the Yale Cancer Center, a field arm of the Connecticut (CT) Tumor Registry that identifies women shortly after cancer diagnosis from hospitals in CT. Specifically, the LEAN Study enrolled 100 women who had been recruited, screened, and found ineligible for a randomized trial of exercise on aromatase inhibitor (AI) side effects, called the

Hormones and Physical Exercise (HOPE) Study (NCI R01-132931). Upon recruitment into LEAN, women completed baseline questionnaires before randomization into the weight loss trial.

Measures

Demographics, weight and height at breast cancer diagnosis and LEAN enrollment, menopausal status, years since diagnosis, and breast cancer stage and treatment were obtained from participants by standard questionnaires at enrollment into the LEAN study.

Dietary patterns were measured using a 120-item food frequency questionnaire (FFQ) that was previously developed and validated against 4-Day Food Records and 24-hour Dietary Recalls for the Women's Health Initiative Study.[27] These values were compared to the Dietary Guidelines for Americans (DGA) recommendations[26] and the percent of study participants meeting DGA recommendations was calculated.

To examine change in dietary patterns, participants completed a 42-item LEAN questionnaire at the time of enrollment into LEAN that included 16 questions asking whether participants had increased, decreased, or made no change in various diet components (butter, caffeine, fast food, fat, fiber, fish, fruit, meat, olive oil, salt, soy, sugar, vegetables, vitamins and minerals, whole grain bread, and total calories) since the time of their breast cancer diagnosis.

Statistical Analysis

Descriptive statistics were completed for the study sample using the baseline LEAN questionnaire data. BMI was calculated from participants' self-reported height and weight measurements. Changes in BMI and body weight from breast cancer diagnosis to LEAN enrollment were calculated overall and stratified by BMI at the time of diagnosis. P-values of less than 0.05 for change in BMI and body weight from diagnosis to LEAN enrollment were considered significant.

Generalized linear models were used to determine marginal mean change in weight associated with change in consumption of each dietary component. Multivariate analyses included all changes in diet components as well as possible confounders (age, time since enrollment, cancer stage, treatment type, endocrine therapy, and menopausal status). Significance testing was done for average weight change for each combination of increase, decrease, and no change (increase vs. decrease; increase vs. no change; decrease vs. no change). P-values of less than 0.05 for difference in weight changes between consumption groups were considered significant.

All analyses were done using SAS 9.3.

RESULTS

Table 1 describes the demographic and prognostic information of the sample. The average age of participants was 59.0 ± 7.5 years and average time between diagnosis and enrollment into the LEAN study was 3.3 ± 2.1 years. The study population was well-educated (100% high school graduates), primarily postmenopausal (82% at diagnosis, 91% at enrollment), non-Latino (98%) white women (92%). Over half (53%) of participants had been diagnosed with stage I breast cancer, 85% had received some form of treatment after surgery, and 78% had used some form of endocrine therapy.

Table 2 shows weight and BMI at diagnosis of breast cancer and LEAN enrollment. Average weight increased by 2.3 ± 7.0 kg between diagnosis and LEAN enrollment, from 84.7 ± 19.2 kg at diagnosis to 87.0 ± 18.1 kg at enrollment (p for difference <0.001). BMI at diagnosis and LEAN enrollment were 31.5 ± 6.8 kg/m^2 and 32.4 ± 6.5 kg/m^2, respectively (p for difference <0.001). 92% of normal weight women, 93% of overweight women, and 40% of obese women gained weight between diagnosis and LEAN enrollment. Weight increased by a greater percentage and amount among normal weight women

(7.5 ± 4.2% weight gain; 4.7 ± 2.5 kg weight change) and overweight women (6.5 ± 5.0% weight gain; 4.7 ± 3.6 kg weight change) compared to obese women (-0.3 ± 9.6% weight gain; -0.5 ± 8.9 kg weight change), $p<0.05$.

