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Research Article

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Weight Change in Breast Cancer Survivors Compared to Cancer-Free Women: A Prospective Study in Women at Familial Risk of Breast Cancer

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Abstract

Background: This study prospectively examines weight gain in breast cancer survivors compared with cancer-free women from a familial risk cohort.

Methods: Absolute and percent weight change over 4 years was compared among 303 breast cancer survivors and 307 cancer-free women matched on age and menopausal status, from the same familial risk cohort. Linear and logistic regression was used to estimate the association between survivor status and weight gain.

Results: Overall, breast cancer survivors gained significantly more weight [β = 3.06 pounds; 95% confidence intervals (CI), 0.94–5.17] than cancer-free women. Significant weight gain was observed in survivors diagnosed less than 5 years prior to baseline (β = 3.81 pounds; 95% CI, 1.22–6.29) and women with estrogen receptor (ER)-negative tumors (β = 7.26 pounds; 95% CI, 2.23–12.30). Furthermore, survivors treated with chemotherapy were 2.1 times more likely to gain at least 11 pounds during follow-up compared with cancer-free women (OR, 2.10; 95% CI, 1.21–3.63). Weight gain was even greater among survivors who took statins while undergoing chemotherapy treatment ($P_{interaction} = 0.01$).

Conclusion: This is the first study to demonstrate that weight gain is an important issue in breast cancer survivors with a familial risk. In the first five years posttreatment, breast cancer survivors gain weight at a faster rate than cancer-free women, particularly after chemotherapy and statin use but not after hormone therapy alone.

Impact: Our findings provide support for the development of weight gain interventions for young breast cancer survivors with a familial risk. *Cancer Epidemiol Biomarkers Prev; 24(8); 1262–9. ©2015 AACR.*

Introduction

Weight gain after breast cancer diagnosis has been commonly reported in studies of breast cancer survivors (1), although comparisons to cancer-free women are limited. It is still unclear whether breast cancer survivors gain more weight than their cancer-free peers over the same period of time and to what degree factors such as early menopause or age confound this association. In cancer-free women, adult weight gain is an established risk factor for postmenopausal breast cancer (2–4) and has been associated with increased risk for cardiovascular disease and diabetes (5, 6). In studies among breast cancer survivors alone, the frequency of weight gain ranges from 27% to 100%, and is on average between 1 kg and 6 kg, over a follow-up time of a few months to 7 years (1). Younger age at diagnosis and/or earlier age at menopause, and receipt of adjuvant chemotherapy, appear to increase risk for weight gain (7, 8).

Among survivors, weight gain and higher body mass index (BMI) have been associated with an increased risk for a second primary cancer (9) and weight gain has been shown to increase risk for breast cancer recurrence (10–12). Notably, chemotherapy is the treatment most consistently associated with weight gain in survivors and may be due to a reduction in physical activity (13, 14) or metabolic disturbances such as insulin resistance (15–17) and increased inflammation (18, 19). Only two studies, with mixed results, have compared weight gain in survivors with cancer-free women (20, 21).

Survivors with a family history of breast cancer are a distinct subset of the breast cancer survivor population that has been less studied. Comprising about 20% of survivors, they are often diagnosed at a young age or with hormone-negative tumors and may undergo early menopause due to chemotherapy or ovarian suppression/removal (22, 23). Compared with older survivors, they are also more likely to experience depression (24), a risk factor for weight gain. On the other hand, these women are highly motivated when it comes to cancer screening, as they are at a higher risk of a second breast cancer (25).

In this study, we examine whether breast cancer survivors with a familial risk, experience a greater weight gain trajectory postdiagnosis compared with women without cancer.

Materials and Methods

Study participants

The Breast and Ovarian Surveillance Service (BOSS) Cohort Study is an ongoing prospective study consisting of women and

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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men with a familial risk for breast and/or ovarian cancer, recruited in 2005–2013 from the cancer genetics clinic at the Johns Hopkins Sidney Kimmel Comprehensive Cancer Center (Baltimore, MD). At enrollment, after informed consent was obtained, participants were asked to complete an extensive baseline questionnaire on demographic characteristics, weight, height, lifestyle factors, including physical activity, and breast cancer risk factors, cancer history and treatments, and medication use. A detailed family history and plasma, serum, and DNA samples were obtained at this time. Follow-up questionnaires are administered every 3 to 4 years and have been completed for >90% of participants enrolled between 2005 and 2010. All cancer diagnoses were based on pathology records and all treatment information was confirmed by medical record.

