Association of Diet Quality and Physical Activity on Obesity-Related Cancer Risk and Mortality in Black Women: Results from the Women's Health Initiative

Joy J. Chebet[1], Cynthia A. Thomson[1,2], Lindsay N. Kohler[2], John E. Ehiri[1], Juhua Luo[3], Ting-Yuan David Cheng[4], Kathy Pan[5], Rowan T. Chlebowski[5], Rami Nassir[6], Shawnita Sealy-Jefferson[7], JoAnn E. Manson[8], Nazmus Saquib[9], and Melanie L. Bell[1]

ABSTRACT

Background: Obesity-related cancers disproportionately affect the Black community. We assessed the relationship between diet quality, physical activity, and their combined effect on obesity-related cancer risk and mortality in Black women enrolled in the Women's Health Initiative (WHI).

Methods: Data from postmenopausal (50–79 years of age) Black women enrolled in WHI clinical trials or observational studies were analyzed. Exposure variables included baseline physical activity [metabolic equivalent of tasks (MET)-hours/week of moderate-to-vigorous physical activity (MVPA)] and diet quality [Healthy Eating Index (HEI)-2015]. Outcomes included adjudicated obesity-related cancer incidence and mortality. Cox proportional hazard models were used to evaluate the association between MVPA and HEI-2015 and obesity-related cancer risk and mortality.

Results: The analytical sample included 9,886 Black women, with a baseline mean body mass index (BMI) of 31.1 kg/m^2 (SD = 6.8); mean HEI-2015 score of 63.2 (SD = 11.0, possible range 0 to 100); and mean MVPA of 5.0 (SD = 9.4) MET-hours/week. Over an average of 13 years of follow-up, 950 (9.6%) obesity-related cancer cases were observed, with 313 (32.9%) resulting in death. Physical activity [HR, 1.05; 95% confidence interval (CI), 0.86–1.30], diet quality (HR, 0.99; 95% CI, 0.92–1.08), and their combination (HR, 1.05; 95% CI, 0.85–1.29) were not associated with risk for any or site-specific obesity-related cancers. Similarly, these health behaviors had no association with mortality.

Conclusions: Diet quality, physical activity and their combined effect, as measured, were not associated with obesity-related cancer risk and mortality in Black women enrolled in WHI.

Impact: Other social, behavioral, and biological factors may contribute to racial disparities observed in obesity-related cancer rates.

Introduction

Trends in global overweight and obesity prevalence have been increasing over the last two decades, and are projected to continue growing (1). In the United States, the age-adjusted national prevalence of obesity, defined as a body mass index (BMI) greater than 30 kg/m^2, is 33.9%, with women experiencing a slightly higher obesity prevalence of 35.5% (2). Among Black Americans, the obesity epidemic is more pronounced at 44.1%, with 49.6% of Black women classified as being obese (2).

BMI ($\geq$25 kg/m^2) has been shown to be a risk factor for many cancers, collectively referred to as obesity-related cancers (3–6). These obesity-related cancers—ones where being overweight/obese increases the risk of their diagnosis—include liver, kidney, multiple myeloma, pancreatic, colorectal, gallbladder, postmenopausal breast, thyroid, esophageal, upper stomach, uterine, ovarian, and meningioma cancers (7). When compared to other racial groups, Black women exhibit higher incidence rates of obesity-related cancers (8). In addition, Black Americans bear a disproportionate burden of cancer-related deaths and experience the shortest survival after cancer diagnosis when compared to all other racial and ethnic groups (9). In fact, while recent data shows racial convergence (10), White women have traditionally exhibited higher incidence rates of breast cancer. Despite lower or similar breast cancer incidence rates, studies have shown Black women continue to have disproportionally higher mortality rates (11–14).