Table 3 shows dietary data obtained from the Food Frequency Questionnaire completed by participants at LEAN enrollment and the corresponding DGA recommendations. Although the FFQ contained data on other dietary components, only those that were also present in the LEAN questionnaire were examined. The average total calories consumed by participants was 1805.3 ± 803.9 kCal per day which was somewhat higher than the DGA recommendation of 1600 kCal per day for sedentary women 51 years and older.[26,28] The consumption of fruits (1.5 ± 1.0 servings/day) and vegetables (2.7 ± 1.8 servings/day) was consistent with the DGA recommendations of 1.5 servings (1.5 cups) of fruit and 2-2.5 servings (2-2.5 cups) of vegetables per day.[26,28] However, the participants were consuming 66.5 ± 37.7 grams of fat per day, equivalent to 598.5 ± 339.3 calories from fat, which greatly exceeds the DGA recommended 120 calories from solid fats and added sugars combined per day.[26,28] The participants were also exceeding the recommended consumption of carbohydrates and protein (224.3 ± 108.9 g/day of carbohydrates compared to 75-90 g/day recommended; 74.8 ± 30.8 g/day of protein compared to 35 g/day recommended).[26,28,29]

Table 4 shows the unadjusted and adjusted average changes in weight as a function of changes in dietary components, assessed by dietary questions the baseline questionnaire. The associations differ slightly between the unadjusted and the adjusted models; however, the direction of the effects (increase or decrease in weight) remains largely consistent. Average weight change among those who increased consumption of total calories, fat (unadjusted model only), sugar, and fast food differed significantly ($p<0.05$) from those who decreased consumption of these components. In the adjusted model, an increase in total caloric consumption was associated with 5.1 ± 1.6 kg weight gain compared to a -0.8 ± 1.7 kg weight loss associated with a decrease in total calories ($p=0.018$). An increase in sugar was

associated with 7.2 ± 2.1 kg weight gain while a decrease was associated with a -1.0 ± 1.5 kg weight loss (p=0.004). An increase in fast food consumption was associated with an 11.4 ± 3.0 kg weight gain compared to a 0.9 ± 1.3 kg gain associated with a decrease in fast food consumption (p=0.002).

Similar, yet slightly attenuated, differences in weight changes from diagnosis to LEAN enrollment occurred between women who increased total caloric intake, sugar intake, and fast food consumption compared with women who made no change in consumption of these dietary components. This difference in weight change was also seen between women who decreased sugar intake compared to women who had no change in sugar intake.

DISCUSSION

This study examined changes in diet and weight after a breast cancer diagnosis. The results supported current research that the majority of breast cancer survivors experience weight gain in the years following diagnosis.[13-19] The amount of weight gained (2.3 ± 7.0 kg) and the demographic and prognostic characteristics of the study population were similar to thse of breast cancer survivors in other weight, diet, and nutrition studies.[13-16] Several studies have shown the impact of chemotherapy,[14-16] endocrine therapy,[16,18] age,[14,18,19] ethnicity,[18] menopausal status,[14,16,19] reduced physical activity,[19,24,25] and smoking status[18] on weight gain; however, this study is unique in looking at incidental post-diagnosis diet changes exclusively, outside of a weight-loss intervention trial.

As expected, some of the weight changes observed in this study were significantly associated with changes in diet composition among breast cancer survivors. There was substantial variability in diet changes among participants with changes occurring both in favorable and unfavorable directions for each component studied. Changes in diet components were categorized as favorable or unfavorable

based on DGA recommendations. Favorable changes included decreases in consumption of butter, fast food, meat, salt, sugar and total calories and increases in consumption of fiber, fish, fruit, olive oil, vegetables, vitamins and minerals, and whole grain bread.[26] Changes in the opposite direction were considered unfavorable.[26] Soy and caffeine were not categorized because there is no DGA recommendation for their intake. As hypothesized, weight loss or maintenance was associated with certain favorable changes in diet while weight gain was associated with certain unfavorable changes.