Study eligibility

Women who had enrolled in the cohort, completed a baseline questionnaire, and at least 1 follow-up questionnaire through December 31, 2013 were included in the study ($n = 938$). In addition, women had to have either: (i) a family history of breast or ovarian cancer, (ii) a documented deleterious *BRCA1/2* mutation, or (iii) a diagnosis of breast cancer at age $\leq$40 years, and (iv) provided height and weight on baseline questionnaire ($n = 911$). Survivors were eligible if they had a personal history of breast cancer (ductal carcinoma *in situ* or stage I-III breast cancer) treated with surgery at any time prior to baseline ($n = 303$). Eligible cancer-free women based on the study inclusion criteria were frequency matched to survivors on age and menopausal status ($n = 307$), to ensure a similar distribution of these strong confounding factors between the two groups.

Statistical analysis

Baseline characteristics of survivors and cancer-free women were compared using *t* tests for normally distributed continuous variables and Wilcoxon rank-sum test for continuous variables without a normal distribution. Categorical variables were compared using the χ^2 or Fisher exact tests.

Figure 1 outlines the study design. Survivor status was stratified by the time (in years) that had elapsed between breast cancer diagnosis and baseline questionnaire completion; two categories were defined by clinically relevant milestones in relation to recurrence risk: $\leq$5 years or >5 years (26). Absolute weight change was calculated by subtracting baseline weight (T_1) from follow-up weight (T_2) for both survivors and cancer-free women. In addition, weight change was defined as percent weight change (follow-up weight − baseline weight/baseline weight) × 100, and as a binary outcome: weight gain of less than/greater than 5 kg. In a subset of participants, Pearson correlation coefficient was used to calculate correlation between baseline weight and clinic-measured weight ($n = 81$).

Multivariable linear regression models were used to estimate the association of survivor status and change in weight. Logistic regression was used to estimate the association of survivor status with weight gain of $\geq$5 kg or <5 kg, and $\geq$5% or <5% weight gain. Potential confounders such as age, baseline BMI, enrollment year, menopausal status, statin use, and baseline physical activity (measured by metabolic equivalence tasks; MET; ref. 27) were included in adjusted models. Women who had a hysterectomy alone (i.e., without oophorectomy) before menopause ($n = 53$) were assigned a menopausal age of 50 years, based on the mean age of natural menopause among cancer-free women. Stratified models were used to examine if the association between survivor status and change in weight differed by estrogen receptor (ER) tumor status, menopausal status at diagnosis versus baseline (premenopausal at both diagnosis and baseline; premenopausal at diagnosis and postmenopausal at baseline, or postmenopausal at diagnosis), and according to breast cancer treatment category. An interaction term between family history and survivor status was included in the main models to account for modest differences in the family history of women with and without breast cancer that are seen in high-risk clinics. Interaction terms were added to multivariable models to test for potential interactions between baseline BMI category (18.5–25 kg/m^2 and $\geq$25 kg/m^2) and survivor status on weight gain, as well as between statin use and survivor status on weight gain. The Wald test was used to evaluate statistical significance of all interaction terms. All analyses were performed using Stata (version 13; StataCorp LP).

Results

The baseline characteristics and matching factors are described in Table 1. The average age of survivors and menopausal status was similar between the two groups. Twenty-five percent of both groups were premenopausal. Age at menopause was younger than in the general population (28), but did not differ significantly between groups, with a mean of 48.0 years in survivors and 48.9

