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Lifestyle, cancer recurrence, and survival after a cancer diagnosis

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Doctor of Philosophy

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Abstract

Lifestyle, cancer recurrence, and survival after a cancer diagnosis

By Alyssa N. Troeschel

Several lifestyle factors, such as diet, physical activity, and body fatness, have a clear role in the development of some cancers; however, their role in cancer prognosis remains unclear. The overarching goal of this dissertation was to gain a better understanding of lifestyle factors and their role in cancer recurrence and survival. In **Aim 1**, we evaluated the one-year reproducibility and relative validity of a modified semi-quantitative food frequency questionnaire (FFQ) to assess food groups and diet quality in accordance with the American Cancer Society's (ACS) dietary guidelines. Reproducibility was good (≥0.50) for the diet quality score and most food groups analyzed. Validity was good for the diet score but varied substantially by food group. In **Aim 2**, we investigated associations of body mass index (BMI) and weight change on prostate cancer-specific mortality (PCSM) and all-cause mortality among men diagnosed with non-metastatic prostate cancer. Using Cox proportional hazards models, hazard ratios (HR) associated with BMI >30 kg/m^2, compared to 18.5-<25.0 kg/m^2, were 1.28 for PCSM (95% confidence interval (95%CI): 0.97, 1.69) and 1.23 for all-cause mortality (95%CI: 1.11, 1.36). Post-diagnosis weight gain (>5%), compared with stable weight (±<3%), was associated with a higher risk of PCSM (HR=1.64, 95%CI: 1.20, 2.24) and all-cause mortality (HR=1.27, 95%CI: 1.11, 1.44). In **Aim 3**, we investigated the separate and combined role of lifestyle factors on the risk of breast cancer recurrence and mortality due to breast cancer and all causes among women diagnosed with invasive breast cancer. Using Cox proportional hazards models, increasing concordance with lifestyle recommendations was inversely associated with all-cause mortality (HR per 2-point increase=0.89, 95%CI: 0.82, 0.98) and breast cancer mortality (HR=0.78, 95%CI: 0.65, 0.94), but not recurrence. In our model including all 9 lifestyle recommendations together in a multivariable model, higher intake of legumes and higher levels of aerobic physical activity appeared inversely related with all-cause mortality. The findings of this dissertation support the use of the modified FFQ to assess most major food groups and a diet quality score in future studies of diet and cancer survival, and suggest that lifestyle factors may play a role in cancer prognosis.

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Chapter 1 − Introduction and Background

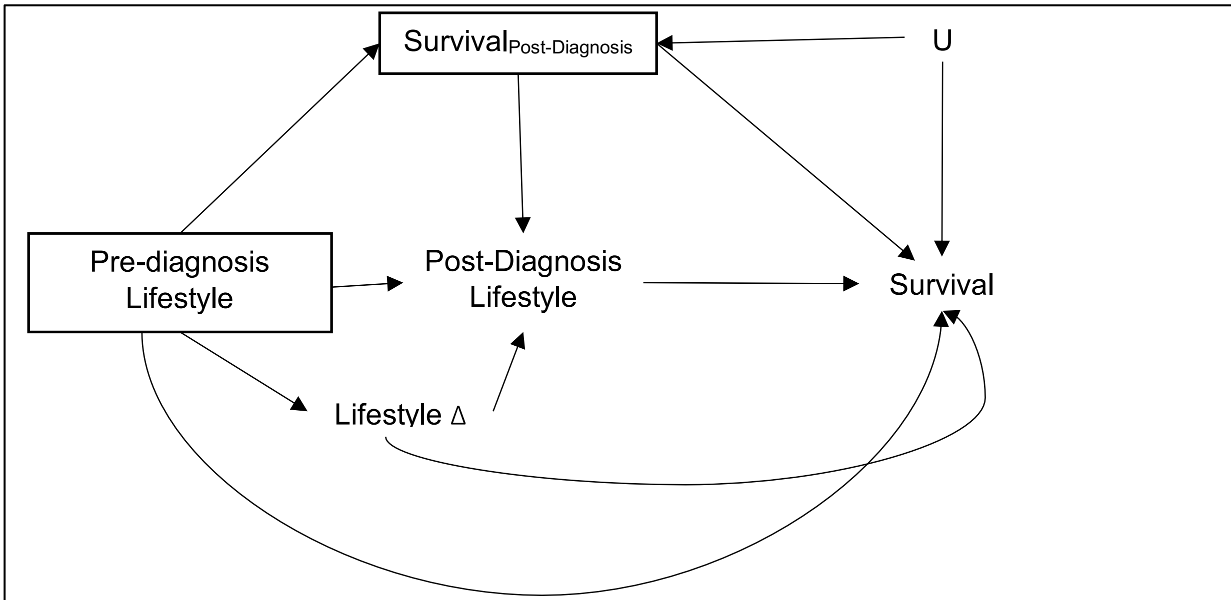
In the United States (US), an estimated one in three men and women develop cancer during their lifetime, and one in five die from the disease (1). Advances in the treatment and early detection of cancer, in addition to an aging population, have led to a dramatic increase in the number of cancer survivors (2). Currently, there are over 15.5 million cancer survivors in the US; an estimate projected to increase to over 20 million in the next decade (3). Although the probability of 5-year survival after a cancer diagnosis is relatively high in the US (~67%) (1), long-term care remains especially important for cancer survivors, who are at risk for recurrence and increased risk of mortality (4). Studies suggest that cancer survivors may continue to experience excess mortality for up to 15-years post-diagnosis (5,6), highlighting the importance of identifying self-care strategies that could improve long-term outcomes in this growing population.