In this study, some "unfavorable" dietary changes were associated with significant weight gains compared to "favorable" dietary changes or no changes in dietary patterns. Specific dietary changes associated with weight gain were increases in total calories, sugar, fat, and fast food. Generally, breast cancer survivors who increased consumption of these components had significantly higher weight gain compared to participants who decreased or did not change consumption. While this association would be expected in any population, these results are particularly concerning because they demonstrate that some of the breast cancer survivors in this study increased consumption of these unfavorable diet components (total calories: 25%; sugar: 17%; fat: 11%; fast food 7%) despite the growing recognition that weight gain and unfavorable dietary patterns among breast cancer survivors are known to worsen prognosis. These participants saw significantly greater weight gain than participants who did not increase these unfavorable dietary components, suggesting that these factors may be of particular importance in leading to post-diagnosis weight gain. These unfavorable dietary changes could be due to participants not knowing the risks of post-diagnosis weight gain or the associations between these foods and weight gain or as an indirect result of their cancer diagnosis or treatment. For example, depressive symptoms that can occur after a cancer diagnosis are associated with changes in eating patterns[30] and chemotherapy can alter taste perception, potentially leading to increased consumption of sugar and strongly flavored foods.[31]

Conversely, significant weight loss was seen among participants who decreased total caloric intake and sugar intake compared to those who increased or did not change consumption, suggesting that a reduction in these components may be particularly useful in promoting weight management or weight loss among breast cancer survivors. This result is consistent with the DGA recommendation that successful weight management can be achieved through a decrease in total caloric intake, particularly through decreases in added sugars and solid fat intake.[26] Between diagnosis and LEAN enrollment 25% of participants decreased total caloric intake, 32% decreased sugar intake, 28% decreased fat intake, and 40% decreased fast food intake, demonstrating that the changes in diet composition of some participants aligned with this DGA recommendation. There is some evidence suggesting the feasibility of further decreasing these unfavorable diet components through dietary intervention. The Women's Intervention Nutrition Study (WINS) saw that a diet intervention was able to decrease participants' fat intake by about half, which led to a significant weight loss compared to women without dietary intervention (between group difference, 1.9 kg, $p<0.001$ at 1 year and 0.4 kg, $p=0.01$ at 7.5 years).[32,33]

Although there was not statistically significant weight loss among individuals who increased intake of fruits, vegetables, fiber, and other "favorable" dietary components in this study, the results demonstrated that some of the participants made changes toward more nutrient-dense diets which could have clinically significant results.[34] 49% and 42% of participants increased consumption of fruits and vegetables, respectively, and 28% increased dietary fiber intake. These changes are consistent with the DGA recommendations for improving diet quality and maintaining a healthy weight.[26]

Interestingly, the post-diagnosis weight gain was not seen consistently among the participants who were obese at diagnosis. Instead, obese individuals actually lost weight. Similar weak inverse relationships between BMI and weight gain have also been seen in other studies.[14,35] The lack of weight gain among women with a BMI > 30 kg/m^2 is favorable outcome, however the increased weight among normal and

overweight individuals is of particular concern because weight gain among these BMI groups is associated with worse breast cancer outcomes.[14]

Because this study was retrospective and relied on data previously collected as part of the LEAN study, some variables that would have been of interest were not available. For example, due to the lack of measured weight at diagnosis self-reported weight was used throughout the study. Based on self-report, 3% of the study population was normal weight (BMI < 25) at LEAN enrollment, however based on BMIs calculated from measured height and weight at LEAN enrollment, all of the subjects were overweight or obese, suggesting that self-reported weight was not entirely accurate. However other studies have suggested that self-reported weight is consistently underreported but only by a small amount, so the errors due to self-reported weight may be small.[14,17,36]

Similarly, the self-reported nature of the dietary data likely resulted in overestimation of healthy diet components and underestimation of unhealthy components. However, because these reporting errors were most likely consistent across participants, and because the FFQ has been validated, these errors were likely small as well. The fact that diet change data was recorded as increase, decrease, or no change may have invited some reporting bias, but participants' recall of conscious changes in dietary trends may be more likely to be accurate than estimates of specific consumption amounts of dietary components.

Other studies have shown associations between post-diagnosis weight gain and prognostic factors, including cancer stage, menopausal status, and cancer treatment.[14-16,18] Although these factors were adjusted for in this analysis, it may have been useful to have more in depth looks at these variables, particularly because when examining treatment and diet together, Demark-Wahnefried et al. observed no association between total caloric intake and post-diagnosis weight gain.[37] Another limitation of this study was the lack of adjustment for multiple comparisons in the statistical analysis. A larger sample

size in combination with more complex statistical analysis and detailed information on variables would create a more comprehensive picture of dietary factors influencing post-diagnosis weight change.