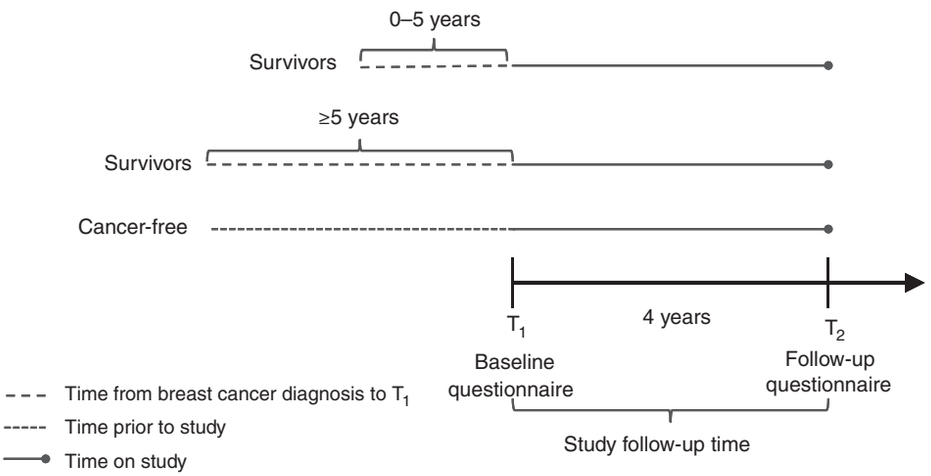

Figure 1.
Study design schematic for timing of weight gain assessment among breast cancer survivors.

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Table 1. Baseline and follow-up characteristics of cancer-free women and breast cancer survivors from the BOSS Cohort Study

	Cancer-free ($n = 307$)	Survivors ($n = 303$)	*P*
Age, mean y (SD)	53.8 (11.2)	54.0 (9.9)	0.8
Menopausal status, %			0.69
Premenopausal	26.7	25.1	
Postmenopausal, nonsurgical	55.7	59.1	
Postmenopausal, surgical	17.6	15.8	
Age at menopause, mean y (SD)	48.9 (6.6)	48.0 (5.3)	0.11
Race, %			0.39
Black	5.2	4.6	
White	93.2	92.1	
Other	1.6	3.3	
Education, 4-year college or greater, %	73.6	75.8	0.55
BRCA status[a], %			0.24
Negative	64.7	71.3	
Positive	34.5	26.7	
Variant of uncertain significance	0.9	2.1	
BMI category (kg/m^2)			0.22
Normal (18.5–24.9)	43.3	51.5	
Overweight (25–30)	34.2	30.4	
Obese ($\geq$30)	20.9	16.5	
BMI category at age 16 y (kg/m^2)			0.09
Normal (18.5–24.9)	73.4	71.4	
Overweight (25–30)	5.4	2.1	
Obese ($\geq$30)	0.3	1.1	
Missing	3.3	6.6	
Physical activity at baseline, mean MET-h/wk (SD)	27.3 (30.1)	25.5 (31.8)	0.47
Physical activity at baseline: $\geq$8.3 MET-h/wk[b], %	71.7	68.3	0.37
Hypothyroid disease, %	15	11	0.28
Diabetes, %	6.5	5	0.41
High cholesterol, %	35.8	33.3	0.81
Statins[c] ever use, %	22.8	19.8	0.37
Duration of statin use, mean y (SD)	6.6 (5.9)	5.1 (4.7)	0.13
Age at breast cancer diagnosis, mean y (SD)	—	48.2 (9.9)	—
Time from diagnosis to baseline, mean y (SD)	—	5.6 (6.5)	—
Invasive cancer (stage I–III), %	—	81.9	—
Estrogen receptor status[d], %			
Positive	—	70.6	—
Negative	—	23.4	—
Missing/untested	—	6.3	—
Triple-negative breast cancer[e], %	—	15.9	
Breast cancer treatment, %			
Surgery	—	100	—
Hormonal therapy	—	68	—
Radiation	—	53.8	—
Chemotherapy, any	—	51.5	—
Chemotherapy, by regimen, %			
AC		27.1	
AC-T, TAC, AC-TH		44.3	
Other[f]		28.6	

Abbreviations: AC, doxorubicin plus cyclophosphamide; AC-T, doxorubicin plus cyclophosphamide followed by paclitaxel; TAC, docetaxel, doxorubicin, and cyclophosphamide; AC-TH, doxorubicin plus cyclophosphamide followed by paclitaxel plus trastuzumab.

[a]Among women who were tested, $n = 356$.

[b]Meeting or exceeding physical activity recommendations of American Heart Association (29).

[c]Statins includes: atorvastatin, lovastatin, pravastatin, rosuvastatin, simvastatin, and ezetimibe/simvastatin.

[d]Among invasive cases only ($n = 248$).

[e]Among invasive cases diagnosed in 2003 or later.

