

Multilevel Factors for Adiposity Change in a Population-Based Prospective Study of Black Breast Cancer Survivors

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PURPOSE Unfavorable weight change after breast cancer diagnosis increases the risk of mortality, but individual and neighborhood risk factors affecting postdiagnosis weight and body fat changes are unclear among Black women, who have higher rates of obesity and mortality than any other racial/ethnic group.

METHODS Adiposity changes during the period approximately 10 months-24 months after diagnosis were evaluated among 785 women diagnosed between 2012 and 2018 and enrolled in the Women's Circle of Health Follow-Up Study, a population-based prospective cohort of Black breast cancer survivors in New Jersey. Multilevel factors for weight and fat mass change (with gain or loss defined as a relative difference of 3% or more, and considering whether changes were intentional or unintentional) were estimated using multivariable polytomous logistic regressions and multilevel models.

RESULTS Adiposity gain was prevalent: 28% and 47% gained weight and body fat, respectively, despite a high baseline prevalence of overweight or obesity (86%). Risk factors for fat mass gain included receiving chemotherapy (relative risk ratio: 1.59, 95% CI, 1.08 to 2.33) and residing in neighborhoods with a greater density of fast-food restaurants (relative risk ratio comparing highest with lowest tertile: 2.18, 95% CI, 1.38 to 3.46); findings were similar for weight gain. Only 9% of women had intentional weight loss, and multilevel risk factors differed vastly from unintentional loss.

CONCLUSION Both individual and neighborhood factors were associated with adiposity change among Black breast cancer survivors. Residential environment characteristics may offer clinically meaningful information to identify cancer survivors at higher risk for unfavorable weight change and to address barriers to postdiagnosis weight management.

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INTRODUCTION

Weight change after breast cancer diagnosis continues to receive considerable clinical attention, with both weight gain and weight loss predicting higher mortality.¹ A meta-analysis found a 59% increase in breast cancer-specific mortality and a 43% increase in overall mortality among women who had the highest weight gain one year or more after breast cancer diagnosis¹ and a more than doubled risk of overall mortality in women with the highest postdiagnosis weight loss.¹ On the other hand, intentional weight loss improves quality of life and potentially reduces cancer recurrence, which is being evaluated by several ongoing large trials.^{2,3} Because of the clinical significance of weight management, it is now included in the American Cancer Society (ACS)/ASCO Breast Cancer Survivorship Care Guideline.⁴ Several individual risk factors for weight gain after breast cancer diagnosis have been reported, although not consistently, including younger age and

premenopausal status at diagnosis, advanced cancer stage and related treatment, high caloric intake, and reduction in physical activity since diagnosis.⁵⁻⁸

Individual-level behaviors and decision making are often shaped by the surrounding social and built environment. Ignoring the upstream risk factors may inhibit the success or sustainability of weight management strategies, especially for patients who are unable to comply with recommendations from cancer care providers because of neighborhood factors beyond their control (eg, lack of health-promoting resources). However, to our knowledge, neighborhood risk factors for weight change among breast cancer survivors have not been evaluated.

Black women are more likely to have higher weight and die after a breast cancer diagnosis than other racial/ethnic groups,^{9,10} but questions remain as to how prevalent weight gain or weight loss is among Black breast cancer survivors and for whom such weight

ASSOCIATED CONTENT

Appendix

Author affiliations and support information (if applicable) appear at the end of this article.

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CONTEXT

Key Objective

Considering the clinical attention of weight change among cancer survivors, this study aimed to evaluate adiposity gain and unintentional versus intentional weight loss and the associated individual factors and neighborhood social and built environment factors among Black breast cancer survivors, an understudied population.

Knowledge Generated

Adiposity gain was common during the period approximately 10 months–24 months after breast cancer diagnosis, whereas 86% of women were already overweight or obese. Several individual and neighborhood characteristics, such as receiving chemotherapy and living in neighborhoods with a higher density of fast-food restaurants, collectively increased the risk of postdiagnosis adiposity gain. Multilevel risk factors identified for intentional weight loss differed considerably from those for unintentional weight loss.

Relevance

Residential environment features can provide clinically valuable information to identify breast cancer survivors at risk for undesirable weight change. Weight management counseling for cancer survivors would need to consider the environmental barriers.

change is most likely. Furthermore, cancer survivors tend to experience unique unfavorable changes in body composition that are only partially captured through weight change, but evidence evaluating fat mass change has been based on relatively small studies. Attention is also needed to disentangle risk factors for intentional versus unintentional weight loss, a critical distinction for cancer survivors.

In a large longitudinal cohort of Black breast cancer survivors, we investigated the changes in body adiposity (gain in body weight and fat, and intentional versus unintentional loss) from approximately 10 months to 24 months after diagnosis and associated multilevel risk factors including individual sociodemographic, lifestyle, and clinical factors and neighborhood social and built environment factors.

METHODS

Participants were enrolled in the Women's Circle of Health Follow-Up Study (WCHFS), a longitudinal cohort of Black breast cancer survivors. Study methods have been described in detail elsewhere.¹¹ In brief, participants were identified by rapid case ascertainment in 10 counties of New Jersey by the New Jersey State Cancer Registry (NJSCR). Women who self-identified as Black or African American, with a histologically confirmed ductal carcinoma in situ or invasive breast cancer, and were age 20–75 years at diagnosis, able to speak English, and without a history of cancer except nonmelanoma skin cancer were eligible to participate. All participants provided written informed consent. The study was approved by the Institutional Review Boards at all participating institutions.

Data collection at baseline (approximately 10 months since diagnosis) and annual follow-up interviews through home visits included anthropometric and blood pressure measurements; biospecimen collection; computer-assisted questionnaires on sociodemographic, reproductive, and

lifestyle factors (smoking, alcohol, diet, physical activity, and intentional weight change); and medical history.

Anthropometric measures, including weight, height, and body composition, were taken by trained interviewers following a standardized protocol.^{11,12} Body composition, including fat mass, was measured using a bioelectrical impedance analysis scale (Tanita TBF-300A Total Body Composition Analyzer).

Breast cancer clinicopathologic features, including American Joint Committee on Cancer (AJCC) stage, grade, and information for tumor subtypes (estrogen receptor, progesterone receptor, and human epidermal growth factor receptor 2 status), were abstracted from pathology reports or NJSCR files. Breast cancer treatment information was collected from medical records or, when unavailable, from NJSCR or self-report. In a previous analysis, we found high concordance between the self-reported basic treatment information and medical records (eg, kappa was 0.91 for chemotherapy and 0.74 for radiation therapy).¹²

History of hypertension and diabetes was based on medical records or, if unavailable, self-report. Participants with measured systolic/diastolic blood pressures \geq 140/90 mmHg during home visits were also classified as having hypertension.

Neighborhood characteristics, including social, food, and physical activity environment measures, were based on the census tract of participants' residence at diagnosis. Because we previously found that breast tumor biology was influenced by social environmental factors, measured by the NCI's neighborhood socioeconomic status (nSES) index¹³ and percentage of Black residents (from the US Census),¹⁴ these two factors were included in the current analysis. Densities of food stores (primarily for off-premise consumption such as supermarkets and convenience

stores), all restaurants, fast-food restaurants, and commercial physical activity facilities were estimated using National Establishment Time Series (NETS) data. Methods to categorize and enhance the accuracy of business data from NETS are published elsewhere.¹⁵⁻¹⁷ Descriptions of neighborhood measures are provided in Table 1. Two widely used walkability elements were also included: walkable destinations (locations that can facilitate activities of daily living such as stores, postal service, and schools) and population density,¹⁸⁻²⁰ which were based on NETS and census data, respectively. The census data were from 2010, and the nSES

index and NETS data were from 2014, the median year of diagnosis in our study (range: 2012-2018).