Despite attempts to control for demographic factors, the study population may not be generalizable to all breast cancer survivors. This study population was highly educated and predominantly non-Hispanic white women. All participants in this study were overweight or obese as measured at enrollment and there may have been some self-selection bias present as a function of the LEAN study attracting individuals willing to undergo lifestyle and diet changes. Past studies have seen consistency in weight gain between breast cancer survivors enrolled into lifestyle intervention trials and breast cancer survivors enrolled into observational studies, however, so this self-selection bias may not have large negative effects on external validity.[14]

This study included a longer average (3.3 ± 2.1 years) and wider range (0.6 to 13.5 years) of time post-diagnosis than most other studies of weight gain among breast cancer survivors.[13] It would have been useful to have more data point between participants' cancer diagnosis and LEAN enrollment in order to see whether participants experienced weight fluctuations rather than consistent gain or loss. However, the range and average time between diagnosis and enrollment for participants was appropriate in that post-diagnosis weight gain is thought to occur and accumulate both short- and long-term after diagnosis.[14,16]

In conclusion, this study confirms the need for weight management programs for breast cancer survivors of all BMI levels. Because many of the predictors of weight gain among breast cancer survivors cannot easily be modified (treatment, age, menopausal status), lifestyle behavioral interventions seem to be an ideal approach.[12,19,38] The fact that this study shows weight changes associated with changing diet factors points to the potential for successful weight loss and weight management among breast cancer survivors through dietary intervention. The WINS and WHEL studies showed changes in diet without

weight loss to not be effective in improving prognosis, suggesting the importance of addressing weight change specifically.[24] This study suggests that decreasing consumption of unhealthy dietary components – e.g. fat, sugar and fast food—as a part of a reduction in total caloric intake may be particularly effective in promoting weight management and weight loss among breast cancer survivors. In order to maintain diet quality, however, increasing consumption fruits and vegetables is also recommended.[26] The dietary components considered in this study undoubtedly need to be studied in more depth, with a larger, more diverse population, but this study suggests further research is warranted.

WORKS CITED

1. *United States Cancer Statistics: 1999-2010 Incidence and Mortality Web-based Report.* Online: Department of Health and Human Services, Centers for Disease Control and Prevention;2013.
2. Kulie T, Slattengren A, Redmer J, Counts H, Eglash A, Schrager S. Obesity and women's health: an evidence-based review. *Journal of the American Board of Family Medicine : JABFM.* Jan-Feb 2011;24(1):75-85.
3. DeSantis C, Ma J, Bryan L, Jemal A. Breast cancer statistics, 2013. *CA: a cancer journal for clinicians.* Jan-Feb 2014;64(1):52-62.
4. Flegal KM, Graubard BI, Williamson DF, Gail MH. Cause-specific excess deaths associated with underweight, overweight, and obesity. *JAMA : the journal of the American Medical Association.* Nov 7 2007;298(17):2028-2037.
5. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009-2010. *NCHS data brief.* Jan 2012(82):1-8.
6. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report.* Online: National Heart, Lung, and Blood Institute;1998.
7. Gilbert CA, Slingerland JM. Cytokines, obesity, and cancer: new insights on mechanisms linking obesity to cancer risk and progression. *Annual review of medicine.* 2013;64:45-57.
8. Carmichael AR. Obesity as a risk factor for development and poor prognosis of breast cancer. *BJOG : an international journal of obstetrics and gynaecology.* Oct 2006;113(10):1160-1166.
9. Lahmann PH, Hoffmann K, Allen N, et al. Body size and breast cancer risk: findings from the European Prospective Investigation into Cancer And Nutrition (EPIC). *Int J Cancer.* Sep 20 2004;111(5):762-771.
10. Patterson RE, Rock CL, Kerr J, et al. Metabolism and breast cancer risk: frontiers in research and practice. *J Acad Nutr Diet.* Feb 2013;113(2):288-296.
11. Carmichael AR. Obesity and prognosis of breast cancer. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* Nov 2006;7(4):333-340.
12. Demark-Wahnefried W, Campbell KL, Hayes SC. Weight management and its role in breast cancer rehabilitation. *Cancer.* Apr 15 2012;118(8 Suppl):2277-2287.
13. Vance V, Mourtzakis M, McCargar L, Hanning R. Weight gain in breast cancer survivors: prevalence, pattern and health consequences. *Obesity reviews : an official journal of the International Association for the Study of Obesity.* Apr 2011;12(4):282-294.
14. Rock CL, Flatt SW, Newman V, et al. Factors associated with weight gain in women after diagnosis of breast cancer. Women's Healthy Eating and Living Study Group. *Journal of the American Dietetic Association.* Oct 1999;99(10):1212-1221.
15. Tredan O, Bajard A, Meunier A, et al. Body weight change in women receiving adjuvant chemotherapy for breast cancer: a French prospective study. *Clin Nutr.* Apr 2010;29(2):187-191.
16. Heideman WH, Russell NS, Gundy C, Rookus MA, Voskuil DW. The frequency, magnitude and timing of post-diagnosis body weight gain in Dutch breast cancer survivors. *Eur J Cancer.* Jan 2009;45(1):119-126.
17. Kroenke CH, Chen WY, Rosner B, Holmes MD. Weight, weight gain, and survival after breast cancer diagnosis. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology.* Mar 1 2005;23(7):1370-1378.
18. Sedjo RL, Byers T, Ganz PA, et al. Weight gain prior to entry into a weight-loss intervention study among overweight and obese breast cancer survivors. *Journal of cancer survivorship : research and practice.* Mar 6 2014.
19. Irwin ML, McTiernan A, Baumgartner RN, et al. Changes in body fat and weight after a breast cancer diagnosis: influence of demographic, prognostic, and lifestyle factors. *Journal of clinical*

