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Adherence to diet, physical activity and body weight recommendations and breast cancer incidence in the Black Women's Health Study

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Abstract

Adherence to cancer prevention recommendations has been associated with lower incidence of breast cancer in previous studies, but evidence in African American women is limited. This project evaluated the association between adherence to the World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) cancer prevention recommendations and breast cancer incidence among African American women. The Black Women's Health Study (analytic cohort=49,103) is an ongoing prospective cohort study of African American women, ages 21–69 years at baseline (1995). Adherence scores for seven WCRF/AICR recommendations (adherent=1, partial adherence=0.5, non-adherence=0) were calculated using questionnaire data and summed for overall (Maximum=7) and diet only (Maximum=5) scores. Associations between baseline and time-varying adherence scores and breast cancer incidence (N=1,827 incident cases through 2011) were evaluated using proportional hazards regression. In this cohort, 8.5% adhered >4 recommendations. Adherence at baseline was not associated with breast cancer incidence. Higher overall time-varying adherence (per 0.5 point increase) was associated with lower breast cancer incidence (HR: 0.90, 95% CI: 0.84–0.96). Adherence to physical activity, sugar beverage, and red and processed meat recommendations were also associated with reduced risk. Adherence to the WCRF/AICR recommendations was low and may be associated with lower breast cancer incidence in African American women.

Keywords

Breast Cancer; Diet; Physical Activity; Body Weight; African American

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Introduction

Breast cancer is the leading cancer type in African American women ¹ and African American women are also more likely to be diagnosed with hormone receptor negative subtypes ², resulting in poorer prognoses ³. Diet, physical activity and body composition are considered to be important potential modifiable risk factors in breast cancer risk and represent targets for primary prevention ⁴. The impact of these factors may differ by breast cancer subtypes ⁵ and menopausal status ⁴. The World Cancer Research Fund and American Institute for Cancer Research (WCRF/AICR) Report indicates that high alcohol intake, overall body fatness, abdominal fatness, adult weight gain and low physical activity are associated with an increased risk for postmenopausal breast cancer ⁴. Data is inconsistent among premenopausal women, but higher alcohol intake may increase risk, while a larger body size and high physical activity levels may lower risk ⁴.

Adherence to dietary, physical activity and body composition recommendations targeting cancer prevention has previously been shown to be associated with lower cancer incidence overall ^{6–12}, and breast cancer, specifically ^{7–15}. Most studies have evaluated the WCRF/AICR diet, physical activity and body weight recommendations ¹⁶, which include eight categories ^{6–9, 13–15}. A recently published systematic review of studies evaluating adherence to diet and physical activity cancer prevention recommendations and cancer reported consistently lower breast cancer incidence (19–60%) among women who adhered to a larger number of recommendations ¹⁷. In the Women's Health Initiative, better adherence to recommendations was associated with a lower risk of cancer (any type) among African American women, but generally adherence studies have been conducted in primarily Caucasian populations ¹¹. Evidence remains limited among African Americans and the relation of guidelines to breast cancer risk has not previously been evaluated in African American women.

Adherence to the WCRF/AICR recommendations may be lower in African American women than women of other races/ethnicities. African Americans are less likely to meet U.S. Dietary Guideline recommendations for intake of fruits, vegetables, dairy and added sugars than whites and Hispanics ¹⁸. Additionally, the prevalence of obesity is higher in African American women (56.6% compared to 32.8% in Caucasian and 44.4% in Hispanic women 20 years of age in the United States) ¹⁹, and African American women are also less likely to meet physical activity recommendations ^{20–22}. Data on levels of adherence could illuminate areas of limited adherence to target for breast cancer prevention among African American women. The objective of this project assess levels of adherence to the 2007 WCRF/AICR diet, physical activity and body composition cancer prevention recommendations among African American women and investigate whether adherence to the recommendations is associated with breast cancer incidence.

Materials and Methods

The Black Women's Health Study (BWHS) is an ongoing prospective cohort study of 59,000 African American women in the United States begun in 1995 ²³. Women who were 21–69 years of age and completed mailed health questionnaires comprised the cohort. Most

were subscribers to Essence magazine, and a small number were recruited from several professional organizations or were friends or relatives of early respondents. Every other year after baseline, participants were followed through mailed questionnaires. Deaths were identified by reports from family members, U.S. Postal Service and via the National Death Index. Follow-up of the baseline cohort is complete for 87% of potential years of follow-up through 2011. The study was approved by the Institutional Review Board of Boston University Medical Center and informed consent was obtained from all study participants.

Data Collection

The baseline questionnaire collected data on demographics, medical and reproductive history, diet and lifestyle habits, including data utilized to operationalize adherence to the WCRF/AICR cancer prevention recommendations (diet, physical activity, body weight). Every other year after 1995, follow-up questionnaires updated information on risk factors, covariates and ascertained incident disease. The baseline questionnaire (68-item) and 2001 follow-up questionnaire (85-item) included a food frequency questionnaire (FFQ). Additional data on other recommendation components were collected on follow-up questionnaires as follows: diet (2001), alcohol intake (all questionnaires), physical activity (1997, 1999, 2001, 2007, 2009), time sitting (1997, 1999, 2001) and weight (all questionnaires).

Height (1995) and current weight were used to calculate body mass index (BMI) (kg/m^2). Adult weight change was calculated by subtracting weight at age 18 from reported current weight. Physical activity was ascertained by selecting hours per week (None, <1, 1, 2, 3–4, 5–6, 7–9, 10 hours/week) spent engaged in strenuous activities and walking for exercise. Sedentary time was estimated from hours per day (None, <1, 1–2, 3–4 5 hours/day) spent sitting at work and watching television. A validation study of self-reported physical activity and body measures was previously published ²⁴.

Most diet data was collected via FFQ. For each food item, participants reported their frequency of intake (foods: ‘never’ to ‘2+ per day; beverages: ‘never’ to ‘6 or more per day’) and identified their typical portion size (1995: ‘small’, ‘medium’ and ‘large’; 2001: added ‘super’ size) relative to a defined medium size for each food or beverage item. A small portion was weighted as 0.5, a large as 1.5 times, and a super as 2.0 times a medium serving size. Nutrient estimates for caloric, fiber and sodium intakes were calculated using the National Cancer Institute’s DietCalc software. The baseline FFQ was previously validated in this study population ²⁵. Alcohol use was collected separately from the FFQ and reported as the frequency of drinks (beer, wine, liquor) consumed per week (<1, 1–3, 4–6, 7–13, 14–20, 21).

Data on covariates were also collected at baseline and on follow-up questionnaires, including menopausal status. Menopausal status was determined by presence/absence of menstruation and age. Women were classified as postmenopausal if they reported their periods had ceased due to natural causes or removal of both ovaries or if they had a hysterectomy but retained one or both ovaries and were older than 56 years. Women who still had periods were classified as premenopausal; in addition, women who reported a

hysterectomy, but retained one or both ovaries and were less than 43 years of age were classified as premenopausal.