Major outcomes of interest included percent weight change and percent fat mass change between two time points, calculated as [(weight or fat mass measurement at first follow up – measurement at baseline)/measurement at baseline] × 100. The study period was between around 10 months and 24 months after diagnosis, which is considered an excellent teachable moment for weight management since patients would have completed active treatment at that time.²¹

TABLE 1. Neighborhood Characteristics: Descriptions and Distributions

Neighborhood Factor	Data Source	Description of Measure	NJ State-Wide Tertiles	Participants, No. (%) ^a
nSES index	American Community Survey via NCI census tract-level SES and rurality database (2014)	Census tract-level composite measure of income, house value, rent value, poverty, education, occupation, and employment. A greater score indicates a higher census tract-level SES.	T1 (≤ 9,433)	434 (56.5)
			T2 (9,434-10,558)	229 (29.8)
			T3 (≥ 10,559)	105 (13.7)
Percentage of Black residents	2010 US Census	Census tract-level percentage of the US population that identifies as Black or African American	T1 (≤ 2.8)	18 (2.3)
			T2 (2.9-10.6)	101 (13.0)
			T3 (≥ 10.7)	657 (84.7)
Food stores	NETS database (2014)	Tract-level density measure (count per square km land area, same below) of food stores primarily for off-premise consumption, including wholesale/warehouses, supermarkets, convenience stores/gas stations, small grocers/bodegas, bakery, candy, and ice cream stores	T1 (≤ 1.0)	101 (13.0)
			T2 (1.1-4.3)	259 (33.4)
			T3 (≥ 4.4)	416 (53.6)
All restaurants	NETS database (2014)	Tract-level density measure of a wide variety of restaurants and other eating places	T1 (≤ 1.3)	115 (14.8)
			T2 (1.4-5.3)	293 (37.8)
			T3 (≥ 5.4)	368 (47.4)
Fast-food restaurants	NETS database (2014)	Tract-level density measure of fast-food establishments or eating places that are specialized in low-preparation time foods that are eaten cafeteria style (no waiter service) or takeaway	T1 (≤ 0.04)	210 (27.1)
			T2 (0.05-0.92)	205 (26.4)
			T3 (≥ 0.93)	361 (46.5)
Commercial physical activity facilities	NETS database (2014)	Tract-level density measure of all commercial physical activity facilities, including multiuse facilities, light/moderate physical activity establishments, and vigorous physical activity facilities	T1 (≤ 0.22)	273 (35.2)
			T2 (0.23-1.16)	190 (24.5)
			T3 (≥ 1.17)	313 (40.3)
Walkable destinations	NETS database (2014)	Tract-level density measure of destinations that are part of vibrant neighborhoods and can facilitate activities of daily living without a car (eg, retail stores, services, and schools)	T1 (≤ 12.9)	96 (12.4)
			T2 (13.0-41.5)	246 (31.7)
			T3 (≥ 41.6)	434 (55.9)
Population density	2010 US Census	Tract-level population density per square mile	T1 (≤ 890.6)	80 (10.3)
			T2 (890.7-2,490.1)	217 (28.0)
			T3 (≥ 2,490.2)	479 (61.7)

Abbreviations: NETS, National Establishment Time Series; NJ, New Jersey; nSES, neighborhood socioeconomic status.

^aNo. of participants for neighborhood-level analysis is 776 except for nSES (missing for eight participants).

TABLE 2. Selected Individual-Level Characteristics by Weight Change Categories

Characteristic	Overall Cohort, No. (%)	Weight Change Categories, No. (%)			P ^b
		Weight Loss ($\leq -3\%$)	Stable (within $\pm 3\%$) ^a	Weight Gain ($\geq 3\%$)	
		157 (20.0)	411 (52.4)	217 (27.6)	
Age categories, years					
20-45	151 (19.2)	28 (17.8)	73 (17.8)	50 (23.0)	.15
46-60	357 (45.5)	79 (50.3)	178 (43.3)	100 (46.1)	
61-75	277 (35.3)	50 (31.9)	160 (38.9)	67 (30.9)	
Mean \pm SD	55.4 \pm 10.7	55.0 \pm 11.1	56.2 \pm 10.5	54.2 \pm 10.7	
Education ^c					
\leq High school graduate	270 (34.4)	60 (38.2)	139 (33.9)	71 (32.7)	.80
Some college	262 (33.4)	47 (29.9)	140 (34.2)	75 (34.6)	
\geq College	252 (32.1)	50 (31.9)	131 (32.0)	71 (32.7)	
Household income, USD					
< \$25,000	225 (28.7)	52 (33.1)	101 (24.6)	72 (33.2)	.03
\$25,000-\$69,999	262 (33.4)	54 (34.4)	141 (34.3)	67 (30.9)	
\geq \$70,000	250 (31.9)	37 (23.6)	147 (35.8)	66 (30.4)	
Unknown	48 (6.1)	14 (8.9)	22 (5.4)	12 (5.5)	
Menopausal status					
Premenopausal	270 (34.4)	45 (28.7)	134 (32.6)	91 (41.9)	.02
Postmenopausal	515 (65.6)	112 (71.3)	277 (67.4)	126 (58.1)	
Baseline BMI categories					
Normal	111 (14.1)	13 (8.3)	55 (13.4)	43 (19.8)	.01
Overweight	220 (28.0)	44 (28.0)	109 (26.5)	67 (30.9)	
Obese I	218 (27.8)	42 (26.8)	118 (28.7)	58 (26.7)	
Obese II/III	236 (30.1)	58 (36.9)	129 (31.4)	49 (22.6)	
Mean \pm SD	32.1 \pm 6.7	33.3 \pm 6.7	32.3 \pm 6.7	30.7 \pm 6.5	
Smoking status at diagnosis					
Never	475 (60.5)	86 (54.8)	263 (64.0)	126 (58.1)	.23
Former	195 (24.8)	42 (26.8)	93 (22.6)	60 (27.7)	
Current	115 (14.7)	29 (18.5)	55 (13.4)	31 (14.3)	
Change in physical activity level since diagnosis ^c					
Remain the same	260 (33.2)	51 (32.7)	148 (36.0)	61 (28.2)	.26
Decreased	332 (42.4)	64 (41.0)	164 (39.9)	104 (48.2)	
Increased	191 (24.4)	41 (26.3)	99 (24.1)	51 (23.6)	
AJCC stage ^c					
0	154 (19.8)	29 (18.8)	98 (24.0)	27 (12.4)	.03
I	295 (37.9)	55 (35.7)	150 (36.8)	90 (41.5)	
II	257 (33.0)	52 (33.8)	125 (30.6)	80 (36.9)	
III/IV	73 (9.4)	18 (11.7)	35 (8.6)	20 (9.2)	
Tumor subtype ^d					
Luminal A	401 (51.1)	86 (54.8)	207 (50.4)	108 (49.8)	.36
HER2-positive	128 (16.3)	24 (15.3)	67 (16.3)	37 (17.1)	
Triple-negative	134 (17.1)	22 (14.0)	66 (16.1)	46 (21.2)	
Unknown	122 (15.5)	25 (15.9)	71 (17.3)	26 (12.0)	

(continued on following page)

TABLE 2. Selected Individual-Level Characteristics by Weight Change Categories (continued)

Characteristic	Overall Cohort, No. (%)	Weight Change Categories, No. (%)			P ^b
		Weight Loss ($\leq -3\%$)	Stable (within $\pm 3\%$ ^a)	Weight Gain ($\geq 3\%$)	
Received chemotherapy	406 (51.7)	157 (20.0)	411 (52.4)	217 (27.6)	.02
Received radiation therapy	567 (72.2)	111 (70.7)	294 (71.5)	162 (74.7)	.63
Received endocrine therapy	528 (67.3)	109 (69.4)	289 (70.3)	130 (59.9)	.02

NOTE. See Appendix Table A1 for the distribution of individual-level characteristics not presented in Table 2.

Abbreviations: AJCC, American Joint Committee on Cancer; ANOVA, analysis of variance; BMI, body mass index; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2; PR, progesterone receptor; SD, standard deviation; USD, US dollars.

^aStable weight: defined as $> -3\%$ and $< 3\%$ of weight change.

^bANOVA or chi-square test was used as appropriate (missing excluded).

^cNo. of missing values ranged between one and six and is not presented.

^dLuminal A: defined as ER+ or PR+ and HER2-; triple-negative: defined as ER-, PR-, and HER2-.

From May 2014 to March 2020, 819 women completed at least one in-person follow-up interview (follow-up rate: 79%). Thirty-one were excluded because of missing weight data, and four were excluded for being underweight (body mass index [BMI] < 18.5 kg/m²) at baseline as there were too few to allow for analysis of intentional weight gain, resulting in an analytical sample of 785 participants.

Participants were grouped into mutually exclusive categories of stable weight (within $\pm 3\%$ to reflect expected diurnal variations in weight and measurement error), weight gain ($\geq 3\%$), and weight loss ($\leq -3\%$).^{22,23} For 13 women without measured weight during follow-up visits, we used self-reported weight, which had a high concordance with measured data (intraclass correlation = 0.99).²⁴ Percent fat mass change was evaluated using the same cut points as the percent weight change. Weight change using an additional common cut point of $\pm 5\%$ was also examined.