Given that excess body fatness and other lifestyle-related factors (e.g., diet, physical activity) have a clear role in the incidence of certain cancers (2,7), it seems plausible that they might also play a role in cancer prognosis. In addition, evidence from animal studies suggests that energy balance (*i.e.*, dynamic balance between dietary intake and energy expenditure, partially through physical activity) may be a key factor in the carcinogenic process, including tumor progression, potentially through the alteration of hormones, adipocytes, and inflammatory factors (8). Despite the increased interest in understanding whether lifestyle after a cancer diagnosis plays a role in cancer prognosis, and especially whether *changes* in lifestyle can improve prognosis, according to the World Cancer Research Fund, the current evidence remains too limited to provide any strong, evidence-based recommendations for cancer survivors (2). This is largely due to the heterogeneous nature of cancer (e.g., different cancers may have different etiologies) and cancer survivorship, as well as several methodological challenges in the setting of cancer survivorship, some of which are detailed below.

First, as lifestyle changes over time, the timing in which lifestyle is measured in studies of cancer survivorship is important. Cancer and some of its treatments can impact appetite, energy levels, and weight(9–11), all of which are strongly associated with survival, which may confound results. The World Cancer Research Fund (WCRF) identified three specific time-frames that take into account exposure assessment at various stages of treatment (11): before treatment (referred to hereafter as the pre-diagnosis period), during treatment (peri-diagnosis, within one year of diagnosis), and after treatment (post-diagnosis, one year or more after diagnosis). The period of particular relevance to cancer survivors, and this dissertation, is the post-diagnosis period, as cancer survivors cannot change behaviors that occurred prior to their diagnosis, and studies investigating peri-diagnosis behaviors may be severely confounded by treatment.

Second, studies conducted among cancer survivor populations may be subject to special type of selection bias, sometimes referred to as “index-event” bias (12), in the presence of uncontrolled risk factors for the outcome when examining an exposure related to cancer incidence. While this is particularly true for exposures measured during the pre-diagnosis period, this bias could also affect exposures measured during the post-diagnosis period. However, if our causal diagram is correct (see **Figure 1.1**), while the effects of post-diagnosis lifestyle on survival may be biased, we could potentially mitigate this bias by accounting for pre-diagnosis lifestyle.

Third, is the concept commonly referred to as “reverse causation”, where underlying severe disease leading to changes in lifestyle and death, could distort true effects of lifestyle and survival. For example, when examining the association of body mass index (BMI) and survival, underlying disease causing both weight loss and death may make those in the healthy weight range appear to have may have lower survival than those who were obese, despite no true benefits of obesity. Most studies mitigate the potential for bias due to reverse causation by excluding deaths and person-time occurring within the first few years of obtaining the exposure data.