Case ascertainment

Cases of invasive breast cancer from baseline through 2011 were ascertained through self-report on the follow-up questionnaires and through linkage with 24 cancers registries in states in which 95% of participants lived. Hospital or registry pathology data were obtained for >85% of cases, among which 99.4% were confirmed. Unless a self-reported case was found to be incorrectly reported, all self-reported cases were included. During follow-up, 1,827 (n=711 premenopausal, n=881 postmenopausal, n=235 undefined menopausal status) primary breast cancer cases were identified.

Among breast cancer cases with pathology reports there were 686 cases positive for estrogen receptor (ER) and progesterone receptor (PR) (ER+/PR+), 196 positive for either ER or PR (ER+/PR- or ER-/PR+), and 399 negative for both ER and PR (PR-/PR-). Additionally, there were 166 women diagnosed with triple negative breast cancer (ER-/PR-/HER2-).

Analytical cohort

Women who reported a previous history of cancer (excluding non-melanoma skin cancer) (n=1,256, including 729 breast cancer cases), were pregnant at baseline (n=1,002), or reported implausible energy intake (<600 kcal or >3,800 kcal) (standard cut-points used in BWHS) or left more than 10 FFQ items blank (n=7,640) were excluded. The analytic cohort included 49,103 women (681,125 person-years through 2011).

WCRF/AICR Score Creation

Questionnaire data were used to create adherence scores for the 2007 WCRF/AICR recommendations¹⁶. The guidelines, definitions and cut-points are outlined in Table 1. Seven categories were included in the adherence score for this analysis. The energy density recommendation only includes sugar beverage intake and the supplement usage recommendation was not included due to a lack of data available necessary to calculate adherence to these recommendations. The WCRF/AICR recommendations include two supplementary recommendations for special populations: a recommendation to breastfeed for up to 6 months and for survivors to follow the recommendations for cancer prevention. We elected to not include adherence to the breastfeeding recommendation to our score because it is a recommendation targeted for specific populations. It is not a modifiable risk factor in the general population in the same way as diet, physical activity and body weight recommendations due to its dependence on parity and other factors, such as sufficient milk supply. This approach is consistent with several previous studies evaluating adherence to cancer prevention recommendations and breast cancer risk^{13, 15, 26, 27}.

For each individual recommendation, 1 point was assigned for adherence, 0.5 points for partial adherence (closer to adherence cut-point) and 0 points for non-adherence (further from adherence cut-point). The three level scores were used rather than a binary variable of adherences vs. non-adherence to allow for evaluations of the difference between complete adherence and differing levels of non-adherence. The rationale for this was that barely

missing the cut-point for adherence is different from missing the adherence cut-point by a larger margin. This approach is consistent with several previously published articles evaluating WCRF/AICR adherence levels and cancer incidence ^{7, 28}.

When the WCRF/AICR recommendations provided specific cut-points, they were used in score creation ¹⁶. Other cut-points were chosen for comparability to previously published analyses or based on other standard dietary recommendations. To be considered adherent to a recommendation participants had to meet all components of the recommendation for which data was available in this study. The standard BMI cut-points defined as the normal range (18.5 –<25 kg/m) was utilized for adherence to maintaining a body weight in the normal range. There is no standardized cut-point for adult weight gain. A weight gain of more than 15 pounds (6.8kg) was previously associated with an increased breast cancer in the BWHS and was chosen as the cut-point for avoiding adult weight gain ²⁹. Physical activity adherence was defined as reporting 3–4 hours/week of vigorous activity to approximate a minimum of 30 minutes/day. Women who reported walking for exercise for 5–6 hours/week were additionally considered adherent. There are no established cut-points for sedentary time and time spent sitting has not been included in previous adherence studies. Limiting sedentary behavior was defined as sitting a combined <8 hours/day at work and watching television to approximate a full day sitting at work, while limiting leisure time spent sitting.

Among the dietary recommendations, sugar beverage intake cut-points were chosen to be consistent with previous reports that have included the sugar intake component ^{7, 26, 28}. Adherence to the plant food recommendation was operationalized using fruit and vegetable intake and fiber intake similar to previous reports ^{7, 26, 28}. The cut-off for adherence at 5 servings (400 grams=1 serving) and 25 grams of fiber are based on WCRF/AICR defined cut-points ¹⁶. Adherence to the meat intake recommendation for overall intake was defined as 500g/week based on the WCRF/AICR recommendation ¹⁶. The cut-point for adherence to limit processed meat to <3 grams/week was chosen for comparability with previous adherence studies ^{7, 10, 28}. The WCRF/AICR report recommends consuming an average of less than 1 alcohol drink/day for women ¹⁶. Due to the way alcohol intake was collected in the BWHS a slightly lower cut-point was used (<7 servings/day). Adherence to this recommendation was very high, despite this slightly lower cut-point. A lower sodium intake of 1500 mg/day was chosen because this is the recommended intake for African Americans in the Dietary Guidelines ³⁰. Scores for all individual recommendations were summed to an overall WCRF/AICR recommendation adherence score (maximum=7), and all diet recommendations were summed to create a diet-specific adherence score (maximum=5).

Statistical Analysis

Proportional hazards regression was used to calculate hazard ratios and 95% confidence intervals. Participants contributed person-time from baseline until the occurrence of breast cancer, loss to follow-up, death, or the end of follow-up in 2011. Average follow-up time was 13.86 years. The WCRF/AICR overall score, diet only score, and individual recommendations were evaluated as both continuous (unit size = 0.5 point) and categorical variables. The WCRF/AICR overall score (<3.0, 3.0–4.0, >4.0 points) and diet only score

(<2.0, 2.0–3.0, >3.0 points) were categorized into groups to reflect adherence to less than half, approximately half and more than half of the recommendations. Individual recommendation categories were based on the three scoring levels of adherence, partial adherence and non-adherence. Test for trend was evaluated by analyzing the categorical variable as continuous. All models were additionally run with breast cancer subtypes as the outcome (subtypes evaluated: ER+/HR+, ER+/PR- or ER-/PR+, ER-/PR-).

Two analytic approaches were used to evaluate adherence. In the first, baseline data (1995) on the exposure variables and covariates were used, which is consistent with the approaches of previously published studies^{6–10}. Since adherence to the recommendations likely varies over time, we also conducted a time-varying analysis using the Andersen-Gill method to update individual recommendation scores and covariates³¹.

Covariates in the adjusted model were chosen *a priori* based on factors known or suspected to be associated with breast cancer risk and with lifestyle habits. All adjusted models included age (continuous), geographic region of residence (Northeast, South, Midwest, West), daily caloric intake (continuous), smoking (never, former, <15 cigarettes/day, 15 cigarettes/day), family history of breast cancer (yes/no), education (12, 13–15, 16 years), menopausal status (premenopausal, postmenopausal), duration of postmenopausal female hormone supplement use (none, <5 years, 5 years), duration of oral contraceptive use (never, <5 years, 5 years) and parity (none, 1–2, 3). When diet score and individual recommendations were evaluated, BMI (<25, 25–<30, 30 kg/m²), alcohol intake (<1, 1–6, 7–13, 14 drinks/week), physical activity level (high: 3–4 hours/week vigorous activity or 5–6 hours/week walking for exercise, moderate: 1–2 hours/week vigorous exercise or 1–4 hours/week walking for exercise, low: <1 hour/week vigorous exercise or walking for exercise) and sedentary time (5, 5–7, 8 hours/day sitting) were included in models where the variable was not part of the score being evaluated (diet score example: BMI, physical activity and sedentary time were included, but alcohol was not because it was included in the score). Mammography usage was not associated with breast cancer incidence or adherence to recommendations; therefore, it was not included in the final adjusted models. Analyses were repeated stratified by menopausal status. Women's menopausal status was updated over time. A woman classified as premenopausal at baseline contributed person-time as premenopausal until reclassified as postmenopausal. Tests for interaction by menopausal status were evaluated using likelihood ratio tests.