Pearson's χ^2 tests were used to compare individual factors by categories of change in weight and fat mass. Adjusted relative risk ratios (RRRs) and 95% CIs were estimated using multivariable polytomous logistic regression via a backward elimination approach with a threshold of $P < .1$ for individual-level variable inclusion. Neighborhood factors were evaluated as tertiles (nine women were excluded because of invalid addresses) according to NJ state-wide distributions. Multilevel polytomous logistic regression was used adjusting for both individual and neighborhood factors, with a random intercept for census tracts to account for clustering of participants within tracts. Factors under consideration were selected a priori on the basis of current evidence, including sociodemographic factors (age, education, household income, and health insurance), menopausal status, lifestyle factors (baseline BMI, smoking, alcohol intake, total energy intake and physical activity during the year before diagnosis, and change in physical activity level since diagnosis), obesity-related comorbidities (history of diabetes and hypertension), clinical factors (AJCC stage; grade; tumor subtype; surgery type; and

receipt of chemotherapy, radiation, and endocrine therapy), and neighborhood characteristics (nSES index; percentage of Black residents; densities of all restaurants, fast-food restaurants, physical activity facilities, and walkable destinations; and population density).

For unintentional and intentional weight loss (*v* stable weight), individual and neighborhood risk factors were computed using polytomous logistic regressions and multilevel models, respectively. Trend tests for ordinal variables were conducted by fitting the median value of each category as a continuous variable.²⁵ We additionally adjusted for the study period (in days) and excluded baseline BMI in the sensitivity analyses.²⁶ We also repeated the analyses among women diagnosed with stage I-III breast cancer. Statistical significance was defined as a two-sided $P < .05$. Statistical analyses were performed using SAS version 9.4 and Stata version 16.1.

RESULTS

During a median follow-up of 12 months (mean [standard deviation; SD]: 13.5 [6.9] months), weight change by 3% or more was prevalent, with 48% of the cohort experiencing weight change, and among them, 58% had weight gain. The gainers group experienced a mean weight gain of 5.7 (SD 3.3) kg during the study period. The entire cohort had a mean weight gain of 0.5 (SD 4.8) kg and a fat mass gain of 1.0 (SD 4.8) kg.

Compared with breast cancer survivors with stable weight, women with weight gain or weight loss were more likely to have lower household income and to be at a higher cancer stage. Women with weight gain were also more likely to be premenopausal at diagnosis, have lower baseline BMI, and have received chemotherapy (Table 2 and Appendix Table A1, online only). These observations were generally similar for women with fat mass gain (Appendix Table A2, online only). In this population-based study, more than or close to half of the participants resided in neighborhoods with lower

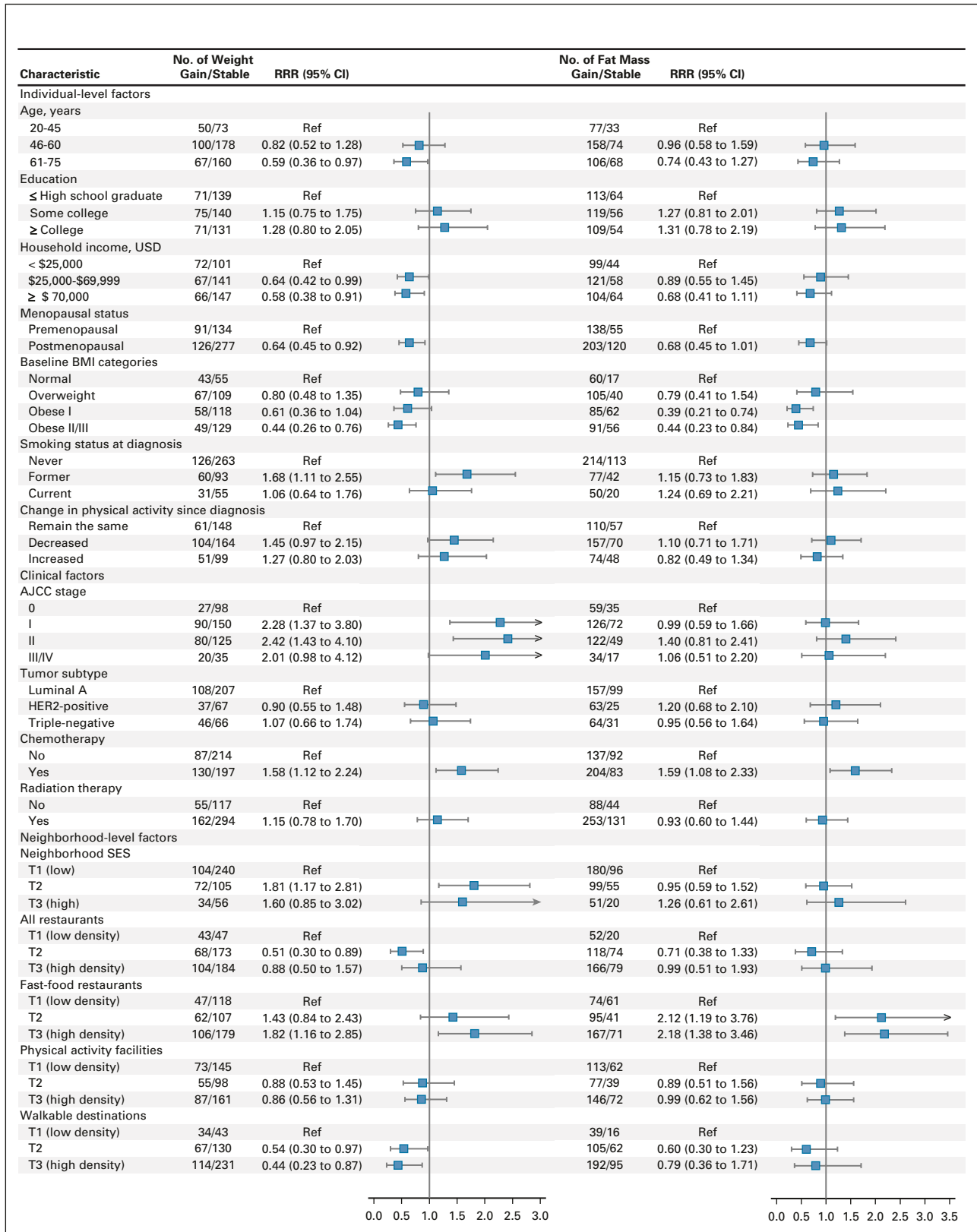


FIG 1. Multilevel risk factors for weight gain and fat mass gain among Black breast cancer survivors. See Appendix Tables A3 and A4 for weight change–related results not included in Figure 1. For individual-level and clinical factors, multivariable polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, and chemotherapy. For neighborhood-level factors, multivariable multilevel polytomous logistic regressions additionally adjusted for nSES, %Black residents, fast-food restaurant density, and physical (continued on following page)

FIG 1. (Continued). activity facility density. For menopausal status, tumor stage, and walkability under study, the model was not adjusted for age, chemotherapy, and nSES, respectively, because of collinearity concerns. AJCC, American Joint Committee on Cancer; BMI, body mass index; HER2, human epidermal growth factor receptor 2; nSES, neighborhood socioeconomic status; Ref, reference; RRR, relative risk ratio; USD, US dollars.

nSES (first state-wide tertile); a higher density of food stores, restaurants including fast-food restaurants, and walkable destinations (third state-wide tertile); and a higher density of the overall population and Black residents (Table 1).

In multivariable models, we found that age, household income, and baseline BMI were inversely associated with the relative risk of weight gain and being premenopausal at diagnosis was positively associated with weight gain (Fig 1). Other individual SES factors (education and health insurance) and obesity-related comorbidities (history of diabetes and hypertension) were not associated with weight gain (Appendix Table A3, online only). Among lifestyle factors, former smoking and decreased physical activity since diagnosis were associated with 68% (RRR, 1.68; 95% CI, 1.11 to 2.55) and 45% (RRR, 1.45; 95% CI, 0.97 to 2.15) increased relative risk of weight gain, respectively. For clinical characteristics, higher tumor stage and receiving chemotherapy were significant predictors of weight gain (RRR_{chemo}: 1.58; 95% CI, 1.12 to 2.24), whereas tumor grade and subtype, type of surgery, radiation, and endocrine therapy were not.

Several neighborhood factors were associated with weight gain. The strongest associations were for fast-food restaurants, which revealed a significant dose-response relationship between increasing density and higher relative risk of gaining weight ($P = .02$; Appendix Table A4, online only). Women living in the highest tertile of fast-food restaurant density compared with the lowest had an 82% higher relative risk of weight gain (RRR, 1.82; 95% CI, 1.16 to 2.85), whereas those in the highest tertile of walkable destinations had a 56% lower relative risk (RRR, 0.44; 95% CI, 0.23 to 0.87). Similar individual and neighborhood risk factors, including lower baseline BMI, receiving chemotherapy, and residing in areas with a greater density of fast-food restaurants, were observed for fat mass gain (Fig 1) and weight gain using a cut point of $\geq 5\%$ (Appendix Tables A5 and A6, online only).