Survival$_{\textit{post-diagnosis}}$ represents survival through the post-diagnosis survey assessing lifestyle.
U represents the uncontrolled risk factor for mortality.
By restricting the study population to individuals who survived long enough to complete the post-diagnosis survey, a biasing pathway is opened in the presence of an uncontrolled risk factor, U (Post-Diagnosis Lifestyle ←Pre-diagnosis Lifestyle → Survival$_{\text{post-diagnosis}}$ ← U → Survival).
If the causal diagram is correct, we can control for bias induced by conditioning on Survival$_{\text{post-diagnosis}}$ by estimating the effect of lifestyle change on survival, conditional on both the prior lifestyle and Survival$_{\text{post-diagnosis.}}$

Figure 1.1. A causal diagram representing the effect of post-diagnosis lifestyle and lifestyle change on survival.

Last, although not specific to the survivorship setting, lifestyle measures are often self-reported by participants, and are subject to measurement error, especially diet. Food frequency questionnaires (FFQs) are commonly used to assess usual diet in large-scale studies because they are cost-effective with relatively low participant burden (13). However, FFQs rely on participants' ability to recall mean food intake, usually over long intervals (e.g. 12 months), and are more prone to systematic error than other methods, such as repeated, 24-hour dietary recalls (24HR) (13–15). As diet may play an important role in cancer survivorship, it is important for researchers in this area to understand the degree of error in which diet is measured, and what impact that error may have on the interpretation of dietary findings.

Overarching Goal and Specific Aims

The **overarching goal of this dissertation** was to evaluate the relative validity of an FFQ, designed for use in the American Cancer Society's Cancer Prevention Study-3, and to investigate the role of lifestyle on cancer survivorship among breast and prostate cancer survivors, the two most commonly diagnosed cancers among US women and men, respectively. In **Aim 1**, I will evaluate the relative validity of a modified semi-quantitative FFQ to assess food groups and diet quality in accordance with the American Cancer Society's (ACS) dietary guidelines(16). In **Aim 2**, I will investigate associations of body mass index (BMI) and weight change, markers of energy balance, on disease-specific mortality and all-cause mortality among men diagnosed with non-metastatic prostate cancer. Finally, in **Aim 3**, I will investigate the separate and combined role of energy balance-related lifestyle factors on risk of breast cancer recurrence, disease-specific mortality and all-cause mortality among women diagnosed with invasive breast cancer.

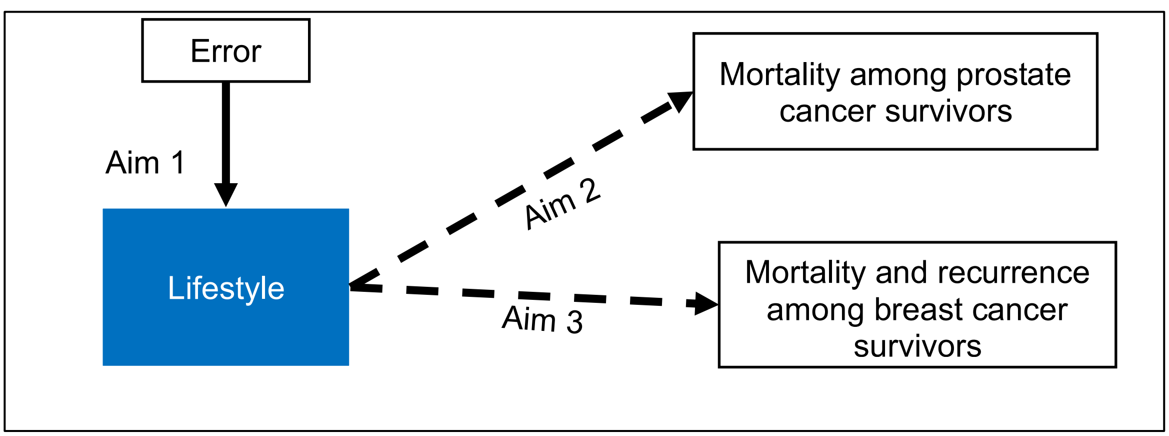


Figure 1.2. Diagram representing overall dissertation goal

Chapter 2 − The American Cancer Society Cancer Prevention Study-3 food frequency questionnaire has reasonable validity and reproducibility for food groups and a diet quality score

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Abstract

Background: Food frequency questionnaires (FFQ) are commonly used to assess usual dietary intake in large cohort studies and it is important to evaluate their performance in the target population.