[f]Other regimens includes: 5-fluorouracil, epirubicin, plus cyclophosphamide; docetaxel plus cyclophosphamide; docetaxel, carboplatin, and trastuzumab; cyclophosphamide, methotrexate, and 5-fluourouracil; and 5-fluourouracil, doxorubicin and cyclophosphamide.

years in cancer-free women. *BRCA1/2* mutation carrier status among those tested ($n = 357$) was similar between groups. Sixty-eight percent of survivors and 72% of cancer-free women reported baseline physical activity levels that met American College of Sports Medicine and the American Heart Association recommendations at baseline (at least 500 MET-minutes, or 8.3 MET-hours per week; ref. 29). BMI category at T_1 did not differ between groups, nor did the proportion of women who were overweight or obese at T_1 or age 16. Statin use was reported by 19.8% of survivors and 22.8% of cancer-free women; duration of statin use did not differ significantly between groups.

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Half of all survivors reported receiving chemotherapy, and approximately two-thirds received hormonal therapy (Table 1). In addition to self-reported weight, we also had information on measured weight obtained from clinic visits within 3 months of T_1 for 81 survivors. There was a high correlation between the self-reported and measured weight, irrespective of time since diagnosis ($r = 0.98$).

In age-adjusted linear regression models, survivors had a higher mean weight gain than cancer-free women ($\beta = 2.84$ pounds; 95% CI, 0.75–4.93). This difference persisted in multivariable models ($\beta = 3.24$ pounds; 95% CI, 0.63–5.85) after adjusting for age, menopausal status, BMI at T_1, enrollment year, statin use, physical activity, and family history (Fig. 2A). In analyses stratified by time since diagnosis, a significant weight gain of 3.81 more pounds (95% 1.33–6.29) was observed in women diagnosed with breast cancer in the last 5 years only. In survivors diagnosed with ER-negative invasive disease, weight gain was also significantly greater than in cancer-free women ($\beta = 4.45$ pounds; 95% CI, 0.45–8.45). The greatest weight gain was seen in survivors diagnosed with ER-negative invasive breast cancer in the past 5 years compared with cancer-free women ($\beta = 7.26$ pounds; 95% CI, 2.23–12.30; Fig. 2C). This same pattern was not observed in ER-positive invasive breast cancer survivors, for whom modest weight gain persisted over time (Fig. 2B).

In logistic regression models, survivors diagnosed less than 5 years prior to T_1 were twice as likely as cancer-free women to have gained at least 11 pounds over follow-up, (OR, 2.07; 95% CI, 1.22–3.50), whereas survivors diagnosed >5 years prior to T_1 had no significantly increased risk (Table 2). To compare our findings with other studies, we also evaluated association based on a 5% weight gain. Survivors diagnosed with breast cancer within 5 years prior to T_1 had a 66% increased risk for gaining at least 5% of their baseline weight. Of note, sensitivity analyses, excluding survivors who had been diagnosed with a new primary cancer ($n = 77$), yielded similar results to the main analyses.

Next, we examined weight gain in survivors versus cancer-free women, stratified by menopausal status at diagnosis. Premenopausal survivors gained significantly more weight than premenopausal cancer-free women ($P = 0.03$); particularly those women diagnosed in the 5 years prior to T_1 ($\beta = 5.55$ pounds; 95% CI, 1.13–9.98; Fig. 2D). Survivors who were postmenopausal at time of diagnosis gained 4.17 more pounds (0.71–7.63) than postmenopausal cancer-free women over follow-up (Fig. 2F). There was no difference in weight gain in survivors who became postmenopausal after diagnosis compared with postmenopausal cancer-free women (Fig. 2E).

We then evaluated the effect of treatment on weight gain. Significant weight gain was seen in survivors who had received adjuvant chemotherapy ± hormone therapy ($\beta = 4.26$; 95% CI, 1.49–7.02) when compared with cancer-free women. Treatment with chemotherapy alone was associated with even greater weight gain (7.86; 95% CI, 1.85–13.87; pounds). Survivors treated with chemotherapy within 5 years prior to T_1 gained 5.58 (95% CI, 2.13–9.03) more pounds than cancer-free women, whereas no significant weight gain was observed in survivors treated with chemotherapy more than 5 years prior to T_1 (Table 3). Weight gain in survivors who had received hormone therapy alone, or surgery alone, did not differ significantly from that seen in cancer-free women.