In the analysis to explore weight loss intention, several individual and neighborhood factors were associated with reduced risk of unintentional weight loss, including higher household income, increased physical activity since diagnosis, and greater density of food stores (Fig 2). Women with moderate alcohol intake before diagnosis (≤ 1 drink/day) were more likely to lose weight unintentionally than non-drinkers. Because there were too few (4%) with > 1 drink/day, we were unable to detect a meaningful association with higher levels of drinking.

Although obesity was highly prevalent (58%), an intentional weight loss of 3% or more was uncommon (9%). Women with a college degree or more, greater baseline BMI, and

increased physical activity since diagnosis were more likely to lose weight intentionally, whereas women residing in neighborhoods with high proportions of Black residents were less likely to have voluntary weight loss. Results remained materially unchanged after excluding baseline BMI or adding duration of follow-up in the multivariable models. Similar associations were observed after limiting the analyses to women who had nonmetastatic invasive breast cancer (data not shown).

DISCUSSION

This is the first study, to our knowledge, that investigated the multilevel factors for adiposity change among Black breast cancer survivors who are disproportionately affected by excess body fat and breast cancer mortality. We found that gaining weight and fat mass is a common problem among Black cancer survivors. Considering that 86% of our participants were already overweight or obese at baseline, this finding is unique and distressing. We found that individual and neighborhood factors collectively influenced the risk of weight and fat mass gain, including being premenopausal before diagnosis, having received chemotherapy, and residing in neighborhoods with a greater density of fast-food restaurants. Furthermore, we showed that intentional weight loss was much less common than weight gain and its multilevel risk factors were considerably different from unintentional weight loss.

Individual risk factors for postdiagnosis change in adiposity have not been consistently reported in previous studies,^{5,7} which may be due to the use of an oversimplified linear model or comparisons of weight gain with combined stable and weight loss. The model assumption in previous studies was that factors for weight loss are the same as those for prevention of weight gain, but we demonstrated that this is not the case. Both weight gain and fat mass gain were more pronounced among premenopausal women at diagnosis, as reported in some studies among White and Asian women,^{27,28} possibly because of the onset of menopause during treatment and associated physiologic changes including fat accumulation.²⁹ Because age and menopausal status are highly correlated, we conducted a post hoc analysis and found that adiposity gain was greatest among women who were younger and premenopausal at diagnosis, whereas among postmenopausal women, age was no longer a risk factor. Our study also adds to the evidence mostly from non-Black women that recent chemotherapy regimens continue to contribute to adiposity gain although they were reported to contribute less than the older types.^{6,30} We showed that change in physical activity since diagnosis, not the level before diagnosis, was associated

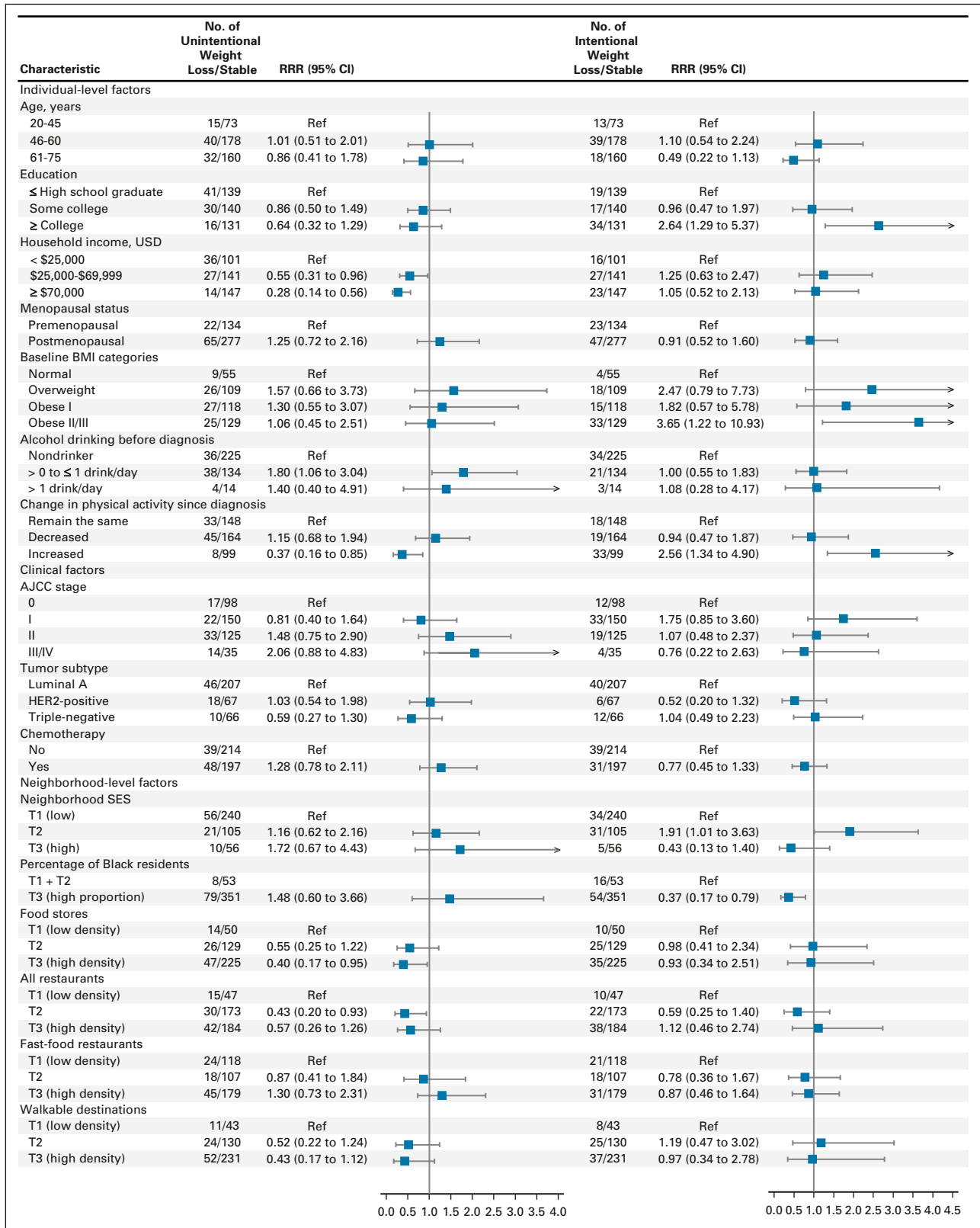


FIG 2. Multilevel risk factors for unintentional and intentional weight loss among Black breast cancer survivors. Other factors under study were not associated with unintentional or intentional weight loss (data not shown). For individual-level and clinical factors, multivariable polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, and chemotherapy. For neighborhood-level factors, multivariable multilevel polytomous logistic regressions were additionally adjusted for nSES, %Black residents, fast-food (continued on following page)

FIG 2. (Continued). restaurant density, and physical activity facility density. For menopausal status, tumor stage, and walkability under study, the model was not adjusted for age, chemotherapy, and nSES, respectively, because of collinearity concerns. For %Black residents, the first two tertiles were combined because of the small sample size in T1. AJCC, American Joint Committee on Cancer; BMI, body mass index; HER2, human epidermal growth factor receptor 2; BMI, body mass index; nSES, neighborhood socioeconomic status; Ref, reference; RRR, relative risk ratio; USD, US dollars.

with weight change. In our study, more than 40% of Black breast cancer survivors reported a decreased level of physical activity, which was associated with a greater risk of weight gain. Twenty-four percent of cancer survivors increased their physical activity; they were less prone to weight loss unintentionally or were more likely to lose weight intentionally, patterns that previous population-based studies could not evaluate. These findings reinforce the importance of physical activity as a modifiable factor in weight management during cancer survivorship.⁹

Residential neighborhoods might have stronger influences on breast cancer survivors because of time and energy constraints and lower workforce participation compared with cancer-free populations. Regular employment dropped from 66% prediagnosis to 49% at around 24 months postdiagnosis in our study. Social and community resources may be particularly important for individuals facing stressful events,³¹ such as cancer. Our findings extend previous evidence supporting the associations of fast-food restaurant density with adiposity gain among breast cancer survivors^{32,33}; however, heterogeneity across racial and ethnic groups remains to be understood. Fast-food restaurants were more prevalent in the residential areas of our participants than elsewhere in NJ. The observations in other racial and ethnic minority neighborhoods were similar and appeared to be independent of nSES.^{34,35} These findings suggest that residential environments with excess fast-food availability may be a unique barrier to controlling adiposity gain in Black breast cancer survivors.