Sensitivity analyses were completed excluding participants diagnosed with breast cancer within 4 years of baseline; associations were weaker, but directions of associations did not change. Therefore, only results from analyses including all cancer cases diagnosed after baseline are presented. We also evaluated additional BMI cut-off points for defining overweight and obese (additional analyses: (1) tertiles, (2) adherent BMI<30, non-adherent BMI 30–<35 or 35, (3) adherent BMI <27, non-adherent BMI 27–<32 or 32) since the standard BMI cut-offs may not be as appropriate in African American women³⁰. Changing BMI cut-points did not alter the association between adherence to the body composition recommendation and breast cancer, so we present results with the standard BMI cut-points. Analyses were conducted using SAS 9.3 (SAS Institute, Inc.).

Results

Combined adherence and adherence to the individual recommendations for the overall cohort are presented in Table 1. For the overall score, 8.5% of women adhered to more than 4 recommendations, while 5.4% adhered to at least 3 diet recommendations. Except for the alcohol recommendation (94.2%), adherence to individual recommendations was less than 25% for any particular recommendation. Participants were least likely to meet the body weight (15.0%), plant food intake (1.8%), and sugar beverage intake (1.8%) recommendations.

Baseline population characteristics by baseline WCRF score category are presented on Table 2. Greater adherence scores were associated with younger age, lower BMI, lower caloric intake, lower alcohol intake, never smoking, and higher education levels ($p < 0.01$ for all associated characteristics, Wald chi-square test or analysis of variance). Scores did not vary ($p > 0.05$) by marital status, mammography use, family history of breast cancer, age at menarche, menopausal status, parity, or oral contraceptive use.

In the baseline model, regardless of analytic approach (continuous or categorical), the WCRF/AICR overall score was not associated with breast cancer incidence (per-0.5 unit increase in score HR: 0.96, 95% CI: 0.90–1.02) (Table 3). Similarly, adherence to more dietary recommendations at baseline was not associated with breast cancer incidence (per-0.5 unit increase in score HR: 0.99, 95% CI: 0.91–1.07). With the exception of physical activity (adherent vs. non-adherent HR: 0.85, 95% CI: 0.74–0.97), adherence to individual recommendations at baseline was also not associated with breast cancer risk.

In time-varying models, the overall WCRF/AICR score was significantly associated with breast cancer incidence when evaluated continuously (per-0.5 point increase HR: 0.90, 95% CI: 0.84–0.96). While the test for trend was significant, adherence to more than four recommendations was not significantly associated with breast cancer incidence compared to adherence to less than three (HR: 0.84, 95% CI: 0.65–1.08). Combined diet score was borderline significantly associated when evaluated continuously (per-0.5 unit increase HR: 0.91, 95% CI: 0.83–0.99), but not when evaluated categorically (>3 vs. <2 HR: 0.89, 95% CI: 0.70–1.13). Consistent with results from the baseline model, higher adherence to the physical activity recommendations was associated with lower incidence (adherent vs. non-adherent HR: 0.73, 95% CI: 0.60–0.89), while sugar beverage intake (borderline) (adherent vs. non-adherent HR: 0.73, 95% CI: 0.54–1.00), and red and processed meat intake (adherent vs. non-adherent HR: 0.80, 95% CI: 0.66–0.95) recommendations were additionally associated with lower breast cancer incidence in time-varying analyses.

Results stratified by menopausal status are presented on Table 4. Consistent with the overall model, associations were not significant in the baseline models, so only time-varying models are presented. Premenopausal women with greater adherence to WCRF/AICR recommendations (per-0.5 unit increase HR: 0.90, 95% CI: 0.82–1.00) and diet recommendations (per-0.5 unit increase HR: 0.87, 95% CI: 0.76–1.00) had a borderline statistically significant lower breast cancer incidence compared to women who adhered to fewer recommendations. Adherence to the red and processed meat recommendation was the

only individual recommendation significantly associated with premenopausal breast cancer (adherent vs. non-adherent HR: 0.71, 95% CI: 0.53–0.94). Sugar beverage intake test for trend was statistically significant ($p=0.02$), but the hazard ratio for adherence compared to non-adherence included the null value. Among postmenopausal women, adherence to more WCRF/AICR recommendations was also associated with reduced breast cancer incidence in the continuous model (per-0.5 unit increase HR: 0.90, 95% CI 0.81–0.99). Diet score and individual dietary factors were not associated with postmenopausal breast cancer risk, but higher adherence to physical activity recommendations was associated with lower breast cancer risk (adherent vs. non-adherent HR: 0.70, 95% CI: 0.52–0.95). Except for adherence to diet recommendations evaluated categorically ($p=0.01$), tests for interaction between adherence and menopausal status were not statistically significant.

Time-varying analyses by breast cancer tumor subtypes (ER+/PR+, ER+/PR- or ER-/PR+, and ER-/PR-) are presented on Table 5. Supplementary Table 1 provides study results for triple negative breast cancer. Combined adherence was only associated with ER-/PR- breast cancer incidence (>4 vs. <3 recommendations HR: 0.32, 95% CI: 0.14–0.74), but this was based on only 12 cases in the >4.0 category. Adherence to combined diet recommendations was not statistically significantly associated with any subtype. Among the individual recommendations, non-adherence to sugary beverage intake recommendations was associated with a higher incidence of ER+/PR+ breast cancers (adherence vs. non-adherence HR: 0.55, 95% CI: 0.32–0.93). Adherence to the intake of plant foods recommendation was positively associated with ER+/PR+ breast cancer incidence, but should be interpreted with caution due to high non-adherence to this recommendation (27 cases, 15,238 person years in adherent group). Adherence to the red and processed meat recommendations inversely associated with ER-/PR- breast cancers (adherent vs. non-adherent HR: 0.60, 95% CI 0.43–0.94). Adherence to the physical activity recommendation was associated with a lower risk of triple negative breast cancer (adherence vs. non-adherence HR: 0.40, 95% CI: 0.16–0.99). Adherence to individual recommendations was not associated with breast cancers positive for either ER+ or PR+ only.

Discussion

In this prospective cohort of African American women, adherence to the WCRF/AICR cancer prevention recommendations in time-varying analyses was associated with a lower incidence of breast cancer in both pre- and postmenopausal women. Higher overall adherence was associated with a lower incidence of ER-/PR- tumors, but not with ER+/PR+, ER+/PR- or ER-/PR+ subtypes. With regard to individual recommendations, adherence to diet recommendations (red and processed meat and sugar beverage intake), and the physical activity recommendation were inversely associated with breast cancer risk. However, body weight and alcohol recommendations, factors that are considered important for breast cancer prevention^{4, 32}, were not associated with breast cancer risk in this population. Associations with dietary factors were stronger among premenopausal women, while physical activity was associated with breast cancer incidence in postmenopausal women. Sugary beverage intake was associated with ER+/PR+ tumors, red and processed meat was associated with ER-/PR- tumors, and adherence to the physical activity recommendation was inversely associated with triple negative breast cancer.