oncology : official journal of the American Society of Clinical Oncology. Feb 1 2005;23(4):774-782.
20. George SM, Irwin ML, Smith AW, et al. Postdiagnosis diet quality, the combination of diet quality and recreational physical activity, and prognosis after early-stage breast cancer. *Cancer Causes Control.* Apr 2011;22(4):589-598.
21. Ogden CL, Carroll MD, McDowell MA, Flegal KM. Obesity among adults in the United States--no statistically significant chance since 2003-2004. *NCHS data brief.* Nov 2007(1):1-8.
22. Prentice RL, Caan B, Chlebowski RT, et al. Low-fat dietary pattern and risk of invasive breast cancer: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. *JAMA : the journal of the American Medical Association.* Feb 8 2006;295(6):629-642.
23. Pakiz B, Flatt SW, Bardwell WA, Rock CL, Mills PJ. Effects of a weight loss intervention on body mass, fitness, and inflammatory biomarkers in overweight or obese breast cancer survivors. *Int J Behav Med.* Dec 2011;18(4):333-341.
24. Kampman E, Vrieling A, van Duijnhoven FJ, Winkels RM. Impact of Diet, Body Mass Index, and Physical Activity on Cancer Survival. *Current nutrition reports.* 2012;1:30-36.
25. Irwin ML, Crumley D, McTiernan A, et al. Physical activity levels before and after a diagnosis of breast carcinoma: the Health, Eating, Activity, and Lifestyle (HEAL) study. *Cancer.* Apr 1 2003;97(7):1746-1757.
26. *Dietary Guidelines for Americans & Supplementary Materials at http://www.cnpp.usda.gov/DGAs2010-DGACReport.htm.* Online: U.S. Department of Agriculture and U.S. Department of Health and Human Services;2010.
27. Patterson RE, Kristal AR, Tinker LF, Carter RA, Bolton MP, Agurs-Collins T. Measurement characteristics of the Women's Health Initiative food frequency questionnaire. *Annals of epidemiology.* Apr 1999;9(3):178-187.
28. Agriculture USDo. Choose My Plate. 2014.
29. *Exchange Lists for Meal Planning.* The American Diabetes Association and the American Dietetic Association;1995.
30. Rock CL, McEligo, A. J., Flatt, S. W., Sobo, E. J., Wilfley, D. E., Jones, V. E., Hollenback, K. A., Marx, R. D. Eating Pathology and Obesity in Women at Risk for Breast Cancer Recurrence. *International Journal of Eating Disorders.* 1998;27(2).
31. Speck RM, DeMichele A, Farrar JT, et al. Taste alteration in breast cancer patients treated with taxane chemotherapy: experience, effect, and coping strategies. *Supportive care in cancer : official journal of the Multinational Association of Supportive Care in Cancer.* Feb 2013;21(2):549-555.
32. Howard BV, Manson JE, Stefanick ML, et al. Low-fat dietary pattern and weight change over 7 years: the Women's Health Initiative Dietary Modification Trial. *JAMA : the journal of the American Medical Association.* Jan 4 2006;295(1):39-49.
33. Parry BM, Milne JM, Yadegarfar G, Rainsbury RM. Dramatic dietary fat reduction is feasible for breast cancer patients: Results of the randomised study, WINS (UK) - stage 1. *European journal of surgical oncology : the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology.* Oct 2011;37(10):848-855.
34. Demark-Wahnefried W, Rock CL. Nutrition-related issues for the breast cancer survivor. *Seminars in oncology.* Dec 2003;30(6):789-798.
35. Wang JS, Cai H, Wang CY, Zhang J, Zhang MX. Body weight changes in breast cancer patients following adjuvant chemotherapy and contributing factors. *Molecular and clinical oncology.* Jan 2014;2(1):105-110.
36. Spencer EA, Appleby PN, Davey GK, Key TJ. Validity of self-reported height and weight in 4808 EPIC-Oxford participants. *Public health nutrition.* Aug 2002;5(4):561-565.