Interestingly, there was a suggestion of lowered risks of postdiagnosis weight gain and unintentional weight loss with the medium density of restaurants of all types (v the lowest density). Together with the findings for fast-food restaurants, they indicate that both restaurant quantity and quality in residential neighborhoods matter for breast cancer survivorship. The risk of unintentional weight loss was also inversely associated with density of food stores, consistent with the concept of food deserts (areas lacking nutritious food) and adverse health outcomes.³⁶ Intentional weight loss, after controlling for individual SES and clinical factors, was still more likely among Black women residing in areas of medium nSES and low/intermediate proportions of Black residents, possibly through the influence of social networks—larger, diverse social networks were associated

with favorable lifestyle factors after breast cancer diagnosis.³⁷ Our findings support the need to examine the neighborhood food environment for unintentional weight loss; however, social environment may be important for intentional reduction in adiposity.

Recognizing the indispensable support within environments in which people live, the 2020 ACS lifestyle guidelines for cancer prevention and the 2022 guidelines for cancer survivors now discuss community influences on the cancer continuum.^{38,39} In our study among Black breast cancer survivors, walkability-related neighborhood factors were associated with lower risks of weight gain, whereas commercial physical activity facilities, which often incur cost and transportation needs, were not. Community actions for all members may need considerations beyond having some health-promoting resources available.

Our study limitations were that we could not perform meaningful stratified analyses by menopausal status and tumor subtypes because of limited statistical power among subsets of participants. Furthermore, we did not have residential histories, but excluding women who moved within approximately 24 months after diagnosis (9%) did not alter our findings. This study has many strengths. Through linking well-characterized social and built environment data to a large prospective cohort with detailed individual information including the intention of weight loss, our study is uniquely suited to understanding multilevel risk factors for adiposity change among Black breast cancer survivors. Furthermore, the distributions of tumor characteristics in the WCHFS were consistent with all cases in the recruitment area found in our previous analysis,¹¹ supporting the generalizability of the findings.

In conclusion, our study demonstrates that adiposity gain is common among Black breast cancer survivors despite a high prevalence of overweight or obesity at diagnosis and that both individual and neighborhood factors are clinically meaningful in identifying cancer survivors at higher risk of unfavorable weight change. For breast cancer survivors residing in areas with limited resources, weight management counseling from health care providers would need to consider the unique environmental barriers. Our findings also provide insights into community actions, necessary for cancer health equity in the long run.

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Multilevel Factors for Adiposity Change in a Population-Based Prospective Study of Black Breast Cancer Survivors

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APPENDIX

TABLE A1. Additional Individual-Level Characteristics by Weight Change Categories

Characteristic	Overall Cohort, No. (%)	Weight Change Categories, No. (%)			P ^b
		Weight Loss ($\leq -3\%$)	Stable (within $\pm 3\%$ ^a)	Weight Gain ($\geq 3\%$)	
Insurance status					
Private	419 (53.4)	79 (50.3)	229 (55.7)	111 (51.2)	.73
Medicare/Medicaid	247 (31.5)	55 (35.0)	123 (29.9)	69 (31.8)	
Uninsured	77 (9.8)	17 (10.8)	37 (9.0)	23 (10.6)	
Others/unknown	42 (5.4)	6 (3.8)	22 (5.4)	14 (6.5)	
Alcohol drinking before diagnosis					
Nondrinker	407 (51.9)	70 (44.6)	225 (54.7)	112 (51.6)	.49
> 0 to ≤ 1 drink/day	269 (34.3)	59 (37.6)	134 (32.6)	76 (35.0)	
> 1 drink/day	29 (3.7)	7 (4.5)	14 (3.4)	8 (3.7)	
Unknown	80 (10.2)	21 (13.4)	38 (9.3)	21 (9.7)	
Total energy intake before diagnosis, kcal/day					
T1 ($\leq 1,329.3$)	234 (29.8)	45 (28.7)	120 (29.2)	69 (31.8)	
T2 (1,329.4-1,958.3)	236 (30.1)	45 (28.7)	124 (30.2)	67 (30.9)	.78
T3 ($\geq 1,958.4$)	235 (29.9)	46 (29.3)	129 (31.4)	60 (27.7)	
Unknown	80 (10.2)	21 (13.4)	38 (9.3)	21 (9.7)	
Physical activity before diagnosis ^c					
< 150 minutes/week	471 (60.1)	97 (61.8)	252 (61.3)	122 (56.5)	.45
≥ 150 minutes/week	313 (39.9)	60 (38.2)	159 (38.7)	94 (43.5)	
History of diabetes	215 (27.4)	46 (29.3)	114 (27.7)	55 (25.4)	.68
History of hypertension	563 (71.7)	112 (71.3)	310 (75.4)	141 (65.0)	.02
Tumor grade					
I	109 (13.9)	25 (15.9)	57 (13.9)	27 (12.4)	.27
II	306 (39.0)	61 (38.9)	171 (41.6)	74 (34.1)	
III	325 (41.4)	67 (42.7)	157 (38.2)	101 (46.5)	
Missing	45 (5.7)	4 (2.6)	26 (6.3)	15 (6.9)	
Type of surgery					
No surgery	21 (2.7)	7 (4.5)	6 (1.5)	8 (3.7)	.16
Lumpectomy	420 (53.5)	79 (50.3)	231 (56.2)	110 (50.7)	
Mastectomy	344 (43.8)	71 (45.2)	174 (42.3)	99 (45.6)	

Abbreviation: ANOVA, analysis of variance.

^aStable weight: defined as $> -3\%$ and $< 3\%$ of weight change.

^bANOVA or chi-square test was used as appropriate (missing excluded).

^cNo. of missing values was one and is not presented.

TABLE A2. Individual Characteristics by Fat Mass Change Categories

Characteristic	Overall Cohort, n = 732, No. (%)	Fat Mass Change Categories, No. (%)			P ^b
		Fat Mass Loss (≤ 3%)	Stable (within ±3% ^a)	Fat Mass Gain (≥ 3%)	
Age categories, years					
20-45	148 (20.2)	38 (17.6)	33 (18.9)	77 (22.6)	.33
46-60	335 (45.8)	103 (47.7)	74 (42.3)	158 (46.3)	
61-75	249 (34.0)	75 (34.7)	68 (38.9)	106 (31.1)	
Mean ± SD	55.0 ± 10.7	55.7 ± 10.9	55.8 ± 10.7	54.2 ± 10.5	
Education ^c					
≤ High school graduate	252 (34.5)	75 (34.7)	64 (36.8)	113 (33.1)	.94
Some college	247 (33.8)	72 (33.3)	56 (32.2)	119 (34.9)	
≥ College	232 (31.7)	69 (31.9)	54 (31.0)	109 (32.0)	
Household income, USD					
< \$25,000	207 (28.3)	64 (29.6)	44 (25.1)	99 (29.0)	.72
\$25,000-\$69,999	248 (33.9)	69 (31.9)	58 (33.1)	121 (35.5)	
≥ \$70,000	236 (32.2)	68 (31.5)	64 (36.6)	104 (30.5)	
Unknown	41 (5.6)	15 (6.9)	9 (5.1)	17 (5.0)	
Insurance status					
Private	394 (53.8)	106 (49.1)	101 (57.7)	187 (54.8)	.22
Medicare/Medicaid	222 (30.3)	81 (37.5)	45 (25.7)	96 (28.2)	
Uninsured	76 (10.4)	19 (8.8)	20 (11.4)	37 (10.9)	
Others/unknown	40 (5.5)	10 (4.6)	9 (5.1)	21 (6.2)	
Menopausal status					
Premenopausal	261 (35.7)	68 (31.5)	55 (31.4)	138 (40.5)	.04
Postmenopausal	471 (64.3)	148 (68.5)	120 (68.6)	203 (59.5)	
Baseline BMI categories					
Normal	104 (14.2)	27 (12.5)	17 (9.7)	60 (17.6)	.02
Overweight	207 (28.3)	62 (28.7)	40 (22.9)	105 (30.8)	
Obese I	203 (27.7)	56 (25.9)	62 (35.4)	85 (24.9)	
Obese II/III	218 (29.8)	71 (32.9)	56 (32.0)	91 (26.7)	
Mean ± SD	32.0 ± 6.7	32.3 ± 6.5	32.9 ± 6.5	31.4 ± 6.9	.04
Smoking status at diagnosis					
Never	445 (60.8)	118 (54.6)	113 (64.6)	214 (62.8)	.21
Former	181 (24.7)	62 (28.7)	42 (24.0)	77 (22.6)	
Current	106 (14.5)	36 (16.7)	20 (11.4)	50 (14.7)	
Alcohol drinking before diagnosis					
Nondrinker	381 (52.1)	105 (48.6)	94 (53.7)	182 (53.4)	.12
≤ 1 drink/day	251 (34.3)	75 (34.7)	58 (33.1)	118 (34.6)	
> 1 drink/day	29 (4.0)	16 (7.4)	5 (2.9)	8 (2.4)	
Unknown	71 (9.7)	20 (9.3)	18 (10.3)	33 (9.7)	