To address underlying cancer risk factors, including those associated with overweight/obese status, leading cancer researchers, cancer-focused non-profit agencies and government institutions recommend changes in diet and exercise. These include consuming a diet high in plant foods and restricted in red and processed meat; engaging in 150 minutes of moderate to vigorous physical activity per week; maintaining a healthy body weight; avoiding tobacco products; and limiting or avoiding alcohol consumption (15). Among the more prominent cancer prevention guidelines are those published by the American Cancer Society (ACS) (16). Mounting epidemiological

[1]Department of Health Promotion Sciences, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, Arizona. [2]University of Arizona Cancer Center, Tucson, Arizona. [3]Department of Epidemiology and Biostatistics, School of Public Health, Indiana University, Bloomington, Indiana. [4]Department of Epidemiology, University of Florida, Gainesville, Florida. [5]Los Angeles Biomedical Institute, Torrance, California. [6]Department of Pathology, Faculty of Medicine, Umm Al-Qura University, Mecca, Saudi Arabia. [7]Division of Epidemiology, College of Public Health, The Ohio State University, Columbus, Ohio. [8]Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts. [9]College of Medicine, Sulaiman AlRajhi Colleges, Al Bukayriyah, Saudi Arabia.

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Corresponding Author: Cynthia A. Thomson, University of Arizona, 3950 S. Country Club, Suite 330, Tucson, AZ 85714. Phone: 520-626-1565; Fax: 520-741-3248; E-mail: cthomson@email.arizona.edu

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evidence suggests greater adherence to the ACS guidelines is associated with a significant reduction in risk of overall cancer, several specific cancers and cancer mortality (17–20). Similarly, the Healthy Eating Index (HEI), a diet quality score, where higher scores (signifying better diet quality) have been shown to be associated with lower cancer risk and cancer mortality (21–25).

In this paper, we evaluate the role of lifestyle behaviors on obesity-related cancer risk and mortality in Black women enrolled in WHI. We do so first reporting the incidence of obesity-related cancers and mortality in Black women enrolled in WHI, and then by assessing the relationship between diet quality (HEI-2015) and ACS-recommended physical activity levels and obesity-related cancer risk and mortality in postmenopausal Black women enrolled in the Women's Health Initiative (WHI). The goal of this study is to identify modifiable lifestyle factors that contribute to obesity-related cancer risk and mortality. Ultimately, this work could inform intervention studies focused on reducing the racial disparity in cancer risk and mortality, which disproportionately impact Black women.

Materials and Methods

The WHI

WHI clinical trials and prospective observational cohort studies sought to study select exposures in relation to fracture risk, cardiovascular disease, breast and colorectal cancers in postmenopausal women (26). The study included 3 randomized, controlled clinical trials (CT) to examine the effects of: (i) hormone therapy on cardiovascular health and breast cancers; (ii) diet modification on prevention of breast and colorectal cancers; and (iii) calcium/vitamin D supplementation for osteoporotic fractures and colorectal cancer (26). In addition, an observational study (OS) was conducted to assess the relationship between lifestyle and health risk (26).

Between 1993 and 1998, 161,808 women were enrolled into the WHI studies in 40 sites located in 24 states and the District of Columbia (DC; ref. 26). Women were included in the study if they were ages between 50 and 79 years at enrollment, were postmenopausal, and intended to stay in the study area for at least 3 years (26). Women were excluded if they had any medical condition that predicted short survival (<3 years), including a history of any cancer (except for successfully treated nonmelanoma skin cancer; refs. 26, 27). Targeted recruitment and enrollment strategies (elaborated elsewhere) were developed to ensure adequate representation of minority women in WHI studies (27–29). Briefly, enrollment was weighted to the 1990 census to obtain a racially representative sample (18.2% minority women; refs. 26, 27). Ten of the 40 research sites prioritized 60% enrollment of minority women each, including Black women (27).

Inclusion and exclusion criteria

To maximize the analytical sample size, we included Black women from both the WHI OS and CT studies. Participants were excluded from analysis if they had unknown BMI at baseline, missing or implausible dietary intake (<600 or >5,000 kcal in the food frequency questionnaire), or missing physical activity, diet score, income, education, or smoking data. Participants missing follow-up time to cancer diagnosis and/or time to death were excluded from the study. In addition, women randomized to the intervention arm of the diet modification trial were excluded, as previous WHI studies showed that a low-fat eating pattern resulted in a reduction in breast cancer incidence of borderline statistical significance ($P = 0.08$; ref. 30).