Despite important differences in score operationalization and analysis, adherence to a larger number of cancer prevention recommendations has consistently been associated with a reduced incidence of both breast cancer^{7–15} and cancer overall^{6, 7, 10–12}. Only baseline data was used in these prior studies to construct the adherence scores. We used both baseline and time-varying approaches and observed associations between overall adherence with breast cancer incidence only in time-varying models. Accounting for changes in habits over time may have reduced misclassification and contributed to stronger associations in the time-varying analysis.

Physical activity levels and alcohol intake are modifiable factors associated with breast cancer risk⁴. Adherence to the physical activity recommendations was inversely associated with breast cancer risk in the BWHS. Among the prior adherence studies that evaluated individual recommendations and breast cancer incidence, adherence to physical activity recommendations was inversely associated in one case-control³³ and two prospective cohort studies (borderline statistically significant)^{13, 15}. In the three other prospective cohort studies^{8–10} and one case-control study¹⁴, adherence to physical activity recommendations was not associated with breast cancer incidence. In addition to the differences in study populations, this difference may be partially due to the inclusion of sedentary behavior in our score, which was not included in any of the previous studies and is increasingly considered a potential risk factor for disease^{34, 35}. While four previous prospective cohort studies reported an association with adherence to alcohol intake recommendations^{8–10, 13}, and one reported a non-statistically significant inverse associations¹⁵, there was no association in the present study. The lack of association between alcohol intake and breast cancer risk in our analysis is likely related to an adherence level exceeding 94% in this study population, which is consistent with low alcohol intake reported among African American women³⁶. The lack of association between adherence to alcohol intake and breast cancer was also observed in two case-control studies with high adherence to this recommendation^{14, 33}.

Despite prior evidence for the role of body composition in breast cancer development and progression, only two previous prospective cohort studies observed a clear benefit of adhering to this recommendation^{8, 13}. One case-control study among Mexican women observed an increased odds of breast cancer among women who adhered to the body weight recommendations compared to non-adherent women³³. The emphasis of the recommendation on weight and standard weight-driven BMI recommendations, as opposed to fat mass or abdominal obesity, may not fully capture the impact of body composition on breast cancer risk among African Americans^{4, 37, 38}.

This is the second prospective cohort study to evaluate combined adherence to diet recommendations and breast cancer. In the Iowa Women's Health Study (IWHS), combined adherence to diet recommendations was not associated with postmenopausal breast cancer risk¹³. While combined adherence to diet recommendations was associated with overall breast cancer incidence in the present study, diet adherence was also unassociated with postmenopausal breast cancer risk in the current study population. In our analysis, sugar beverage intake and red and processed meat intake appeared to be the main dietary factors contributing to the overall diet adherence and breast cancer associations. Two previous

studies observed an association with combined energy density and sugar beverage intake, which the BWHS did not have the relevant data to evaluate^{9, 14}. Higher sugar beverage intake may contribute to breast cancer risk via the role of insulin, insulin-like growth factor and insulin resistance on breast cancer development and progression³⁹. Adherence to red and processed meat intake recommendations was also inversely associated with breast cancer risk in two^{9, 15} previous cohort studies, but positively associated in a prior case-control study³³. Red and processed meat are known to have carcinogenic compounds⁴⁰, but associations and potential mechanisms for breast cancer remain unclear^{41, 42}.

No previous prospective cohort studies have evaluated whether the benefits of adherence differed between pre- and postmenopausal cancer, but current evidence indicates there may be differences in the etiology of pre- and postmenopausal breast cancer⁴. Associations in two prior case-control studies overall did not differ by menopausal status^{14, 33}. While tests for interaction in the present study were generally not statistically significant, associations for dietary factors were generally stronger among premenopausal women and the association for physical activity was stronger among postmenopausal women. Small numbers for some categories likely limited the ability to detect an interaction, which require larger samples than evaluations of main effects. Our dietary findings for both energy density/sugar beverage and red and processed meat recommendations are consistent with results from the only other prospective study to include premenopausal women and evaluate individual diet recommendations and breast cancer incidence⁹. In the IWHS, which is comprised of only postmenopausal women, adherence to physical activity recommendations was inversely associated (borderline statistical significance) with breast cancer incidence¹³.

Only one previous prospective cohort study¹⁵ and one previous case-control study¹⁴ evaluated cancer prevention recommendation adherence associations by breast cancer subtypes. In contrast to our results, a stronger inverse associations with for overall adherence, and body weight recommendation adherence, in particular, for ER+/PR+ breast cancers in the Swedish Mammography Cohort¹⁵. While not statistically significant, adherence to plant food and meat intake recommendations was inversely associated with ER-/PR- breast cancers in the same cohort. In the case-control study, lower overall adherence was associated with increased odds of breast cancer, regardless of sub-type¹⁴. For individual recommendations, adherence to energy density and alcohol intake recommendations was inversely associated with ER+/PR+/HER2- breast cancer, and adherence to energy density and plant food recommendations was inversely associated with triple negative breast cancer. There is limited and inconsistent data on diet, body weight, and physical activity and breast cancer subtypes⁴³⁻⁵¹. Weight gain or obesity may be associated with ER+ tumor types in postmenopausal women^{47, 48}, and ER- tumor types in premenopausal women⁴⁶. Some evidence suggests that diet quality⁴⁹ and fruit and vegetable intake⁴⁵ may also be associated with HR- tumor subtypes. Physical activity has not been consistently associated with any individual subtype^{43, 50, 51}. Numbers of cases by subtype were limited, but results from this study suggest that higher adherence to physical activity recommendations may be associated with lower incidence of triple negative breast cancer. These results warrant further investigation as hormone receptor negative breast cancer overall and triple negative, in particular, are more common among African American women² and are associated with a worse prognosis³.

Observed adherence to cancer prevention recommendations in previous studies has generally been low^{6–12}. Adherence in this cohort of African American women was even lower for many recommendations. Almost 60% of women in this study were non-adherent to body composition recommendations and less than 2% adhered to sugar beverage intake and plant-based diet recommendations. Conversely, adherence to the alcohol intake recommendation, the only consistent factor associated with breast cancer risk in previous studies, was very high in the BWHS, which indicates some recommendations be less helpful targets for reducing cancer risk in African American women.

This is the first study to report on adherence to cancer prevention guidelines and breast cancer risk among African American women. Strengths of the study include the prospective collection of data, the large number of cases, the high follow-up rate, the assessment of both premenopausal and postmenopausal breast cancer, and assessment of breast cancer subtypes. Our time-varying analysis approach accounted for changes in diet and lifestyle behaviors over time.