(continued on following page)

TABLE A2. Individual Characteristics by Fat Mass Change Categories (continued)

Characteristic	Overall Cohort, n = 732, No. (%)	Fat Mass Change Categories, No. (%)			P ^b
		Fat Mass Loss (≤ 3%)	Stable (within ±3% ^a)	Fat Mass Gain (≥ 3%)	
Total energy intake before diagnosis, kcal/day		216 (29.5%)	175 (23.9%)	341 (46.6%)	
T1 (≤ 1,329.3)	220 (30.1)	66 (30.6)	50 (28.6)	104 (30.5)	
T2 (1,329.4-1,958.3)	221 (30.2)	56 (25.9)	57 (32.6)	108 (31.7)	.68
T3 (≥ 1,958.4)	220 (30.1)	74 (34.3)	50 (28.6)	96 (28.2)	
Unknown	71 (9.7)	20 (9.3)	18 (10.3)	33 (9.7)	
Physical activity before diagnosis ^c					
< 150 minutes/week	440 (60.2)	131 (60.7)	100 (57.1)	209 (61.5)	.63
≥ 150 minutes/week	291 (39.8)	85 (39.4)	75 (42.9)	131 (38.5)	
Change in physical activity level since diagnosis ^c					
Remain the same	238 (32.6)	71 (33.2)	57 (32.6)	110 (32.3)	.23
Decreased	308 (42.2)	81 (37.9)	70 (40.0)	157 (46.0)	
Increased	184 (25.2)	62 (29.0)	48 (27.4)	74 (21.7)	
History of diabetes	193 (26.4)	64 (29.6)	54 (30.9)	75 (22.0)	.04
History of hypertension	518 (70.8)	160 (74.1)	131 (74.9)	227 (66.6)	.07
AJCC stage ^c					
0	144 (19.8)	50 (23.5)	35 (20.2)	59 (17.3)	.44
I	278 (38.2)	80 (37.6)	72 (41.6)	126 (37.0)	
II	236 (32.5)	65 (30.5)	49 (28.3)	122 (35.8)	
III/IV	69 (9.5)	18 (8.5)	17 (9.8)	34 (10.0)	
Grade					
I	105 (14.3)	38 (17.6)	21 (12.0)	46 (13.5)	.29
II	282 (38.5)	88 (40.7)	73 (41.7)	121 (35.5)	
III	301 (41.1)	80 (37.0)	72 (41.1)	149 (43.7)	
Missing	44 (6.0)	10 (4.6)	9 (5.1)	25 (7.3)	
Tumor subtype ^d					
Luminal A	372 (50.8)	116 (53.7)	99 (56.6)	157 (46.0)	.19
HER2-positive	119 (16.3)	31 (14.4)	25 (14.3)	63 (18.5)	
Triple-negative	127 (17.4)	32 (14.8)	31 (17.7)	64 (18.8)	
Unknown	114 (15.6)	37 (17.1)	20 (11.4)	57 (16.7)	
Type of surgery					
No surgery	20 (2.7)	8 (3.7)	4 (2.3)	8 (2.4)	.67
Lumpectomy	390 (53.3)	119 (55.1)	88 (50.3)	183 (53.7)	
Mastectomy	322 (44.0)	89 (41.2)	83 (47.4)	150 (44.0)	
Received chemotherapy	352 (48.1)	93 (43.1)	83 (47.4)	204 (59.8)	< .001
Received radiation therapy	531 (72.5)	147 (68.1)	131 (74.9)	253 (74.2)	.21
Received endocrine therapy	493 (67.4)	152 (70.4)	123 (70.3)	218 (63.9)	.18

Abbreviations: AJCC, American Joint Committee on Cancer; ANOVA, analysis of variance; BMI, body mass index; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2; PR, progesterone receptor; SD, standard deviation; USD, US dollars.

^aStable body fat: defined as > -3% and < 3% fat mass change.

^bANOVA or chi-square test was used as appropriate (missing excluded).

^cNo. of missing values ranged between one and five and is not presented.

^dLuminal A: defined as ER+ or PR+ and HER2-; triple-negative: defined as ER-, PR-, and HER2-.

TABLE A3. Associations of Individual Characteristics With Weight Change Among Black Breast Cancer Survivors^a

Characteristic	Weight Change Categories		
	Stable (within $\pm 3\%$) RRR (95% CI)	Weight Loss ($\leq -3\%$) RRR (95% CI)	Weight Gain ($\geq 3\%$) RRR (95% CI)
Sociodemographic factors			
Age categories, years			
20-45	Ref	Ref	Ref
46-60	Ref	1.10 (0.65 to 1.85)	0.82 (0.52 to 1.28)
61-75	Ref	0.69 (0.39 to 1.22)	0.59 (0.36 to 0.97)
Per 5-year increase	Ref	0.92 (0.84 to 1.01)	0.91 (0.84 to 0.99)
Education			
\leq High school graduate	Ref	Ref	Ref
Some college	Ref	0.89 (0.56 to 1.41)	1.15 (0.75 to 1.75)
\geq College	Ref	1.29 (0.77 to 2.16)	1.28 (0.80 to 2.05)
Household income, USD			
< \$25,000	Ref	Ref	Ref
\$25,000-\$69,999	Ref	0.77 (0.48 to 1.23)	0.64 (0.42 to 0.99)
\geq \$70,000	Ref	0.52 (0.31 to 0.87)	0.58 (0.38 to 0.91)
Insurance status			
Private	Ref	Ref	Ref
Medicaid/Medicare	Ref	1.12 (0.68 to 1.86)	1.15 (0.72 to 1.82)
Uninsured	Ref	0.98 (0.49 to 1.95)	0.94 (0.50 to 1.75)
Others/unknown	Ref	0.76 (0.29 to 1.96)	1.38 (0.67 to 2.85)
Menopausal status			
Premenopausal	Ref	Ref	Ref
Postmenopausal	Ref	1.09 (0.72 to 1.65)	0.64 (0.45 to 0.92)
Lifestyle factors			
Baseline BMI categories			
Normal	Ref	Ref	Ref
Overweight	Ref	1.85 (0.91 to 3.78)	0.80 (0.48 to 1.35)
Obese I	Ref	1.49 (0.73 to 3.04)	0.61 (0.36 to 1.04)
Obese II/III	Ref	1.81 (0.90 to 3.62)	0.44 (0.26 to 0.76)
Per 5 kg/m ² increase	Ref	1.08 (0.94 to 1.24)	0.80 (0.70 to 0.91)
Smoking status at diagnosis			
Never	Ref	Ref	Ref
Former	Ref	1.48 (0.93 to 2.34)	1.68 (1.11 to 2.55)
Current	Ref	1.48 (0.87 to 2.50)	1.06 (0.64 to 1.76)
Alcohol drinking before diagnosis			
Nondrinker	Ref	Ref	Ref
≤ 1 drink/day	Ref	1.38 (0.91 to 2.10)	1.04 (0.71 to 1.51)
> 1 drink/day	Ref	1.24 (0.46 to 3.31)	0.90 (0.35 to 2.32)
Total energy intake before diagnosis, kcal/day			
T1 ($\leq 1,330.6$)	Ref	Ref	Ref
T2 (1,330.7-1,954.1)	Ref	0.89 (0.54 to 1.47)	0.88 (0.57 to 1.36)

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TABLE A3. Associations of Individual Characteristics With Weight Change Among Black Breast Cancer Survivors^a (continued)