Outcome definitions and descriptions

For this study, obesity-related cancers were defined as adjudicated cases of any of the obesity cancers, identified by the Centers for Disease Control as being linked to obesity and listed in the "Introduction" section (31). Obesity-related cancer mortality was defined as adjudicated deaths attributed to the aforementioned 13 cancers. Because of their prevalence, a diagnosis of breast and colorectal cancers were evaluated independently as secondary outcomes.

Women enrolled in the study completed annual health status questionnaires, where they reported cancer diagnosis. Clinical records, reviewed by trained physician WHI adjudicators at the clinical site and centrally, were collected to verify self-reported cancer diagnosis (32). Cancers were coded on the basis of primary site. Underlying causes of death were recorded on the basis of medical records, including death certificates, medical records, and autopsy reports. For women lost to follow-up, vital status was determined by linking them to the National Death Index (32).

Exposure definitions and descriptions

Physical activity was defined as energy expended while engaging in Moderate-to-Vigorous Physical Activity (MVPA) analyzed as Metabolic Equivalent of Tasks (METs-hours/week). Categorization of physical activity for these analyses was based on the American College of Sports Medicine's (ACSM) recommendation of 150 minutes of MVPA per week (15). MVPA was therefore categorized as none (0 MET-hr/wk); below recommended physical activity levels (greater than 0 and less than 9 MET-hr/wk); at recommended physical activity levels (greater than 9, and less than 15 MET-hr/wk); or above recommended activity levels (greater than 15 MET-hr/wk). For analyses, physical activity was dichotomized into less than (<9 MET-hr/week), or at/more than ($\geq$9 MET-hr/wk) recommended activity levels.

Diet data were derived from the WHI-validated baseline food frequency questionnaires, which followed a prespecified WHI protocol (33). Questionnaires were reviewed for quality and completeness, and were used to develop a health eating index (HEI) 2015 composite dietary score to estimate diet quality. This score has been associated with cancer risk in several prior studies, including ones conducted using WHI data (34–36). A total HEI score (continuous) was calculated by summing 12 components. These components were: total fruit (0–5 points); whole fruit (0–5 points); total grains (0–5 points); whole grains (0–5 points); milk (0–10 points), meat and beans (0–10 points); total vegetables (0–10); oils (0–10 points); saturated fat (0–10 points); sodium (0–10 points); and calories from solid fat, alcohol and added sugar (0–20 points). The total HEI-2015 ranges between 0 and 100, with higher values indicating healthier diet.

For descriptive analyses, the HEI-2015 score was divided into tertiles. However, for the Cox proportional hazard models, the diet quality score was used as a continuous variable, with resulting hazard ratios reported for a 10-point increase in HEI-2015 score. Finally, the hazard ratio for combined exposures—physical activity and diet quality—was reported. This represented the change in risk for a 10-point increase in HEI-2015 score for participants who achieved the recommended level of physical activity.

Covariates: selection approach and variables

All covariates for this study were selected *a priori* based on background knowledge and literature review. BMI, waist circumference, smoking (pack-years), income, and sedentary time were controlled for in our Cox regression models, and included as continuous

variables. Sedentary time was calculated by summing hours spent sitting (including hours watching TV, eating, driving, working, etc.), and hours lying down (including watching TV, trying to sleep, resting, etc.), and then subtracting hours spent sleeping. Participants' randomization in WHI clinical trials (hormone therapy, calcium, or diet) and participation in OS were also controlled for in the model. In addition, participant educational attainment was controlled for in the multivariable model, as a categorical variable (no schooling-8th grade, some high school, high school diploma or GED, some college/associates degree/vocational school, college degree, and some graduate/master's degree/doctoral degree).

Statistical analyses: primary, sensitivity, and evaluation of models

Baseline descriptive statistics were stratified by physical activity (no or below ACSM recommendation; or at or above ACSM recommendation). Physical activity strata were compared using one-way ANOVA for continuous variables and χ^2 for categorical variables. Cox proportional hazard models were used to assess the relationship between physical activity and diet quality on our primary (obesity-related cancer risk and mortality) and secondary (breast and colorectal cancers) outcomes, starting from baseline (enrollment) to cancer diagnosis for cancer risk, and from cancer diagnosis to death for mortality. The assumption of proportional hazards was verified for both the primary and secondary study outcomes. For each of the outcomes, three models were fit: model 1 included exposures only; model 2 adjusted for age; and model 3 adjusted for age, BMI, waist circumference, smoking (pack-years), educational attainment, income, randomization WHI arm (hormone therapy, calcium, and diet), participating in observation study, and sedentary time. Crude and adjusted hazard ratios and corresponding 95% confidence intervals (CI) estimated risk of obesity-related cancer and mortality. P values <0.05 were considered statistically significant.