All measures included in the score were self-reported and subject to measurement error. However, previous validation studies indicate that self-reported data collected on these factors in the BWHS is sufficiently well reported for use in epidemiologic studies^{24, 25} and have been associated with outcomes in the expected manner in the BWHS^{52–54}. Breast cancer subtype information was not available for all breast cancer cases, which resulted in smaller numbers of cases available for this analysis, limiting our ability to detect associations.

Conclusions

Diet and lifestyle recommendations are major focuses of policies aimed at reducing cancer risk. Breast cancer disparities by race/ethnicity in the United States are well established^{55, 56} and dietary and lifestyle differences may contribute to disparities. Since higher adherence to recommendations was associated with reduced breast cancer incidence, while adherence to recommendations was low, it is possible poor adherence to recommendations could influence disparities. Further research is needed to confirm observed associations between individual recommendations and breast cancer incidence, particularly in more diverse study populations. However, these results suggest that work is needed to improve adherence to cancer prevention recommendations among African American women and there may be potential to reduce breast cancer incidence through improving adherence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations Used

AICR	American Institute for Cancer Research
BMI	Body mass index
BWHS	Black Women's Health Study
CI	Confidence interval
ER	Estrogen receptor
ER+	Estrogen receptor positive
ER-	Estrogen receptor negative
FFQ	Food frequency questionnaire
FV	fruits and vegetable servings
G	grams
HER2-	Human epidermal growth factor receptor 2 negative
HR	Hazard ratio
IWHS	Iowa Women's Health Study
Kcal	kilocalories
Kg	kilograms
Mg	milligrams
PA	Physical activity
P	processed meat
RP	red and processed meat
PR	Progesterone receptor
PR+	Progesterone receptor positive
PR-	Progesterone receptor negative
WCRF	World Cancer Research Fund

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Novelty and Impact

Adherence to cancer prevention recommendations has been associated with lower incidence of breast cancer in previous studies, but evidence in African American women is limited. This study contributes important information on adherence among African American women. Study results suggest that work is needed to improve adherence to cancer prevention recommendations among African American women and there may be potential to reduce breast cancer incidence through improving adherence.

Table 1

WCRF/AICR Guidelines and Adherence Scores at Baseline (1995)

Recommendation	Adherence Components	Categories	Score ¹	Cohort N (%)	Cases N (%)
Baseline WCRF/AICR Adherence Score	Sum of all recommendation scores (Maximum = 7.0)	High Moderate Low	>4.0 points 3.0 – 4.0 points <3.0 points	3,628 (8.5) 19,460 (45.5) 19,704 (46.0)	120 (7.7) 720 (46.0) 727 (46.4)
Baseline WCRF/AICR Diet Adherence Score	Sum of dietary recommendation scores (Maximum = 5.0)	High Moderate Low	>3.0 points 2.0 – 3.0 points <2.0 points	2,556 (5.4) 30,520 (64.3) 14,408 (30.3)	112 (6.3) 1,155 (65.4) 499 (28.3)
Be as lean as possible without becoming underweight.	Maintain body weight within normal range; Normal BMI: 18.5 – <25 kg/m ² Overweight BMI: 25 – <30 kg/m ² Obese BMI: ≥30 kg/m ² + Avoid adult weight gain; Body weight at age 18 - current body weight (kg)	Normal BMI and +6.80 kg Overweight BMI and/or +6.81–13.61 kg Obese BMI and/or +13.62 kg	1 0.5 0	7,246 (15.0) 12,086 (25.1) 28,871 (59.9)	196 (10.9) 382 (21.3) 1,241 (67.8)
Be physically active for at least 30 minutes per day.	Physical activity (PA): walking for exercise and vigorous activity levels; High PA: 3–4 hrs./wk. vigorous or 5–6 hrs./wk. walking for exercise; Moderate PA: 1–2 hrs./wk. vigorous or 1–4 hrs./wk. walking for exercise; Low PA: <1 hrs./wk. vigorous or walking for exercise) + Limit sedentary habits: hours spent sitting at work and watching television. High sedentary: 8 hrs./day sitting; Moderate sedentary: >5–<8 hrs./day sitting; Low sedentary 5 hrs./day)	High PA and Low/Moderate Sedentary High PA and High Sedentary or Moderate PA and Low/Moderate Sedentary or Low PA and Low Sedentary Moderate PA and High Sedentary or Low PA and High/Moderate Sedentary	1 0.5 0	11,005 (24.6) 19,514 (43.6) 14,249 (31.8)	349 (21.2) 742 (45.1) 554 (33.7)
Avoid foods that promote weight gain.	Consume energy dense foods sparingly; Data on caloric intake by food gram was not available. Limit intake of sugary drinks; Sugar beverage intake (g/d)	Not included. 0 g/d <250 g/d 250 g/d	--- 1 0.5 0	--- 861 (1.8) 18,132 (36.9) 30,110 (61.3)	--- 31 (1.7) 763 (41.8) 1,033 (56.5)
Eat more of a variety of vegetables, fruits, whole grains & pulses such as beans.	Eat at least 5 servings of fruits and vegetables each day; Servings of fruits and vegetables (FV) per day: ² + Eat relatively unprocessed grains and legumes; Total grams of fiber per week.	5 FV and 25 g fiber/d	1	861 (1.8)	32 (1.8)

Recommendation	Adherence Components	Categories	Score ¹	Cohort N (%)	Cases N (%)
		3 – <5 FV and/or 12.5 – <25 g fiber/d	0.5	8,991 (18.8)	400 (22.6)
		<3 FV and/or <12.5 g fiber/d	0	37,928 (79.4)	1,342 (75.7)
Limit consumption of red meats (such as beef, pork and lamb) and avoid processed meats.	Consume less than 500 grams red meat a week; Total red and processed meat (RP) intake (g/wk.) Consume very little or no processed meat; processed meat (P) intake (g/wk.)	<500 g/wk. RP and <3 g/wk. P	1	8,615 (17.5)	324 (17.7)
		<500 g/wk. RP and 3 – <50 g/wk. P	0.5	28,029 (57.1)	1,050 (57.5)
		500 g/wk. RP and 50 g/wk. P	0	12,459 (25.4)	453 (24.8)
Limit alcoholic drinks.	Limit alcoholic drinks to 1 a day for women; Servings of alcohol per week. (1 standard serving = 10 g)	<7 servings/wk.	1	45,983 (94.2)	1,687 (92.7)
		7 – 13 servings/wk.	0.5	1,836 (3.8)	93 (5.1)
		14 servings/wk.	0	986 (2.0)	40 (2.2)
Limit consumption of salt & avoid mouldy grains and cereals.	Avoid salt-preserved, salted or salty foods; Sodium intake (mg/d) + Avoid mouldy cereals (grains) or pulses (legumes); no data and mouldy grains are not widespread in United States.	1500 mg/d	1	10,789 (22.0)	423 (23.2)
		> 1500 – 2400 mg/d	0.5	18,003 (36.7)	672 (36.8)
		> 2400 mg/d	0	20,292 (41.3)	731 (40.0)
		Not included.	---	---	---
Don't use supplements to prevent cancer.	Insufficient information on supplement usage and reasons for use.	Not included	---	---	---

Abbreviations: AICR, American Institute for Cancer Research; d, day; FV, fruits and vegetables; g, grams; hrs, hours; kg, kilograms; m, meters; mg, milligrams; P, processed meat; PA, physical activity; RP, red and processed meat; wk, week; WCRF, World Cancer Research Fund