37. Demark-Wahnefried W, Peterson BL, Winer EP, et al. Changes in weight, body composition, and factors influencing energy balance among premenopausal breast cancer patients receiving adjuvant chemotherapy. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology.* May 1 2001;19(9):2381-2389.
38. Rock CL, Demark-Wahnefried W. Nutrition and survival after the diagnosis of breast cancer: a review of the evidence. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology.* Aug 1 2002;20(15):3302-3316.

Table 1. Characteristics of the LEAN study population (N=100)

Characteristic	Mean ± standard deviation or %
Age (years)	59.0 ± 7.5
Ethnicity (%)	
Latino	2
Non-Latino	98
Race (%)	
White	92
Black or African American	7
Other	1
Education (%)	
High school graduate	8
Some college or vocational	26
College graduate	66
Cancer stage at diagnosis (%)	
In situ	16
Stage 1	53
Stage 2	25
Stage 3	7
Treatment after surgery	
No radiation or chemotherapy	15
Radiation	36
Chemotherapy	22
Both radiation and chemotherapy	27
Taking endocrine therapy at LEAN enrollment (%)	
No endocrine therapy	22
Tamoxifen	24
Aromatase inhibitor	54
Menopausal status at diagnosis (%)	
Premenopausal	18
Postmenopausal	82
Menopausal status at enrollment (%)	
Premenopausal	9
Postmenopausal	91
Time between diagnosis and LEAN enrollment (years)	3.3 ± 2.1

Table 2. BMI and weight characteristics of the LEAN study population (N=100); mean ± SD

Characteristic	Diagnosis	Enrollment	Change in weight between diagnosis and enrollment (kg)
Weight (kg)	84.7 ± 19.2	87.0 ± 18.1	2.3 ± 7.0*
BMI (kg/m^2)	31.5 ± 6.8	32.4 ± 6.5	0.9 ± 2.7*
Gaining weight, n (%)	69 (69)		
BMI			
Normal weight (BMI < 25), n (%)	12 (12)	3 (3)	
Weight (kg)	64.0 ± 4.3	67.1 ± 3.2	4.7 ± 2.5*
Gaining weight, n (%)	11 (92)		
% of weight gained		7.5 ± 4.2	
Overweight (≥ 25 BMI <30), n (%)	42 (42)	43 (43)	
Weight (kg)	73.7 ± 6.9	75.4 ± 7.8	4.7 ± 3.6*
Gaining weight, n (%)	40 (93)		
% of weight gained		6.5 ± 5.0	
Obese (BMI≥ 30), n (%)	46 (46)	54 (54)	
Weight (kg)	100.1 ± 17.1	97.4 ± 17.9	-0.5 ± 8.9*
Gaining weight, n (%)	29 (41)		
% of weight gained		-0.3 ± 9.6	