In addition to primary analyses, sensitivity analyses were undertaken to assess the robustness of the multivariable-adjusted Cox proportional hazard model. To ensure women included in the analyses did not have undiagnosed cancer at baseline, women diagnosed with an obesity-related cancer within the first year of enrollment were removed from the dataset and analyses repeated. As a secondary sensitivity analysis, models were developed to reflect diet scores that excluded sodium intake, because it has not been shown to be associated with cancer risk (except for gastric cancers; refs. 37, 38), and dairy consumption to accommodate high-recorded lactose intolerance in Black populations (39, 40). Hazard ratios derived from sensitivity analyses were compared with those from the primary models to gauge the extent to which the results align, and if interpretations from the primary models and sensitivity analyses were the same. All analyses were conducted using the Stata 13 statistical analysis software.

Ethical approval

All data were collected under Human Subjects, Internal Review Board approvals at the 40 institutions participating in the WHI studies. No data were collected without prior written consent from the individual study participant.

Results

Sample size and description of participants

The WHI study included 14,618 Black women enrolled in the OS and clinical trials. Participants were excluded in the present analyses for having missing baseline values for BMI ($n = 133$), smoking ($n = 610$), income ($n = 463$), diet quality score ($n = 14$), physical activity ($n = 293$), education ($n = 103$), and implausible diet values ($n = 1{,}008$). An additional 2,024 and 84 women were excluded for being in the diet modification intervention arm, and not having time-to-event data, respectively. The analytical sample therefore included 9,886 Black women (**Fig. 1**). Generally, the women included ($n = 9{,}886$) and those who were excluded ($n = 4{,}732$) from analysis were comparable with the exception of BMI and educational attainment. Excluded women had higher overall BMI, with 26.4% falling in the obese category, compared with 23.6% of women included in the study. In terms of education, women included in the study exhibited higher attainment, with 27.0% of women included in the analysis receiving some graduate or

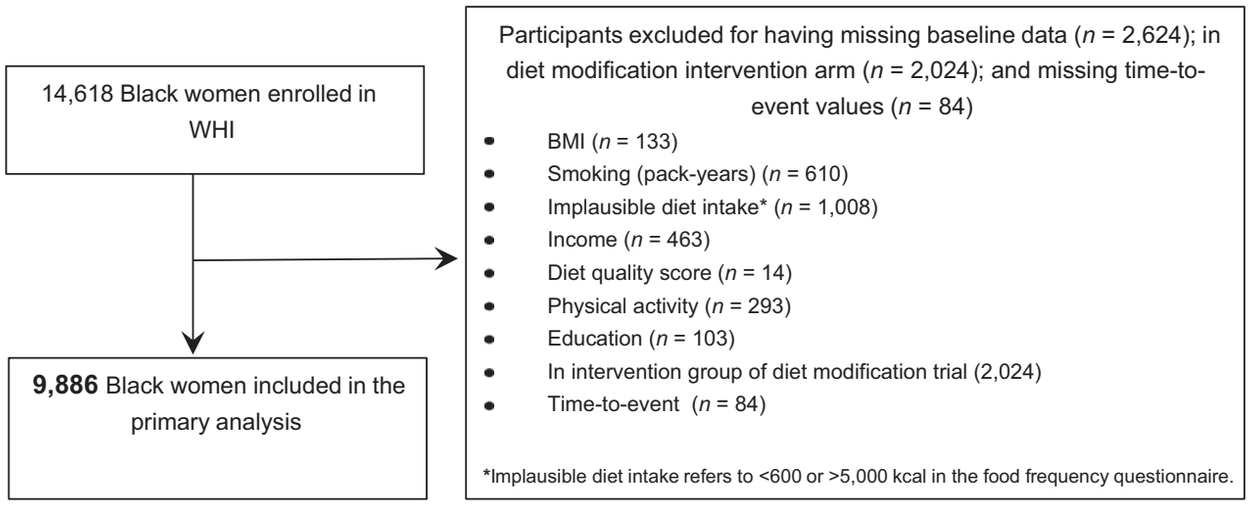

Figure 1.
Flow chart illustrating the number of Black women included in the analyses.

graduate degree, compared with 25.1% of excluded women (Supplementary Table S1).