Among women who were overweight/obese at T_1, survivors appeared to have a more sustained weight gain over time compared with cancer free women (Fig. 3A and B). This was observed particularly among chemotherapy-treated survivors (Fig. 3C and D), and not among survivors receiving hormonal therapy alone (Fig. 3E and F). We were unable to evaluate the effect of chemotherapy versus hormone therapy alone on weight gain among survivors, as there was very little overlap in predictors of each

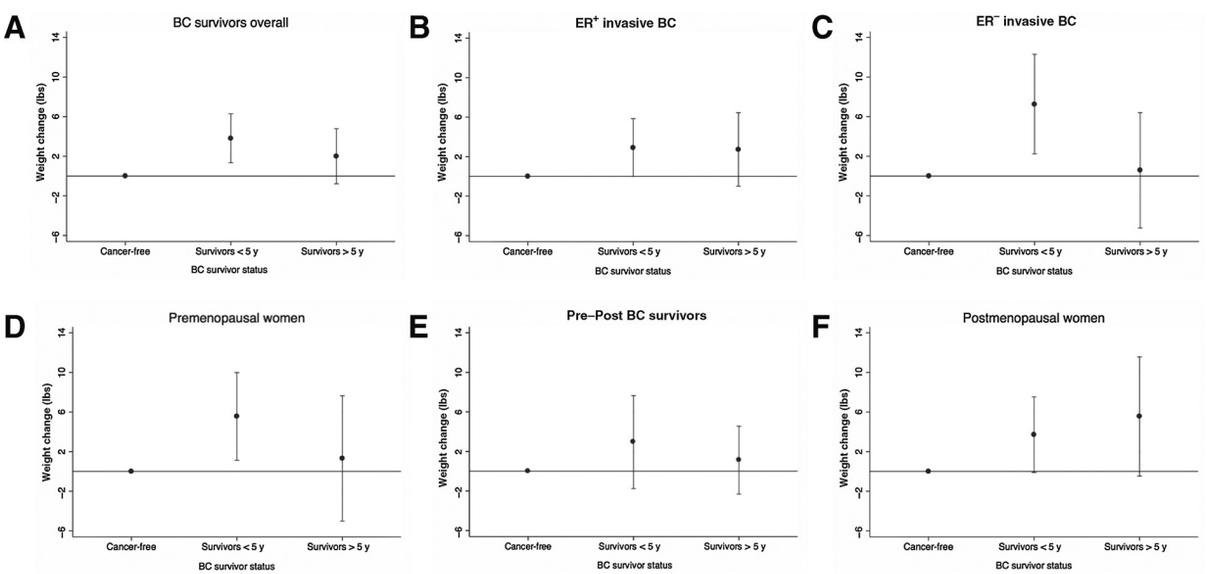

Figure 2.
Adjusted 4-year weight gain in survivors, stratified by time since diagnosis, compared with cancer-free women. Estimates for weight gain in (A) all survivors, (B) survivors diagnosed with ER-positive invasive breast cancer (BC), (C) survivors diagnosed with ER-negative invasive breast cancer, (D) premenopausal survivors and cancer-free women, (E) survivors who became postmenopausal between diagnosis and baseline and postmenopausal cancer-free women, and (F) postmenopausal survivors and cancer-free women.

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Table 2. Adjusted OR and 95% CI for weight gain of ≥11 lbs (5 kg), and ≥5% weight gain, in survivors and cancer-free women

	Absolute weight gain			Percent weight gain		
	<11 lbs	**≥11 lbs**	**OR (95% CI)**	**<5%**	**≥5%**	**OR (95% CI)**
Cancer-free	272	35	Referent	251	56	Referent
Survivors < 5 y	143	37	**2.07 (1.22–3.50)**	129	21	**1.66 (1.05–2.62)**
Survivors ≥ 5 y	111	12	0.96 (0.47–1.96)	95	28	1.51 (0.89–2.56)

NOTE: Adjusted for age, baseline BMI, menopausal status, enrollment year, physical activity, and statin use.
Statistically significant results appear in bold.

treatment type (i.e., ER status, age at diagnosis, and stage). In additional analyses stratified by *BRCA* status, we found that in *BRCA*-positive women, survivors gained significantly more weight than cancer-free women; the point estimate was higher than what we observed overall, but the confidence intervals for these estimates overlapped (Supplementary Table S1).