*p<0.05 comparing diagnosis and enrollment

Table 3. Average diet characteristics at enrollment (N=100)

Dietary Component	Mean ± SD[a]	DGA Recommended Consumption[b]	% Below DGA Recommendations (N=100) [a]
Total Calories (kCal/day)	1805.3 ± 803.9	1600.0-1800.0[c]	45%
Carbohydrates (g/day)	224.3 ± 108.9	75-90[d]	6%
Protein (g/day)	74.8 ± 30.8	35.0[e]	9%
Fat (g/day)	66.5 ± 37.7	13.3-30.0[f]	1%
Fruit (servings/day)	1.5 ± 1.0	1.5	53%
Vegetables (servings/day)	2.7 ± 1.8	2.0-2.5	37%
Fiber (g/day)	21.1 ± 9.7	N/A	N/A
Cholesterol (mg/day)	237.6 ± 143.8	< 300.0 mg/day	74%
Caffeine (mg/day)	182.0 ± 124.3	N/A	N/A

[a] Selected components from Food Frequency Questionnaire[27]
[b] Dietary Guidelines for Americans[26]
[c] 1800 kCal/day for sedentary women 31-50 years old; 1600 kCal/day for sedentary women 51+ years old
[d] 5-6 "ounce-equivalents" of carbohydrate = 75-90 g of carbohydrate; ½ of this daily consumption should be whole grains[29]
[e] "5 ounce-equivalents" of protein = approx. 35 grams of protein[29]
[f] 120 calories recommended for total "empty calories" (fat and added sugar)

Table 4. Changes in diet characteristics and weight from diagnosis to LEAN enrollment (N=100), mean ± SE

Food Item	Increase	Decrease	No Change
Total Calories			
n (% of study population)	25 (25)	23 (23)	50 (51)
Average change in weight (kg)	5.4 ± 1.3	-1.2 ± 1.4*[1]	2.4 ± 0.9*[3]
Adjusted average change in weight (kg)[a]	5.1 ± 1.6	-0.8 ± 1.7*[1]	2.7 ± 1.1
Meat			
n (% of study population)	8 (8)	35 (35)	56 (57)
Average weight change (kg)	4.0 ± 2.5	1.0 ± 1.2	2.9 ± 0.9
Adjusted weight change: (kg)[a]	1.8 ± 2.8	2.1 ± 1.6	2.8 ± 1.1
Fish			
n (% of study population)	27 (27)	11 (11)	62 (62)
Average weight change (kg)	2.2 ± 1.3	6.0 ± 2.1	1.7 ± 0.9
Adjusted weight change: (kg)[a]	2.4 ± 1.6	5.6 ± 2.3	1.9 ± 1.0
Fat			
n (% of study population)	11 (11)	28 (28)	60 (61)
Average weight change (kg)	5.2 ± 2.1	0.1 ± 1.3*[1]	2.9 ± 0.9
Adjusted weight change: (kg)[a]	2.6 ± 2.7	0.5 ± 1.6	3.3 ± 1.0
Fruit			
n (% of study population)	49 (49)	5 (5)	46 (46)
Average weight change (kg)	1.3 ± 1.0	4.8 ± 3.1	3.1 ± 1.0
Adjusted weight change: (kg)[a]	1.8 ± 2.2	6.0 ± 6.7	8.0 ± 2.2
Vegetables			
n (% of study population)	42 (42)	4 (4)	54 (54)
Average change in weight (kg)	2.6 ± 1.1	5.0 ± 3.5	1.9 ± 1.0
Adjusted average change in weight (kg)[a]	3.5 ± 1.4	3.1 ± 4.1	1.6 ± 1.2
Fiber			
n (% of study population)	29 (28)	4 (4)	76 (68)
Average weight change (kg)	0.9 ± 1.3	3.9 ± 3.5	2.9 ± 0.9
Adjusted weight change: (kg)[a]	-4.1 ± 1.6	4.3 ± 4.3	3.5 ± 0.9
Caffeine			
n (% of study population)	12 (12)	19 (19)	69 (69)
Average weight change (kg)	1.7 ± 2.0	<0.1 ± 1.6	3.1
Adjusted weight change: (kg)[a]	1.1 ± 2.4	-0.5 ± 1.8	3.6 ± 0.9
Salt			
n (% of study population)	5 (5)	24 (24)	71 (71)
Average change in weight (kg)	6.5 ± 3.1	1.1 ± 1.4	2.4 ± 0.8
Adjusted average change in weight (kg)[a]	6.3 ± 3.6	1.6 ± 1.6	2.5 ± 0.9
Sugar			
n (% of study population)	17 (17)	32 (32)	51 (51)
Average change in weight (kg)	6.3 ± 1.6	-0.5 ± 1.2*[1]	2.7 ± 0.9*[3]
Adjusted average change in weight (kg)[a]	7.2 ± 2.1	-1.0 ± 1.5*[1]	2.9 ± 1.0*[3]