When stratified by baseline physical activity, we identified that BMI, educational attainment, income, diet quality, smoking and alcohol intake significantly differed between participants who did not meet the recommended physical activity level ($n = 8,013$) and those who did ($n = 1,873$). Compared with women who did not meet the recommended physical activity level, those who did had lower BMI (30.0 kg/m^2 compared with 31.4 kg/m^2); more participants graduating from college (9.8% compared with 8.4%); earned more than $75,000 (15.8% compared with 9.0%); and reported higher diet quality scores (49.3% falling in the highest tertile, compared with 29.6%). Conversely, participants meeting the recommended physical activity level reported fewer never smokers (48.5% compared with 50.6) and fewer never drinkers (14.9% compared with 18%; **Table 1**).

Outcomes: obesity-related, breast, and colorectal cancers

There was no statistically significant difference in the primary or secondary outcomes across physical activity strata (**Table 2**). During the 13-year study follow up period, 950 (9.6%) incident obesity-related cancers were diagnosed within the sample of 9,886 Black women. Of the participants diagnosed with any obesity-related cancer, 146 (15.4%) were classified as being under/normal weight, 560 (58.9%) overweight, and 244 (25.7%) obese. Of the 950 Black WHI participants diagnosed with any obesity-related cancer, 313 (32.9%) died. In the same follow-up period, 500 breast cancer cases were observed in 80 (16.0%) under/normal weight women, 286 (57.2%) overweight women, and 134 (26.8%) obese women. Of the 500 women diagnosed with breast cancer, 97 (19.4%) died. In addition, colorectal cancer was observed in 197 (2%) participants, with 22 (11.2%) of those diagnosed classified as being under/normal weight, 126 (64.0) overweight and 49 (24.8%) being

Table 1. Demographic characteristics of Black women enrolled in the WHI ($n = 9,886$), stratified by baseline physical activity and assessed for difference between physical activity strata.

	Physical activity		
Variable	**None or below recommended level ($n = 8,013$)**	**At or above recommended level ($n = 1,873$)**	***P***
Age, years; *n* (% of sample)			
50–59	3,313 (41.4)	765 (40.8)	0.87
60–69	3,416 (42.6)	811 (43.3)	
70–79	1,284 (16.0)	297 (15.9)	
Body mass index, kg/m^2; *n* (% of sample)			
Underweight/normal weight (≤24.9)	1,256 (15.7)	386 (20.6)	<0.0001
Overweight (25–29.9)	4,745 (59.2)	1,163 (62.1)	
Obese (≥30)	2,012 (25.1)	324 (17.3)	
Educational attainment; *n* (% of sample)			
None–elementary school	254 (3.2)	29 (1.6)	<0.0001
Some high school	746 (9.3)	110 (5.9)	
High school diploma/GED	1,144 (14.3)	208 (11.1)	
Some college, associate degree, or vocational/training school	3,172 (39.6)	692 (37.0)	
College degree	675 (8.4)	184 (9.8)	
Some graduate/graduate degree	2,022 (25.2)	650 (34.7)	
Income, $; *n* (% of sample)			
0–$34,999	4,375 (56.6)	804 (42.9)	<0.0001
$35,000–$74,999	2,626 (32.8)	711 (38.0)	
$75,000–$149,999	662 (8.3)	261 (13.9)	
>$150,000	56 (0.7)	35 (1.9)	
Do not know	294 (3.7)	62 (3.3)	
Diet, HEI-2015 (range 0–100); mean (SD)			
Tertile 1	50.7 (5.8)	52.0 (5.3)	0.001
Tertile 2	63.5 (2.9)	64.1(2.8)	
Tertile 3	74.8 (4.8)	76.0 (4.8)	
Smoking, pack-years; *n* (% of sample)			
Never smoker	4,051 (50.6)	908 (48.5)	0.012
<5 years	1,305 (16.3)	346 (18.5)	
5–20 years	1,478 (18.5)	376 (20.1)	
≥20 years	1,179 (14.7)	243 (13.0)	
Alcohol intake[a]; *n* (% of sample)			
Never drinker	1,430 (18.0)	277 (14.9)	<0.0001
Past drinker	2,728 (34.3)	525 (28.3)	
<1 drink per month	1,027 (12.9)	248 (13.4)	
<1 drink per week	1,373 (17.3)	380 (20.5)	
1–<7 drinks per week	1,050 (13.2)	318 (17.1)	
7+ drinks per week	336 (4.2)	108 (5.8)	