¹ Adherence = 1 point, partial adherence = 0.5 points, non-adherence=0 points

² 5 servings = 400 g, 3 servings = 200 g

Table 2

Age-Standardized Characteristics by Baseline (1995) WCRF/AICR Adherence Score Category

	Cohort N (%)	WCRF/AICR Score Categories in 1995 ^I		
		< 3 (N = 19,704)	3 – 4 (N = 19,460)	> 4 (N = 3,628)
Age (years)	49,103 (100)	38.4 ± 10.0	38.3 ± 10.7	36.9 ± 10.6
Weight at 18 (kg)	49,103 (100)	59.8 ± 13.3	57.7 ± 10.9	58.1 ± 9.7
Weight Change (kg)	49,103 (100)	22.3 ± 14.7	14.6 ± 12.8	6.1 ± 9.5
BMI (kg/m ²)				
<25	18,676 (38.5)	25	46	77
25 – <30	15,293 (31.5)	33	32	19
>30	14,580 (30.0)	42	22	5
Kilocalorie Intake/day	49,103 (100)	1,771 ± 641	1,307 ± 557	1,083 ± 425
Smoking				
Never	31,667 (64.8)	62	68	70
Former	9,427 (19.3)	19	19	21
Current <15 cigarettes/day	4,992 (10.2)	12	9	6
Current 15 cigarettes/day	2,803 (5.7)	7	5	3
Alcohol Intake				
<1 drink/week	36,307 (74.4)	71	77	79
1–6 drinks/week	9,676 (19.8)	20	20	20
7–13 drinks/week	1,836 (3.8)	6	2	1
14 drinks/week	989 (2.0)	4	1	0
Education				
12 years	8,753 (17.9)	20	15	9
13–15 years	17,688 (36.1)	39	34	29
16 years	22,575 (46.1)	41	51	62
Marital Status				
Married/Living as Married	19,408 (39.9)	41	40	37
Separated/Divorced/Widowed	12,355 (25.4)	24	24	24
Single	16,870 (34.7)	34	35	39
Mammogram				
Never	20,654 (42.6)	44	43	43
Ever	27,890 (57.5)	55	56	56
Family History				
No	45,370 (92.4)	92	93	93
Yes	3,72 (7.6)	8	7	7
Age at Menarche				
<12 years	14,019 (35.4)	30	28	29
12–15 years	22,043 (45.1)	61	63	64
16 years	9,521 (9.1)	9	9	7
Menopausal Status				

	Cohort N (%)	WCRF/AICR Score Categories in 1995 ^I		
		< 3 (N = 19,704)	3 – 4 (N = 19,460)	> 4 (N = 3,628)
Premenopausal	37,732 (82.0)	78	79	79
Postmenopausal	8,269 (18.0)	16	15	15
Parity				
No children	17,295 (35.4)	32	39	47
1–2 children	22,043 (45.1)	47	44	41
3 children	9,521 (19.5)	21	17	12
Oral Contraceptive Use				
Never	11,474 (23.4)	22	23	24
<5 years	22,158 (45.1)	46	45	44
5 years	15,471 (31.5)	33	33	32

Abbreviations: AICR, American Institute for Cancer Research; BMI, body mass index; kg, kilograms; m, meters; WCRF, World Cancer Research Fund

^I Mean ± standard deviation or percentage

Table 3**WCRF/AICR Guideline Adherence Scores and Breast Cancer Risk**

	Cases N (%)	Person-Years	Baseline Score ¹		Time-Varying Score ²	
			HR (95% CI)	p ³	HR (95% CI)	p ³
WCRF/AICR Score ⁴	1,567	646,097	0.96 (0.90–1.02)	0.16	0.89 (0.84–0.96)	0.002
WCRF/AICR Score				0.66		0.02
< 3.0 points	727 (46.4)	342,263	Reference		Reference	
3.0 – 4.0 points	720 (46.0)	266,850	1.01 (0.90–1.12)		0.87 (0.78–0.99)	
> 4.0 points	120 (7.7)	36,784	0.95 (0.77–1.16)		0.84 (0.65–1.08)	
Diet Score ^{4,5,6}	1,766	658,647	0.99 (0.91–1.07)	0.71	0.91 (0.83–0.99)	0.04
Diet Score ^{5,6}				0.52		0.58
< 2.0 points	499 (28.3)	186,864	Reference		Reference	
2.0 – 3.0 points	1,155 (65.4)	428,748	0.96 (0.86–1.09)		0.98 (0.85–1.12)	
> 3.0 points	112 (6.3)	43,035	0.95 (0.76–1.19)		0.89 (0.70–1.13)	
Body Weight ^{6,7}				0.65		0.79
Non-Adherence	1,214 (67.8)	473,613	Reference		Reference	
Partial Adherence	382 (21.3)	132,326	0.92 (0.82–1.04)		0.96 (0.83–1.10)	
Adherence	196 (10.9)	65,157	1.02 (0.87–1.19)		1.00 (0.81–1.25)	
Physical Activity ^{5,6}				0.03		0.003
Non-Adherence	554 (33.7)	300,817	Reference		Reference	
Partial Adherence	742 (45.1)	282,958	0.98 (0.87–1.09)		0.92 (0.82–1.03)	
Adherence	349 (21.2)	83,020	0.85 (0.74–0.97)		0.73 (0.60–0.89)	
Sugar Beverages ^{5,6,7}				0.70		0.02
Non-Adherence	1,033 (56.5)	383,265	Reference		Reference	
Partial Adherence	763 (41.8)	279,346	1.03 (0.93–1.14)		0.91 (0.81–1.02)	
Adherence	31 (1.7)	18,515	0.71 (0.50–1.02)		0.73 (0.54–1.00)	
Plant Foods ^{5,6,7}				0.87		0.49
Non-Adherence	1,342 (75.7)	512,124	Reference		Reference	
Partial Adherence	400 (22.6)	141,844	1.06 (0.94–1.20)		1.04 (0.91–1.18)	

	Cases N (%)	Person-Years	Baseline Score ¹		Time-Varying Score ²	
			HR (95% CI)	p ³	HR (95% CI)	p ³
Adherence	32 (1.8)	15,442	0.81 (0.56–1.16)	0.49	1.10 (0.81–1.50)	0.01
Red/Processed Meat ^{5,6,7}						
Non-Adherence	453 (24.8)	156,934	Reference		Reference	
Partial Adherence	1,050 (57.5)	400,760	0.94 (0.84–1.06)		0.88 (0.77–1.01)	
Adherence	324 (17.7)	123,431	0.95 (0.82–1.11)		0.80 (0.66–0.95)	
Alcohol ^{5,7}				0.21		0.49
Non-Adherence	40 (2.2)	9,004	Reference		Reference	
Partial Adherence	93 (5.1)	21,628	1.18 (0.81–1.71)		1.40 (0.82–2.39)	
Adherence	1,687 (92.7)	649,801	0.96 (0.70–1.31)		1.12 (0.69–1.81)	
Salt ^{5,6,7}				0.27		0.98
Non-Adherence	731 (40.0)	298,466	Reference		Reference	
Partial Adherence	672 (36.8)	243,247	1.03 (0.89–1.18)		0.88 (0.75–1.02)	
Adherence	423 (23.2)	139,274	1.11 (0.92–1.33)		1.00 (0.82–1.23)	