Food Item	Increase	Decrease	No Change
Whole Grain Bread			
n (% of study population)	25 (25)	18 (18)	57 (57)
Average change in weight (kg)	3.9 ± 1.4	1.3 ± 1.6	2.0 ± 0.9
Adjusted average change in weight (kg)[a]	4.6 ± 1.8	1.4 ± 2.0	1.8 ± 1.1
Vitamin/Minerals			
n (% of study population)	54 (54)	4 (4)	41 (41)
Average change in weight (kg)	2.3 ± 1.0	-0.6 ± 3.5	2.7 ± 1.1
Adjusted average change in weight (kg)[a]	1.9 ± 1.0	0.8 ± 3.9	3.4 ± 1.2
Butter			
n (% of study population)	4 (4)	20 (20)	76 (76)
Average weight change (kg)	4.0 ± 3.5	0.6 ± 1.6	2.7 ±0.8
Adjusted weight change: (kg)[a]	-0.7 ± 4.8	1.2 ± 2.0	2.9 ± 1.0
Olive Oil			
n (% of study population)	25 (25)	5 (5)	70 (70)
Average change in weight (kg)	3.8 ± 1.4	-0.5 ± 3.1	2.0 ± 0.8
Adjusted average change in weight (kg)[a]	3.6 ± 1.7	2.1 ± 3.5	2.1 ± 0.9
Soy			
n (% of study population)	5 (5)	24 (25)	75 (69)
Average change in weight (kg)	2.4 ± 3.1	3.3 ± 1.4	2.3 ± 0.9
Adjusted average change in weight (kg)[a]	2.1 ± 3.4	2.0 ± 1.9	2.7 ± 0.9
Fast Food			
n (% of study population)	7 (7)	40 (40)	52 (52)
Average weight change (kg)	10.5 ± 2.4	1.0 ± 1.1*[1]	2.2 ± 0.9*[2]
Adjusted weight change: (kg)[a]	11.4 ± 3.0	0.9 ± 1.3*[1]	2.4 ± 1.1*[2]

[a] Full adjusted model (includes all diet components, age, cancer stage at diagnosis, treatment, endocrine replacement therapy, menopausal status at diagnosis, time between diagnosis and LEAN enrollment)

*[1]$p<0.05$ comparing increase and decrease

*[2]$p<0.05$ comparing increase and no change

*[3]$p<0.05$ comparing decrease and no change

ACKNOWLEDGEMENTS

I would like to thank my two thesis readers, Dr. Melinda Irwin and Dr. Brian Leaderer for their support and guidance throughout the thesis writing process. In particular, I thank Dr. Irwin for providing me with access to her LEAN study data as well as her generous assistance in developing and carrying out my project plan, her help troubleshooting various issues in the statistical analysis, and her detailed, meaningful comments on my drafts. I would also like to thank Maura Harrigan and Dr. Brenda Cartmel who kindly reviewed and provided helpful feedback on my project and my friends and family who took the time to read and edit numerous drafts throughout the writing process.