Finally, we examined the effect of statin use, a drug with anti-inflammatory properties, in survivors treated with chemotherapy, as a potential preventive agent (Supplementary Table S2). We observed that chemotherapy-treated survivors who used statins had the greatest weight gain when compared with cancer-free women who used statins, chemotherapy-treated survivors who had never used statins, and cancer free women who never used a statin ($P_{\text{interaction}} = 0.01$).

Discussion

The prevalence of overweight/obesity in women with a familial breast cancer risk, irrespective of whether they had breast cancer, was high (55.1% of cancer-free women and 46.9% of survivors). In this prospective study, we observed that breast cancer survivors gained weight at a greater rate than their cancer-free peers, particularly if they received chemotherapy for an ER-negative tumor or were within 5 years of their diagnosis. Women who completed chemotherapy within 5 years of enrollment were more than twice as likely as cancer-free women over the same period to have gained at least 11 pounds. This amount of weight gain has been associated with a significantly increased risk for coronary heart disease and diabetes in women. Post diagnosis weight change in survivors alone has been associated with prognosis (breast cancer recurrence, breast cancer specific, or overall mortality; refs. 11, 12, 30–33).

This is one of only a few studies that have been able to compare weight change in breast cancer survivors to cancer-free women within the same cohort, and the first study to evaluate weight change in women with a familial risk of breast cancer. The design of this study enabled us to examine the association of prior breast cancer treatment and its sequelae with weight gain, independent of the impact of advancing age, which is a strong confounder. Two prior studies conducted in the general population have examined weight gain in breast cancer survivors compared with cancer-free women (20, 21). Although both studies observed weight gain over time for the overall study population, neither study found significantly greater weight gain in the survivors compared with cancer-free women. The first of these studies compared weight change in 20 women diagnosed with breast cancer and undergoing chemotherapy to 51 healthy controls during a 6-month follow-up period. A modest amount of weight gain was observed in the premenopausal survivors during the 6-month posttreatment follow-up, but this weight gain did not differ significantly from that in controls (20). Although the authors did find significant changes in body composition among the breast cancer patients, including increase in body fat percentage and decrease in fat-free body mass, the same measurements were not done on the controls. The second study compared weight change over a mean of 6 years of follow-up in Hispanic and non-Hispanic White breast cancer survivors ($n = 305$) and cancer-free women ($n = 345$; ref. 21). The authors analyzed weight gain as ≥5% increase from baseline body weight, and found no significant difference between women with and without cancer history in adjusted models irrespective of treatment. The women in this study were less likely to have received chemotherapy compared with our study population (43% vs. 52% in our study), were older at baseline (mean age 57 years versus 53 years in our study) and were more likely to be overweight and obese at baseline. Previous studies of breast cancer survivors alone have observed greater weight gain among women at a lower BMI at the time of diagnosis (8); however, in analyses stratified by BMI category, we did not observe a significant difference in estimates for weight gain between the groups.

The greatest weight gain in our study was seen among chemotherapy-treated survivors, and in particular those survivors treated within 5 years prior to T_1. This finding corroborates some previous studies limited to survivors only, (reviewed in ref. 1), and confirms that the weight gain is not related to increasing age or change in menopausal status. We observed a greater than 11 pound weight gain in 21% of the women treated with chemotherapy. This amount of weight gain is shown to have serious implications for future risk of coronary heart disease. In a study of healthy women, adult weight gain of at least 5 kg from age 18 years was associated with a 25% or

Table 3. Adjusted multiple linear regression coefficients for change in weight (lbs) during follow-up, stratified by type of treatment

	Surgery only			Chemotherapy, with or without hormonal therapy[a]			Hormonal therapy[a] alone		
	n	**β**	**95% CI**	***n***	**β**	**95% CI**	***n***	**β**	**95% CI**
Cancer-free	307	0	Referent	307	0	Referent	307	0	Referent
Survivors diagnosed ≤ 5 y	26	1.8	−3.63 to 7.24	86	**5.58**	**2.13–9.03**	67	1.62	−1.99 to 5.24
Survivors diagnosed > 5 y	26	−1.15	−6.57 to 4.27	70	2.72	−0.94 to 6.38	27	2.48	−2.77 to 7.73
All survivors	52	0.32	−3.67 to 4.32	156	**4.26**	**1.49–7.02**	94	1.88	−1.26 to 5.01

NOTE: Adjusted for age, baseline BMI, menopausal status, enrollment year, physical activity, and statin use.
Statistically significant results appear in bold.
[a]Hormonal therapy includes selective estrogen receptor modulators and aromatase inhibitors.