Abbreviations: AICR, American Institute for Cancer Research; CI, confidence interval; HR, hazard ratio; N, number; WCRF, World Cancer Research Fund

¹WCRF Score and covariates are all baseline (1995) data only. Covariates: age, geographic region of residence (Northeast, South, Midwest, West, other), kilocalories/day (continuous), smoking (never, former, <15 cigarettes/day, 15 cigarettes/day), family history of breast cancer (yes/no), education (12, 13–15, 16 years), menopausal status (pre/post), oral contraceptive use (never, 0.5–5, 5 years), parity (none, 1–2, 3 children), menopausal hormone use (premenopausal, postmenopausal-never, postmenopausal-<5 years, postmenopausal- 5 years)

²Time-varying analysis using Anderson-Gill Method to update both WCRF score and covariates. Covariates same as baseline model.

³Test for trend.

⁴Per 0.5 unit increase.

⁵Additionally adjusted for: BMI (<25, 25–<30, 30 kg/m²)

⁶Additionally adjusted for alcohol (<1, 1–6, 7–13, 14 drinks/week)

⁷Additionally adjusted for physical activity (high, moderate, low) and sedentary time (8, 5–7, 5 hrs./day sitting)

Table 4
Time-Varying WCRE/AICR Guideline Adherence Scores and Breast Cancer Risk by Menopausal Status

	Premenopausal				Postmenopausal				P _{int} ⁴
	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	P ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	P ³	
WCRE/AICR Score ⁵	678 (100)	391,123	0.90 (0.82–1.00)	0.05	826 (100)	186,416	0.90 (0.81–0.99)	0.03	0.43
WCRE/AICR Score				0.08				0.24	0.20
< 3.0 points	364 (53.4)	208,968	Reference		429 (51.9)	95,283	Reference		
3.0 – 4.0 points	286 (42.2)	158,726	0.91 (0.76–1.10)		344 (41.6)	80,984	0.85 (0.71–1.01)		
> 4.0 points	28 (4.1)	23,429	0.67 (0.44–1.03)		53 (6.4)	10,149	1.00 (0.72–1.40)		
Diet Score ^{5,6,7}	698 (100)	403,378	0.87 (0.76–1.00)	0.06	862 (100)	194,426	0.93 (0.82–1.06)	0.26	0.65
Diet Score ^{6,7}				0.25				0.96	0.01
< 2.0 points	183 (26.2)	123,970	Reference		201 (23.3)	43,648	Reference		
2.0 – 3.0 points	482 (69.1)	258,232	1.01 (0.82–1.25)		569 (66.0)	133,717	0.90 (0.73–1.10)		
> 3.0 points	33 (4.7)	21,176	0.63 (0.40–1.00)		92 (10.7)	17,061	1.08 (0.79–1.49)		
Body Weight ^{7,8}				0.54				0.85	0.63
Non-Adherence	510 (72.6)	261,928	Reference		692 (80.2)	156,210	Reference		
Partial Adherence	137 (34.1)	93,166	0.93 (0.75–1.15)		116 (13.4)	27,728	0.92 (0.74–1.16)		
Adherence	55 (7.8)	50,472	0.96 (0.71–1.29)		55 (6.4)	10,497	1.11 (0.80–1.55)		
Physical Activity ^{6,8}				0.31				0.006	0.15
Non-Adherence	323 (46.3)	179,473	Reference		411 (49.8)	87,241	Reference		
Partial Adherence	300 (43.0)	167,292	1.03 (0.87–1.23)		374 (45.3)	86,562	0.83 (0.71–0.98)		
Adherence	75 (10.7)	55,792	0.81 (0.60–1.08)		76 (9.2)	19,593	0.70 (0.52–0.95)		
Sugar Beverages ^{6,7,8}				0.02				0.53	0.32
Non-Adherence	419 (58.9)	249,990	Reference		409 (46.4)	93,990	Reference		
Partial Adherence	281 (39.5)	153,161	0.84 (0.70–1.00)		437 (49.6)	95,390	0.98 (0.83–1.16)		
Adherence	11 (1.5)	7,503	0.58 (0.31–1.10)		35 (4.0)	8,892	0.90 (0.62–1.30)		
Plant Foods ^{6,7,8}				0.64				0.21	0.97
Non-Adherence	536 (76.7)	320,266	Reference		586 (68.0)	136,905	Reference		
Partial Adherence	147 (21.0)	75,698	1.05 (0.84–1.30)		244 (28.3)	51,677	1.02 (0.85–1.22)		

	Premenopausal				Postmenopausal				
	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	p ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	p ³	p ⁴ p _{int}
Adherence	16 (2.3)	7,895	1.12 (0.65–1.94)		32 (3.7)	6,058	1.09 (0.72–1.65)		
Red/Processed Meat ^{6,7,8}				0.02				0.10	0.14
Non-Adherence	167 (23.5)	98,453	Reference		206 (23.4)	41,598	Reference		
Partial Adherence	428 (60.2)	237,335	0.91 (0.74–1.12)		512 (58.1)	120,283	0.80 (0.66–0.98)		
Adherence	116 (16.3)	74,866	0.71 (0.53–0.94)		163 (18.5)	36,392	0.81 (0.63–1.04)		
Alcohol ^{6,8}				0.53				0.11	0.35
Non-Adherence	7 (1.0)	5,077	Reference		13 (1.5)	2,710	Reference		
Partial Adherence	23 (3.2)	12,036	1.57 (0.59–4.18)		42 (4.8)	6,983	1.21 (0.60–2.45)		
Adherence	681 (97.8)	393,113	1.51 (0.63–3.66)		826 (93.8)	188,375	0.86 (0.46–1.60)		
Salt ^{6,7,8}				0.68				0.51	0.53
Non-Adherence	292 (41.1)	186,836	Reference		379 (43.0)	82,045	Reference		
Partial Adherence	259 (36.5)	144,121	0.93 (0.73–1.19)		294 (33.4)	72,781	0.88 (0.70–1.10)		
Adherence	159 (22.4)	79,614	0.93 (0.67–1.29)		208 (23.6)	43,416	1.10 (0.82–1.48)		

Abbreviations: AICR, American Institute for Cancer Research; CI, confidence interval; HR, hazard ratio; N, number; WCRF, World Cancer Research Fund

¹Hazard ratios and 95% confidence intervals were calculated using Cox Proportional Hazards Regression.

²Time-varying analysis using Anderson-Gill Method to update both WCRF score and covariates. Covariates: age, geographic region of residence (Northeast, South, Midwest, West, other), kilocalories/day (continuous), smoking (never, former, <15 cigarettes/day, 15 cigarettes/day), family history of breast cancer (yes/no), education (12, 13–15, 16 years), menopausal status (pre/post), oral contraceptive use (never, 0.5–5, 5 years), parity (none, 1–2, 3 children), menopausal hormone use (premenopausal, postmenopausal-never, postmenopausal- <5 years, postmenopausal-5 years)

³Test for trend.