Characteristic	Weight Change Categories		
	Stable (within $\pm 3\%$)	Weight Loss ($\leq -3\%$)	Weight Gain ($\geq 3\%$)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
T3 ($\geq 1,954.2$)	Ref	0.78 (0.47 to 1.29)	0.68 (0.43 to 1.08)
<i>P</i> trend	Ref	.33	.11
Physical activity before diagnosis			
< 150 minutes/week	Ref	Ref	Ref
≥ 150 minutes/week	Ref	0.99 (0.67 to 1.46)	0.85 (0.60 to 1.21)
Change in physical activity level since diagnosis			
Remain the same	Ref	Ref	Ref
Decreased	Ref	1.08 (0.69 to 1.67)	1.45 (0.97 to 2.15)
Increased	Ref	1.25 (0.76 to 2.05)	1.27 (0.80 to 2.03)
Obesity-related comorbidities			
History of diabetes			
No	Ref	Ref	Ref
Yes	Ref	1.06 (0.69 to 1.65)	1.05 (0.70 to 1.58)
History of hypertension			
No	Ref	Ref	Ref
Yes	Ref	0.84 (0.52 to 1.34)	0.75 (0.50 to 1.13)
Clinical factors			
AJCC stage			
0	Ref	Ref	Ref
I	Ref	1.26 (0.74 to 2.13)	2.28 (1.37 to 3.80)
II	Ref	1.30 (0.75 to 2.24)	2.42 (1.43 to 4.10)
III/IV	Ref	1.57 (0.76 to 3.25)	2.01 (0.98 to 4.12)
Grade			
I	Ref	Ref	Ref
II	Ref	0.85 (0.48 to 1.51)	0.79 (0.45 to 1.37)
III	Ref	0.99 (0.54 to 1.81)	1.04 (0.59 to 1.84)
Tumor subtype ^b			
Luminal A	Ref	Ref	Ref
HER2-positive	Ref	0.85 (0.49 to 1.50)	0.90 (0.55 to 1.48)
Triple-negative	Ref	0.77 (0.43 to 1.37)	1.07 (0.66 to 1.74)
Type of surgery ^c			
Lumpectomy	Ref	Ref	Ref
Mastectomy	Ref	1.16 (0.78 to 1.72)	1.04 (0.73 to 1.48)
Chemotherapy			
No	Ref	Ref	Ref
Yes	Ref	1.03 (0.70 to 1.51)	1.58 (1.12 to 2.24)

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TABLE A3. Associations of Individual Characteristics With Weight Change Among Black Breast Cancer Survivors^a (continued)

Characteristic	Weight Change Categories		
	Stable (within $\pm 3\%$)	Weight Loss ($\leq -3\%$)	Weight Gain ($\geq 3\%$)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Radiation therapy			
No	Ref	Ref	Ref
Yes	Ref	0.96 (0.63 to 1.47)	1.15 (0.78 to 1.70)
Endocrine therapy			
No	Ref	Ref	Ref
Yes	Ref	0.99 (0.65 to 1.50)	0.70 (0.49 to 1.01)

Abbreviations: AJCC, American Joint Committee on Cancer; BMI, body mass index; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2; PR, progesterone receptor; Ref, reference; RRR, relative risk ratio; USD, US dollars.

^aMultivariable polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, and chemotherapy. Because of collinearity concerns, for menopausal status and tumor stage, models were not adjusted for age and chemotherapy, respectively.

^bLuminal A defined as ER+ or PR+ and HER2-, and triple-negative defined as ER-, PR-, and HER2-.

^cUnstable estimates were observed for no surgery because of the small sample size and were therefore not presented.

TABLE A4. Associations of Neighborhood Characteristics With Weight Change Among Black Breast Cancer Survivors^{a,b}

Characteristic	Weight Change Categories		
	Stable (within $\pm 3\%$)	Weight Loss ($\leq -3\%$)	Weight Gain ($\geq 3\%$)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Neighborhood SES			
T1: low	Ref	Ref	Ref
T2	Ref	1.49 (0.93 to 2.37)	1.81 (1.17 to 2.81)
T3: high	Ref	0.94 (0.43 to 2.02)	1.60 (0.85 to 3.02)
<i>P</i> for trend	Ref	.56	.04
Percentage of Black residents			
T1 + T2 ^c	Ref	Ref	Ref
T3: high proportion	Ref	0.76 (0.42 to 1.38)	0.69 (0.41 to 1.16)
Food stores			
T1: low density	Ref	Ref	Ref
T2	Ref	0.72 (0.39 to 1.35)	1.09 (0.60 to 1.98)
T3: high density	Ref	0.58 (0.29 to 1.15)	0.91 (0.47 to 1.78)
<i>P</i> for trend	Ref	.19	.51
All restaurants			
T1: low density	Ref	Ref	Ref
T2	Ref	0.55 (0.30 to 1.02)	0.51 (0.30 to 0.89)
T3: high density	Ref	0.81 (0.43 to 1.54)	0.88 (0.50 to 1.57)
<i>P</i> for trend	Ref	.35	.11
Fast-food restaurants			
T1: low density	Ref	Ref	Ref
T2	Ref	0.88 (0.50 to 1.56)	1.43 (0.84 to 2.43)
T3: high density	Ref	1.12 (0.71 to 1.76)	1.82 (1.16 to 2.85)
<i>P</i> for trend	Ref	.49	.02
Physical activity facilities			
T1: low density	Ref	Ref	Ref
T2	Ref	1.08 (0.62 to 1.88)	0.88 (0.53 to 1.45)
T3: high density	Ref	1.07 (0.68 to 1.69)	0.86 (0.56 to 1.31)
<i>P</i> for trend	Ref	.81	.53
Walkable destinations			
T1: low density	Ref	Ref	Ref
T2	Ref	0.82 (0.42 to 1.62)	0.54 (0.30 to 0.97)
T3: high density	Ref	0.66 (0.31 to 1.41)	0.44 (0.23 to 0.87)
<i>P</i> for trend	Ref	.28	.09
Population density			
T1: low density	Ref	Ref	Ref
T2	Ref	1.08 (0.51 to 2.31)	0.56 (0.30 to 1.05)
T3: high density	Ref	0.92 (0.41 to 2.09)	0.57 (0.29 to 1.13)
<i>P</i> for trend	Ref	.57	.48

Abbreviations: BMI, body mass index; NJ, New Jersey; nSES, neighborhood socioeconomic status; Ref, reference; RRR, relative risk ratio; T, tertile.

^aMultivariable multilevel polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, chemotherapy, nSES, % Black residents, fast-food restaurant density, and physical activity facility density. Because of collinearity concerns, for walkability and population density, models were not adjusted for nSES and were not mutually adjusted.

^bNeighborhood factors were evaluated as tertiles according to NJ state-wide distributions.

^cFor %Black residents, the first two tertiles were combined because of the small sample size in T1.

TABLE A5. Associations of Individual Characteristics With Weight Change Using a Cut Point of 5% Among Black Breast Cancer Survivors^a

Characteristic	Weight Change Categories		
	Stable (within $\pm 5\%$)	Weight Loss ($\leq -5\%$)	Weight Gain ($\geq 5\%$)
	559 (71.2%)	87 (11.1%)	139 (17.7%)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Sociodemographic factors			
Age categories, years			
20-45	Ref	Ref	Ref
46-60	Ref	0.94 (0.51 to 1.74)	0.77 (0.47 to 1.26)
61-75	Ref	0.46 (0.23 to 0.94)	0.58 (0.34 to 1.01)
Per 5-year increase	Ref	0.86 (0.77 to 0.96)	0.91 (0.83 to 1.00)
Education			
\leq High school graduate	Ref	Ref	Ref
Some college	Ref	1.41 (0.80 to 2.48)	1.20 (0.75 to 1.92)
\geq College	Ref	1.38 (0.72 to 2.66)	0.97 (0.57 to 1.67)
Household income, USD			
< \$25,000	Ref	Ref	Ref
\$25,000-\$69,999	Ref	0.77 (0.44 to 1.35)	0.65 (0.41 to 1.05)
\geq \$70,000	Ref	0.45 (0.23 to 0.86)	0.52 (0.31 to 0.85)
Insurance status			
Private	Ref	Ref	Ref
Medicaid/Medicare	Ref	1.28 (0.70 to 2.36)	1.22 (0.72 to 2.05)
Uninsured	Ref	0.61 (0.24 to 1.52)	0.82 (0.41 to 1.66)
Others/unknown	Ref	0.39 (0.09 to 1.73)	1.20 (0.52 to 2.77)
Menopausal status			
Premenopausal	Ref	Ref	Ref
Postmenopausal	Ref	0.76 (0.46 to 1.26)	0.57 (0.38 to 0.85)
Lifestyle factors			
Baseline BMI categories			
Normal	Ref	Ref	Ref
Overweight	Ref	2.74 (0.99 to 7.63)	0.62 (0.35 to 1.08)
Obese I	Ref	1.98 (0.71 to 5.55)	0.59 (0.34 to 1.02)
Obese II/III	Ref	2.97 (1.10 to 8.04)	0.30 (0.16 to 0.55)
Per 5 kg/m ² increase	Ref	1.13 (0.96 to 1.34)	0.71 (0.61 to 0.83)
Smoking status at diagnosis			
Never	Ref	Ref	Ref
Former	Ref	1.44 (0.82 to 2.52)	1.33 (0.83 to 2.14)
Current	Ref	1.46 (0.77 to 2.76)	1.20 (0.70 to 2.07)
Alcohol drinking before diagnosis			
Nondrinker	Ref	Ref	Ref
≤ 1 drink/day	Ref	1.27 (0.76 to 2.12)	1.36 (0.89 to 2.06)
> 1 drink/day	Ref	1.48 (0.49 to 4.45)	1.26 (0.45 to 3.52)