Objective: We evaluated the reproducibility and relative validity of the Cancer Prevention Study-3 (CPS-3) FFQ in estimating usual intake of 63 food groups and overall diet quality within strata of sex and race/ethnicity.

Methods: A subset of participants from the CPS-3 (433 women, 244 men), 31-70 years of age, were included in a cross-sectional diet assessment sub-study (2015-2016). Diet quality was calculated in accordance with the American Cancer Society (ACS) dietary guidelines for cancer prevention. Reproducibility was assessed by comparing food group intakes and the diet quality score estimated by repeat FFQs, approximately 1-year apart. Validity was assessed by comparing FFQ estimates with estimates from $\leq$ six interviewer-administered 24-hour dietary recalls (24HR). All analyses were stratified by sex and race/ethnicity.

Results: Reproducibility correlations for repeated FFQs were $\geq$0.50 for 83-97% of food groups analyzed across strata of sex and race. Energy-adjusted, deattenuated Spearman correlations comparing the second FFQ to the 24HRs ranged from 0.05 to 0.82 among men (median: r=0.50) and women (median: r=0.52). Validity was highest for coffee, alcohol, and total dairy, and lowest for pasta and regular-fat yogurt products. Median validity across food groups varied by race/ethnicity and was highest among white (r=0.54) followed by Hispanic (r=0.49) and then African American (r=0.45) participants. The diet quality score had good validity in all subgroups examined, but was higher among men (r=0.70) than women (r=0.60), and lower among white (r=0.62) than Hispanic (r=0.64) or African American (r=0.73) participants.

Conclusion: This study indicates good reproducibility and validity of the CPS-3 FFQ for most major food groups, and for the ACS diet quality score, in all sex and race/ethnicity groups examined.

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Introduction

There is an ongoing need to accurately assess usual (i.e., long-term) dietary intake in epidemiological studies to better understand the role of dietary factors in chronic disease outcomes, such as cancer incidence and mortality(17,18). Food frequency questionnaires (FFQs) are commonly used to assess usual diet in large-scale studies because they are cost-effective with relatively low participant burden(13). However, FFQs rely on participants' ability to recall mean food intake, usually over long intervals (e.g. 12 months), and are more prone to systematic error than other methods, such as repeated, 24-hour dietary recalls (24HR)(13–15).

Understanding the FFQ's ability to produce measures of diet that are consistent within persons, under various conditions, over time (sometimes referred to as test-retest reliability(19); hereafter referred to as *reproducibility*) and correctly rank individual dietary intake according to a presumably superior, but not "gold standard", method (sometimes referred to as construct validity(19); hereafter referred to as *validity*) is important to draw appropriate conclusions in dietary analyses based on FFQ measures. Most reproducibility and validity studies focus on nutrient estimates(13,20), but foods and food groups are often the subject of epidemiological investigations. Further, major food groups are key components used in the development of dietary indices for cancer prevention and survivorship. As food intake is determined by cultural, economic, social, and geographic factors, it is important to understand how well an FFQ assesses usual dietary intake in the population of interest.

The American Cancer Society's (ACS) Cancer Prevention Study-3 (CPS-3) is a large, prospective, United States (US)-based cohort study, designed to examine associations of a variety of lifestyle, medical, environmental, genetic, and other factors with cancer-related outcomes(21). The CPS-3 aimed to enroll a racially/ethnically diverse cohort, as minorities are often under-represented in cohort studies but account for approximately 30% of the US population(22). The Willett FFQ, previously validated in other populations(23–27), was adapted for use in the CPS-3 (hereafter referred to as the CPS-3 FFQ) to better assess diet among minority groups. The aims of this study were to: 1) evaluate 1-year reproducibility of major food groups and a diet quality score assessed by repeat administration of the CPS-3 FFQ; and 2) evaluate the ability of the CPS-3 FFQ to rank individual intake of food groups and diet quality, relative to up to six 24HRs, within strata of sex and race/ethnicity.