[a]Eighty-six participants missing alcohol intake data.

Table 2. Primary (obesity-related cancer risk and mortality) and secondary (breast and colorectal cancers) outcomes among Black women enrolled in the WHI, stratified by baseline physical activity and assessed for difference between physical activity strata.

	Physical activity		
Outcome	None or below recommended level (n = 8,013)	At or above recommended level (n = 1,873)	P
Any obesity-related cancer			
Cases, *n* (% of sample)	756 (9.4)	194 (10.4)	0.22
Deaths, *n* (% of cases)	257 (34.0)	56 (28.9)	0.61
Breast cancer			
Cases, *n* (% of sample)	384 (4.8)	116 (6.19)	0.13
Deaths, *n* (% of cases)	77 (20.1)	20 (17.2)	0.67
Colorectal cancer			
Cases, *n* (% of sample)	162 (2.0)	35 (1.9)	0.67
Deaths, *n* (% of cases)	50 (30.9)	8 (22.9)	0.32

obese. Of the 197 women who were diagnosed with colorectal cancer, 58 (29.4%) died.

Association between antecedent health behavior and obesity-related cancers

Recommended physical activity levels and HEI-2015 diet quality score exhibited no association on the risk of any obesity-related, breast, and colorectal cancers in the crude, age-adjusted and multivariable-adjusted models (**Table 3**). Similarly, there was no association between physical activity and HEI diet quality score on cancer mortality. Risk estimates derived from sensitivity analyses (removal of cancer cases diagnosed within the first year of enrollment and reconstitution of HEI diet scores to exclude sodium and dairy scores) did not differ notably from the primary analysis, giving confidence to the primary analysis and results (Supplementary Table S2).

Discussion

The antecedent behaviors examined in this study—physical activity and diet quality—did not demonstrate an association with obesity-related cancer risk or mortality among Black women enrolled in WHI studies. Numerous studies have shown an inverse relationship between physical activity and cancer risk; however, analyses focused on Black women are sparse. A systematic review of 34 case–control and 28 cohort studies found evidence for reduced risk of breast cancer, but these associations seemed to be driven by findings in White women more so than Black women (41). Earlier work from WHI that applied the ACS cancer prevention guideline score suggested Black, postmenopausal women in WHI may have greater protection against cancer if adherent to the healthy behaviors advocated including diet and physical activity recommendations (42). The difference in findings may be reflective of contrasting exposure estimate definitions; in that, this study focused on physical activity and diet, whereas the ACS guidelines include an emphasis on adult weight gain and more cancer-specific dietary guidance than the HEI score alone, and also consider smoking history.

Importantly, our analysis was designed to evaluate these lifestyle exposures in Black women, rather than compare and contrast across racial groups, as has been the traditional approach. Our intent is to advance our understanding of modifiable risks specifically in older Black women as it is this knowledge that is necessary to inform on future intervention studies. Our results among Black, postmenopausal women ran contrary to the aforementioned studies, and therefore should be interpreted with caution for several reasons. Black women participating in the WHI studies appear to be healthier and more educated than the general Black population. In the present subsample of Black women, about 11.7% were current cigarette smokers, compared with 14.9% of the US Black population (both male and female), and 12.2% of American women (43). Data specific to Black women were not available. In addition, about 27% had attained some post-graduate, professional degree, or a graduate degree (master or doctoral), compared with 8.9% of all Black women (44). The higher health and educational attainment of the group may suggest greater access to care, including preventive care that may have promoted lower cancer rates. In fact, in this sample, 9.6% were diagnosed with any obesity-related cancer over a 13-year follow-up period. This healthy volunteer effect may have attenuated the association of physical activity and diet quality with cancer risk and mortality, because the women were already at a lower risk for obesity-related cancer. However, the mean HEI score reported in our sample, 62.7 (SD = 10.8) was similar to the national average, 62.3 (SD = 0.8) for Black women ages 60 and older (45). In addition, the high proportion of participants categorized as overweight and obese and with diet and physical activity habits that do not achieve national recommendations suggests that although the healthy volunteer effect is a plausible limitation, it likely had limited influence on the results herein.