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TABLE A5. Associations of Individual Characteristics With Weight Change Using a Cut Point of 5% Among Black Breast Cancer Survivors^a (continued)

Characteristic	Weight Change Categories		
	Stable (within $\pm 5\%$)	Weight Loss ($\leq -5\%$)	Weight Gain ($\geq 5\%$)
	559 (71.2%)	87 (11.1%)	139 (17.7%)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Total energy intake before diagnosis, kcal/day			
T1 ($\leq 1,330.6$)	Ref	Ref	Ref
T2 (1,330.7-1,954.1)	Ref	1.07 (0.57 to 2.01)	1.13 (0.69 to 1.85)
T3 ($\geq 1,954.2$)	Ref	1.12 (0.60 to 2.09)	0.86 (0.51 to 1.44)
<i>P</i> trend	Ref	.73	.50
Physical activity before diagnosis			
< 150 minutes/week	Ref	Ref	Ref
≥ 150 minutes/week	Ref	1.06 (0.65 to 1.72)	0.87 (0.59 to 1.29)
Change in physical activity level since diagnosis			
Remain the same	Ref	Ref	Ref
Decreased	Ref	0.98 (0.56 to 1.70)	1.56 (0.98 to 2.47)
Increased	Ref	1.39 (0.77 to 2.54)	1.45 (0.84 to 2.49)
Obesity-related comorbidities			
History of diabetes			
No	Ref	Ref	Ref
Yes	Ref	1.02 (0.59 to 1.76)	1.12 (0.70 to 1.77)
History of hypertension			
No	Ref	Ref	Ref
Yes	Ref	0.77 (0.44 to 1.36)	0.88 (0.56 to 1.38)
Clinical factors			
AJCC stage			
0	Ref	Ref	Ref
I	Ref	0.78 (0.40 to 1.50)	1.53 (0.85 to 2.78)
II	Ref	1.08 (0.56 to 2.07)	2.26 (1.24 to 4.11)
III/IV	Ref	1.20 (0.51 to 2.82)	1.45 (0.63 to 3.32)
Grade			
I	Ref	Ref	Ref
II	Ref	0.82 (0.41 to 1.62)	0.70 (0.37 to 1.34)
III	Ref	0.83 (0.40 to 1.71)	1.01 (0.53 to 1.93)
Tumor subtype ^b			
Luminal A	Ref	Ref	Ref
HER2-positive	Ref	1.03 (0.51 to 2.07)	1.21 (0.71 to 2.08)
Triple-negative	Ref	1.06 (0.53 to 2.13)	1.29 (0.76 to 2.21)
Type of surgery ^c			
Lumpectomy	Ref	Ref	Ref
Mastectomy	Ref	0.93 (0.57 to 1.52)	1.03 (0.69 to 1.55)
Chemotherapy			
No	Ref	Ref	Ref
Yes	Ref	0.85 (0.53 to 1.37)	1.56 (1.05 to 2.33)

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TABLE A5. Associations of Individual Characteristics With Weight Change Using a Cut Point of 5% Among Black Breast Cancer Survivors^a (continued)

Characteristic	Weight Change Categories		
	Stable (within $\pm 5\%$)	Weight Loss ($\leq -5\%$)	Weight Gain ($\geq 5\%$)
	559 (71.2%)	87 (11.1%)	139 (17.7%)
	RRR (95% CI)	RRR (95% CI)	RRR (95% CI)
Radiation therapy			
No	Ref	Ref	Ref
Yes	Ref	0.82 (0.50 to 1.37)	1.10 (0.71 to 1.72)
Endocrine therapy			
No	Ref	Ref	Ref
Yes	Ref	0.93 (0.56 to 1.54)	0.69 (0.46 to 1.04)

Abbreviations: AJCC, American Joint Committee on Cancer; BMI, body mass index; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2; PR, progesterone receptor; RRR, relative risk ratio; USD, US dollars.

^aMultivariable polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, and chemotherapy. Because of collinearity concerns, for menopausal status and tumor stage, models were not adjusted for age and chemotherapy, respectively.

^bLuminal A defined as ER+ or PR+ and HER2-, and triple-negative defined as ER-, PR-, and HER2-.

^cUnstable estimates were observed for no surgery because of the small sample size and were therefore not presented.

TABLE A6. Associations of Neighborhood Characteristics With Weight Change Using a Cut Point of 5% Among Black Breast Cancer Survivors^{a,b}

Characteristic	Weight Change Categories		
	Stable (within $\pm 5\%$) RRR (95% CI)	Weight Loss ($\leq -5\%$) RRR (95% CI)	Weight Gain ($\geq 5\%$) RRR (95% CI)
Neighborhood SES			
T1: low	Ref	Ref	Ref
T2	Ref	0.73 (0.41 to 1.33)	1.05 (0.64 to 1.73)
T3: high	Ref	0.65 (0.24 to 1.73)	1.55 (0.77 to 3.11)
<i>P</i> for trend	Ref	.27	.29
Percentage of Black residents			
T1 + T2 ^c	Ref	Ref	Ref
T3: high proportion	Ref	0.66 (0.32 to 1.37)	0.86 (0.48 to 1.52)
Food stores			
T1: low density	Ref	Ref	Ref
T2	Ref	0.40 (0.18 to 0.85)	0.77 (0.40 to 1.47)
T3: high density	Ref	0.48 (0.21 to 1.09)	0.63 (0.30 to 1.32)
<i>P</i> for trend	Ref	.68	.30
All restaurants			
T1: low density	Ref	Ref	Ref
T2	Ref	0.76 (0.35 to 1.66)	0.71 (0.39 to 1.29)
T3: high density	Ref	1.11 (0.50 to 2.43)	0.77 (0.40 to 1.47)
<i>P</i> for trend	Ref	.29	.89
Fast-food restaurants			
T1: low density	Ref	Ref	Ref
T2	Ref	0.73 (0.35 to 1.50)	1.81 (0.98 to 3.32)
T3: high density	Ref	0.94 (0.54 to 1.64)	1.61 (0.95 to 2.73)
<i>P</i> for trend	Ref	.93	.24
Physical activity facilities			
T1: low density	Ref	Ref	Ref
T2	Ref	1.62 (0.83 to 3.16)	1.16 (0.65 to 2.07)
T3: high density	Ref	1.15 (0.65 to 2.03)	1.11 (0.68 to 1.81)
<i>P</i> for trend	Ref	.85	.75
Walkable destinations			
T1: low density	Ref	Ref	Ref
T2	Ref	0.65 (0.29 to 1.49)	0.44 (0.23 to 0.83)
T3: high density	Ref	0.81 (0.33 to 2.01)	0.39 (0.19 to 0.82)
<i>P</i> for trend	Ref	.85	.13
Population density			
T1: low density	Ref	Ref	Ref
T2	Ref	1.08 (0.41 to 2.83)	0.49 (0.25 to 0.97)
T3: high density	Ref	1.20 (0.43 to 3.34)	0.49 (0.23 to 1.03)
<i>P</i> for trend	Ref	.70	.36

Abbreviations: BMI, body mass index; NJ, New Jersey; nSES, neighborhood socioeconomic status; Ref, reference; RRR, relative risk ratio; T, tertile.

^aMultivariable multilevel polytomous logistic regressions were adjusted for age, baseline BMI, household income, smoking status, chemotherapy, nSES, % Black residents, fast-food restaurant density, and physical activity facility density. Because of collinearity concerns, for walkability and population density, models were not adjusted for nSES and were not mutually adjusted.

^bNeighborhood factors were evaluated as tertiles according to NJ state-wide distributions.

^cFor %Black residents, the first two tertiles were combined because of the small sample size in T1.