⁴Likelihood ratio test. Adjusted for same covariates as main effects model.

⁵Per 0.5 unit increase.

⁶Additionally adjusted for: BMI (<25, 25–30, 30 kg/m²)

⁷Additionally adjusted for alcohol (<1, 1–6, 7–13, 14 drinks/week)

⁸Additionally adjusted for physical activity (high, moderate, low) and sedentary time (8, 5–7, 5 hrs./day sitting)

Time-Varying WCRE/AICR Guideline Adherence Scores and Breast Cancer Risk by Hormone Receptor Subtype

Table 5

	ER+ and PR+				ER+ or PR+				ER- and PR-			
	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	P ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	P ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	P ³
WCRE/AICR Score ⁴	686	637,783	0.93 (0.83–1.03)	0.16	196	632,920	1.02 (0.84–1.24)	0.84	399	634,682	0.85 (0.74–0.98)	0.03
WCRE/AICR Score				0.29				0.86				0.05
< 3.0 points	362	338,321	Reference		109	335,853	Reference		211	336,659	Reference	
3.0 – 4.0 points	285	263,183	0.88 (0.73–1.07)		73	261,018	0.88 (0.61–1.27)		176	262,938	0.94 (0.72–1.20)	
> 4.0 points	39	36,279	0.97 (0.67–1.42)		14	36,049	1.33 (0.70–2.53)		12	36,085	0.32 (0.14–0.74)	
Diet Score ^{4,5,7}	709	659,952	0.98 (0.85–1.13)	0.80	198	654,821	0.99 (0.76–1.29)	0.93	407	656,633	0.85 (0.70–1.03)	0.09
Diet Score ^{6,g}				0.55				0.81				0.32
< 2.0 points	161	184,548	Reference		51	183,326	Reference		96	183,680	Reference	
2.0 – 3.0 points	496	433,039	1.13 (0.90–1.42)		131	429,423	1.01 (0.66–1.54)		282	430,772	1.01 (0.75–1.36)	
> 3.0 points	52	42,365	1.01 (0.69–1.49)		16	42,072	0.84 (0.40–1.76)		29	42,181	0.64 (0.36–1.13)	
Body Weight ^{6,7}				0.49				0.76				0.39
Non-Adherence	557	467,305	Reference		158	463,498	Reference		327	464,796	Reference	
Partial Adherence	109	130,621	0.92 (0.72–1.16)		33	129,720	1.06 (0.68–1.64)		67	130,111	0.90 (0.66–1.23)	
Adherence	42	64,374	0.93 (0.65–1.34)		12	63,988	1.09 (0.58–2.06)		22	64,130	0.85 (0.53–1.37)	
Physical Activity ^{5,6}				0.22				0.49				0.10
Non-Adherence	334	297,124	Reference		101	294,886	Reference		197	295,610	Reference	
Partial Adherence	299	279,179	0.94 (0.79–1.13)		92	277,045	1.10 (0.78–1.54)		173	277,850	0.88 (0.70–1.12)	
Adherence	75	81,901	0.82 (0.60–1.12)		12	81,240	0.65 (0.34–1.24)		41	81,511	0.71 (0.47–1.09)	
Sugar Beverages ^{5,6,7}				0.07				0.98				0.37
Non-Adherence	367	378,418	Reference		99	375,688	Reference		225	376,808	Reference	
Partial Adherence	337	275,534	0.93 (0.78–1.11)		99	273,121	1.02 (0.72–1.45)		182	273,842	0.91 (0.71–1.16)	
Adherence	16	18,275	0.55 (0.32–0.93)		7	18,214	0.95 (0.40–2.23)		11	18,211	0.83 (0.44–1.54)	
Plant Foods ^{5,6,7}				0.01				0.43				0.60
Non-Adherence	496	505,600	Reference		138	501,863	Reference		302	503,280	Reference	
Partial Adherence	186	139,871	1.20 (0.98–1.46)		54	138,633	1.24 (0.85–1.81)		94	139,008	0.90 (0.68–1.21)	
Adherence	27	15,238	1.63 (1.05–2.53)		6	15,073	1.06 (0.42–2.70)		11	15,097	1.02 (0.51–2.03)	

	ER+ and PR+				ER+ or PR+				ER- and PR-			
	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	p ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	p ³	Cases N (%)	Person- Years	HR (95% CI) ^{1,2}	p ³
Red/Processed Meat ^{5,6,7}				0.81				0.35				0.02
Non-Adherence	151	154,822	Reference		40	153,624	Reference		98	154,106	Reference	
Partial Adherence	434	395,505	0.98 (0.78–1.23)		127	392,467	1.43 (0.89–2.29)		252	393,581	0.82 (0.61–1.09)	
Adherence	135	121,899	0.97 (0.72–1.29)		38	120,932	1.35 (0.76–2.41)		68	121,175	0.64 (0.43–0.94)	
Alcohol ^{5,7}				0.59				0.23				0.46
Non-Adherence	4	4,437	Reference		4	8,819	Reference		6	638,228	Reference	
Partial Adherence	29	10,656	2.70 (0.81–9.01)		8	21,081	1.11 (0.29–4.18)		16	21,117	1.02 (0.36–2.85)	
Adherence	687	321,014	2.25 (0.72–7.00)		193	636,445	0.70 (0.22–2.22)		396	8,835	0.83 (0.34–2.02)	
Salt ^{5,6,7}				0.55				0.13				0.85
Non-Adherence	319	294,848	Reference		94	292,562	Reference		170	293,166	Reference	
Partial Adherence	237	240,035	0.77 (0.60–0.98)		75	238,267	0.76 (0.48–1.21)		141	238,957	0.88 (0.63–1.23)	
Adherence	164	137,208	0.90 (0.65–1.25)		36	136,058	0.61 (0.32–1.16)		107	136,603	1.03 (0.67–1.59)	

Abbreviations: AICR, American Institute for Cancer Research; CI, confidence interval; ER+, estrogen receptor positive; ER-, estrogen receptor negative; HR, hazard ratio; N, number; PR+, progesterone receptor positive; PR-, progesterone receptor negative; WCRF, World Cancer Research Fund

¹ Hazard ratios and 95% confidence intervals were calculated using proportional hazards regression.

² Time-varying analysis using Anderson-Gill Method to update both WCRF score and covariates. Covariates: age, geographic region of residence (Northeast, South, Midwest, West, other), kilocalories/day (continuous), smoking (never, former, <15 cigarettes/day, 15 cigarettes/day), family history of breast cancer (yes/no), education (12, 13–15, 16 years), menopausal status (pre/post), oral contraceptive use (never, 0.5–5, 5 years), parity (none, 1–2, 3 children), menopausal hormone use (premenopausal, postmenopausal-never, postmenopausal-5 years)

³ Test for trend.

⁴ Per 0.5 unit increase.

⁵ Additionally adjusted for: BMI (<25, 25–30, 30 kg/m²)

⁶ Additionally adjusted for alcohol (<1, 1–6, 7–13, 14 drinks/week)

⁷ Additionally adjusted for physical activity (high, moderate, low) and sedentary time (8, 5–7, 5 hrs./day sitting)