In considering racial variance in lifestyle behavior cancer risk associations it is increasingly evident that a life course approach is essential to characterizing disease risk profiles in Black women. Childhood and related life-long stressors (including economic hardship, racism etc.) clearly contribute to higher cancer prevalence among Black women (46–48). WHI did not capture these exposures and as such, future analyses should consider the combined influence of lifestyle behaviors and life stressors in driving obesity-related cancer risk in Black women.

Limitations of these analyses include the reliance on self-reported physical activity and diet quality measures. Although the instruments used to collect the data have been validated, there is known measurement error in diet and physical activity. Importantly, the error may be systematic and more substantial in those with lower educational attainment in WHI (49, 50). Measurement error could therefore partially account for the null results shown here, given previous studies that demonstrate misreporting of self-reported health behaviors compared with more objective biomarker measures (51). Second, the statistically significant difference in

Table 3. Cox proportional hazard models of antecedent behavior (physical activity and diet) on obesity-related cancer risk and mortality among Black women enrolled in the WHI.

	Crude model[a] HR (95% CI)	Age-adjusted model[b] HR (95% CI)	Multivariable model[c] HR (95% CI)
Cancer risk			
Physical activity—MET-hr/wk			
No or below recommended PA	Referent	Referent	Referent
Obesity-related cancer ($n = 950$)	1.02 (0.87–1.19)	1.03 (0.86–1.21)	1.05 (0.86–1.30)
Breast cancer ($n = 500$)	1.19 (0.96–1.47)	1.19 (0.96–1.47)	1.19 (0.91–1.57)
Colorectal cancer ($n = 197$)	0.83 (0.57–1.20)	0.84 (0.58–1.22)	0.98 (0.61–1.57)
Diet—HEI-2015[d]			
Obesity-related cancer ($n = 950$)	1.01 (0.95–1.07)	0.99 (0.93–1.05)	0.99 (0.92–1.08)
Breast cancer ($n = 500$)	1.02 (0.94–1.11)	1.01 (0.93–1.10)	0.97 (0.87–1.09)
Colorectal cancer ($n = 197$)	1.07 (0.98–1.23)	1.03 (0.91–1.18)	1.13 (0.94–1.36)
Combined effect of physical activity and diet			
Obesity-related cancer ($n = 950$)	1.02 (0.87–1.20)	1.01 (0.87–1.19)	1.05 (0.85–1.29)
Breast cancer ($n = 500$)	1.22 (0.98–1.50)	1.21 (0.98–1.50)	1.16 (0.89–1.53)
Colorectal cancer ($n = 197$)	0.89 (0.61–1.29)	0.87 (0.60–1.27)	1.11 (0.69–1.78)
Cancer mortality			
Physical activity—MET-hr/wk			
No or below recommended PA	Referent	Referent	Referent
Obesity-related cancer ($n = 313$)	0.83 (0.62–1.11)	0.84 (0.63–1.13)	0.87 (0.60–1.26)
Breast cancer ($n = 97$)	0.98 (0.59–1.62)	0.99 (0.60–1.64)	0.98 (0.53–1.80)
Colorectal cancer ($n = 58$)	0.62 (0.29–1.33)	0.64 (0.30–1.37)	0.72 (0.27–1.91)
Diet—HEI-2015[d]			
Obesity-related cancer ($n = 313$)	1.04 (0.93–1.15)	0.98 (0.89–1.09)	0.98 (0.85–1.12)
Breast cancer ($n = 97$)	1.15 (0.95–1.39)	1.13 (0.94–1.37)	0.96 (0.77–1.22)
Colorectal cancer ($n = 58$)	1.02 (0.81–1.30)	0.96 (0.76–1.22)	1.02 (0.74–1.41)
Combined effect of physical activity and diet			
Obesity-related cancer ($n = 313$)	0.86 (0.64–1.15)	0.83 (0.62–1.11)	0.85 (0.59–1.23)
Breast cancer ($n = 97$)	1.13 (0.68–1.89)	1.12 (0.68–1.85)	0.94 (0.51–1.74)
Colorectal cancer ($n = 58$)	0.64 (0.30–1.36)	0.61 (0.29–1.31)	0.74 (0.28–1.95)