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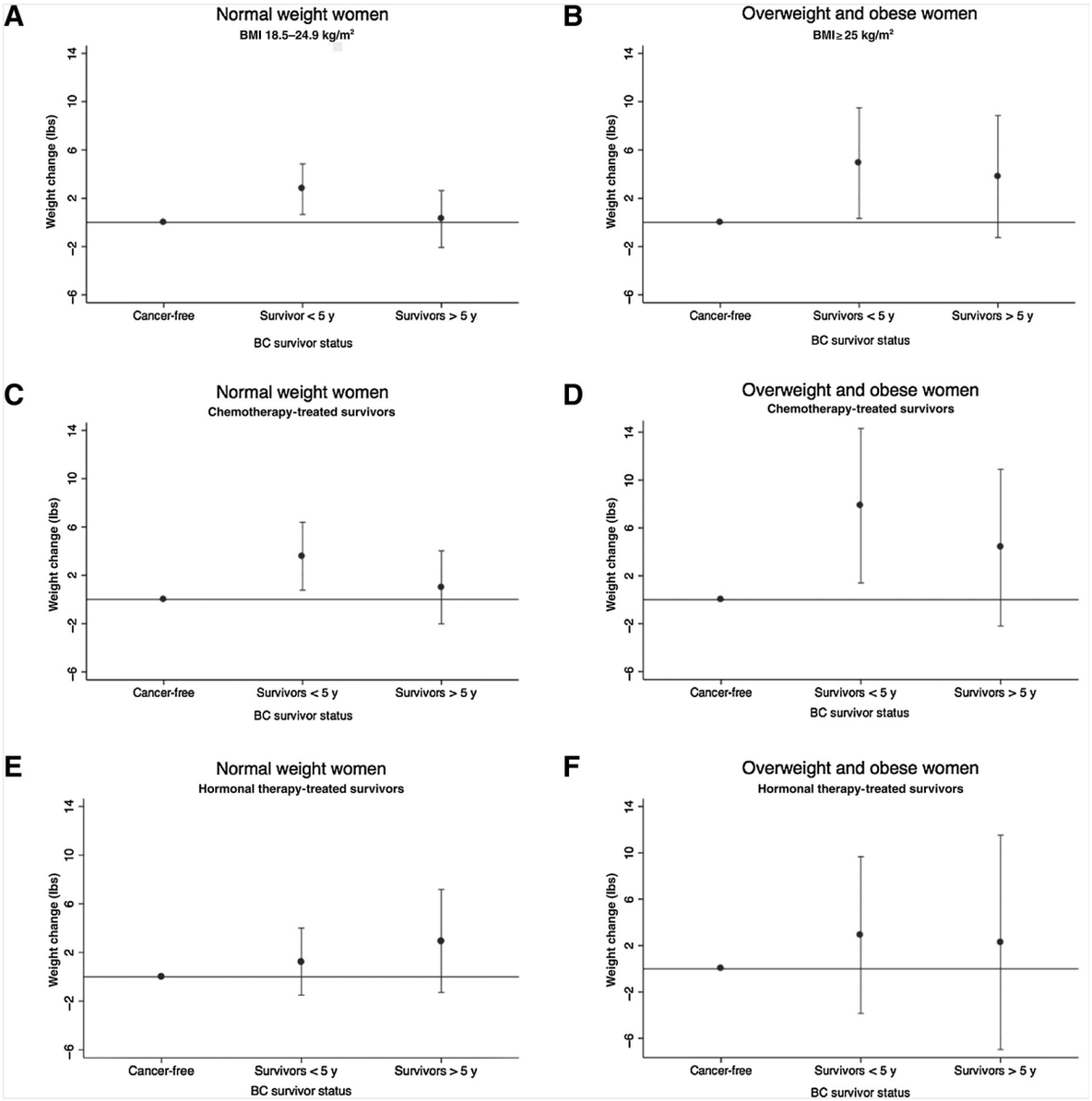

Figure 3.
Adjusted 4-year weight gain in survivors, stratified by time since diagnosis, treatment category, and BMI category at T_1, compared with cancer-free women. Estimates for weight gain among (A) women with BMI between 18.5 and 25 kg/m^2, (B) women with BMI $\geq$ 25 kg/m^2, (C) survivors treated with chemotherapy and cancer-free women, with BMI between 18.5 and 25 kg/m^2, (D) survivors treated with chemotherapy and cancer-free women, with BMI $\geq$ 25 kg/m^2, (E) survivors treated with hormone therapy alone and cancer-free women, with BMI between 18.5 and 25 kg/m^2, and (F) survivors treated with hormone therapy alone and cancer-free women, with BMI $\geq$ 25 kg/m^2.

greater risk for coronary heart disease (5). In comparison with weight maintenance, weight gain of 5 to 10 kg during adulthood has also been associated with significantly increased risks for hypertension (34), and type II diabetes in women (6, 34). The mechanisms underlying chemotherapy-induced weight gain have not been fully elucidated. One line of evidence suggests that chemotherapy may result in unfavorable changes in body composition such as sarcopenic obesity, which is associated with unfavorable metabolic alterations (35), including decreased growth hormone production, increased insulin resistance and inflammation (18, 36), or direct damage to tissues.

Our finding that survivors taking statins actually gained more weight than both cancer-free women taking statins, as well as non-statin users, deserves further study. The differential weight change by survivor status for statin users (survivors gained weight while cancer-free women lost weight) appears to be predominantly in women who received chemotherapy. Although there is evidence that statins can suppress inflammation (37), they also appear to modestly increase risk of diabetes (38), potentially through

decrease in insulin sensitivity. In a small, randomized trial of otherwise healthy women with polycystic ovarian disease, the group treated with atorvastatin was found to have a significant decrease in C-reactive protein, but also a significant decrease in insulin sensitivity compared to women who received placebo (39). It is plausible that statins exert the same effect on breast cancer survivors who are treated with chemotherapy and this counteracts the positive effect statins have on obesity-associated inflammation.

Limitations of our study include the fact that the vast majority of our cohort is white, preventing us from making inferences about change in weight in high-risk survivors of other racial or ethnic background. In addition, we relied on self-reported weight, which may be subject to bias or measurement error. Previous large studies, however, have shown that although self-report of weight compared with measured weight may not be fully accurate, they are highly correlated, and most discrepancies are small, averaging 3 to 4 pounds among women (40, 41). The majority of misclassification based on self-report versus measured BMI falls within one BMI unit (42, 43). In the subset of our participants that we were able to compare self-report weight with measured weight the correlation was high. Importantly, in this high-risk cohort, we believe that self-reported weight is unlikely to differ by exposure group given that the majority of women participate in regular annual and bi-annual screenings for cancer and other chronic diseases, regardless of cancer history. Our study has several strengths, including its prospective nature and the direct comparison to a cancer-free group recruited from the same cohort.

In summary, this is the first study to demonstrate that weight gain is also a concern among breast cancer survivors with a familial risk, where the focus is often on prophylactic surgeries and/or intensive screening. Furthermore, in this high-risk population, breast cancer survivors gain weight at a faster rate than cancer-free women with the same familial risk. The finding that survivors treated with chemotherapy are at greatest risk of rapid weight gain compared with cancer-free women after controlling for age and menopausal status suggests that the underlying etiology is likely to be related to the treatment. Weight gain interventions should also be evaluated in high-risk populations. Further follow-up of this high-risk population is ongoing.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: A.L. Gross, J.E. Axilbund, K. Visvanathan
Development of methodology: A.L. Gross, K. Visvanathan
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): A.L. Gross, B.J. May, J.E. Axilbund, D.K. Armstrong, R.B.S. Roden, K. Visvanathan
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): A.L. Gross, D.K. Armstrong, K. Visvanathan
Writing, review, and/or revision of the manuscript: A.L. Gross, B.J. May, J.E. Axilbund, D.K. Armstrong, R.B.S. Roden, K. Visvanathan
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): A.L. Gross, B.J. May, R.B.S. Roden, K. Visvanathan
Study supervision: B.J. May, K. Visvanathan

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