[a]Model with exposures only (physical activity or diet quality).
[b]Model 1 adjusted for age.
[c]Model 2+ adjusted for BMI, waist circumference, smoking (pack-years), educational attainment, income, randomization WHI arm (hormone therapy, calcium, and diet), participating in observation study, and sedentary time.
[d]HR and confidence interval reported for a 10-point increase in HEI-2015 score.

educational attainment and BMI among women included and excluded in the study may have potentially introduced selection bias. However, these differences do not appear to be clinically significant and are likely explained by the large size of our analytical sample. Finally, heterogeneity in the etiology of some obesity-related cancers may have led to misclassification bias in our sample. For example, while the majority of endometrial cancers are low-grade and appear to be related to obesity, high-grade tumors are more prevalent in black women and have less evidence of an association to body weight (52, 53).

Our work contributes to the evidence against lifestyle behaviors as significant predictors of obesity-related cancer risk and mortality in an understudied and disproportionately affected segment of our population. More research is required to understand which social, behavioral and biological factors contribute to racial disparity in obesity-related cancers, as well as the intervening mechanisms of these associations among Black women.

Disclosure of Potential Conflicts of Interest

R.T. Chlebowski reports receiving speakers bureau honoraria from Novartis, Amgen, AstraZeneca, Genentech, Immunomedics, and Pfizer. No potential conflicts of interest were disclosed by the other authors.

Authors' Contributions

Conception and design: J.J. Chebet, J.E. Manson, M.L. Bell
Development of methodology: J.J. Chebet, L.N. Kohler
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): R.T. Chlebowski, J.E. Manson
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): J.J. Chebet, L.N. Kohler, R.T. Chlebowski, J.E. Manson, M.L. Bell
Writing, review, and/or revision of the manuscript: J.J. Chebet, C.A. Thomson, L.N. Kohler, J.E. Ehiri, J. Luo, T.-Y.D. Cheng, K. Pan, R.T. Chlebowski, R. Nassir, S. Sealy-Jefferson, J.E. Manson, N. Saquib, M.L. Bell
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): J.J. Chebet, C.A. Thomson, J.E. Ehiri
Study supervision: J.J. Chebet, R.T. Chlebowski, R. Nassir

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Clinical Coordinating Center: Garnet Anderson, Ross Prentice, Andrea LaCroix, and Charles Kooperberg (Fred Hutchinson Cancer Research Center, Seattle, WA).
Investigators and Academic Centers: JoAnn E. Manson (Brigham and Women's Hospital, Harvard Medical School, Boston, MA); Barbara V. Howard (MedStar Health Research Institute/Howard University, Washington, DC); Marcia L. Stefanick (Stanford Prevention Research Center, Stanford, CA); Rebecca Jackson (The Ohio State University, Columbus, OH); Cynthia A. Thomson (University of Arizona, Tucson/Phoenix, AZ); Jean Wactawski-Wende (University at Buffalo, Buffalo, NY); Marian Limacher (University of Florida, Gainesville/Jacksonville, FL); Robert Wallace (University of Iowa, Iowa City/Davenport, IA); Lewis Kuller (University of Pittsburgh, Pittsburgh, PA); and Sally Shumaker (Wake Forest University School of Medicine, Winston-Salem, NC).
Women's Health Initiative Memory Study: Sally Shumaker (Wake Forest University School of Medicine, Winston-Salem, NC).

For a list of all investigators who have contributed to WHI science, please visit: https://cleo.whi.org/researchers/SitePages/Write%20a%20Paper.aspx.

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