Methods

Study Design & Participants

The CPS-3 Diet Assessment Substudy (DAS), a yearlong study (2015-2016) of a subset of 745 participants from CPS-3, was designed to evaluate the performance of the CPS-3 FFQ. Briefly, the CPS-3 is a prospective cohort study of 303,682 cancer-free men and women recruited from 35 US states, the District of Columbia, and Puerto Rico between 2006 and 2013(21). Upon enrollment, participants were asked to provide a blood sample, have their waist circumference measured, and complete an enrollment and baseline questionnaire on participant demographics, medical characteristics, and other factors. In 2015, a follow-up questionnaire containing the CPS-3 FFQ was mailed to participants who completed the baseline survey (n=254,650).

From each DAS participant, we collected two FFQs approximately one year apart. In the interval between FFQs we collected up to six telephone-based interviewer-administered 24HRs. As described in detail elsewhere(28), invitations to preregister for the CPS-3 DAS were mailed to 10,000 white, African American, and Hispanic CPS-3 participants living in five US regions defined by Quest Diagnostics business units (Atlanta, GA; Dallas, TX; Auburn Hills, MI, West

Hills, CA, and San Jose, CA). A total of 745 participants completed both FFQs and the first 24HR. Participants were further excluded from this analysis if they: 1) completed fewer than four dietary recalls (n=10); 2) reported extreme energy intakes on the FFQ (men: < 800 or >4500 kcal/day; women: < 600 or >3800 kcal/day) (n=35); 3) missed two or more entire sections or >100 line-items of the 191-items (n=3); or 4) were pregnant at the time of study enrollment or became pregnant during the study year (n=15). The final analytic sample consisted of 677 participants (433 women, 244 men; 417 white, 159 African American, 101 Hispanic).

Food Frequency Questionnaire

The self-administered semi-quantitative CPS-3 FFQ was adapted from the Willett FFQ developed at Harvard University(23,25). ACS investigators modified the Willett FFQ to broaden the food list to capture usual diet in the more diverse CPS-3 cohort, and to add certain food items of scientific interest (e.g., specific soy products). FFQ modifications were informed by a subset of 600 white, African American and Hispanic CPS-3 participants (the largest non-white groups in CPS-3) who completed one 24HR, by examining US National Health and Nutritional Examination Survey sources of key cancer-related nutrients, and also via six sex- and racial/ethnic-specific focus groups. The CPS-3 FFQ asked about the average frequency of consumption of 191 foods and beverages during the previous year (FFQ available upon request). To calculate servings per day for each line item on the CPS-3 FFQ, a standard serving size (see **Table 2.2.1**) was multiplied by frequency of consumption (never, or less than once per month; 1-3 per month; 1 per week; 2-4 per week; 5-6 per week; 1 per day; 2-3 per day; and 4+ per day; beverages extended to 4-5 per day and 6+ per day), using the median value of each frequency response category, except for "never, or less than once per month" which was assigned 0, and "4+ per day" for foods (4.5 per day) and "6+ per day" (6 per day) for beverages.

24-Hour Dietary Recalls

Telephone-based 24HRs were conducted by trained interviewers from the Dietary Assessment Center at Pennsylvania State University using the Nutrition Data System for Research (NDSR) software (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). The 24HRs were unannounced and randomly assigned so that approximately four would occur on weekdays and two on weekends, with each recall occurring at least 30 days apart. The study year was divided into trimesters, with the goal being that two 24HRs were collected during each trimester, to account for seasonal changes and medium-term drifts in food habits.

Food Group Definitions

A detailed summary of the 63 predefined food groups along with definitions for serving sizes are provided in **Table 2.2.1.** In this study, we assessed the FFQ's ability to estimate food groups, many of which included foods not specifically listed on the FFQ. For example, we compared reported consumption of strawberries, blueberries, and raspberries on the FFQ to all berries reported on by the 24HRs for validation purposes (e.g., including cranberries, blackberries). For each of the 24HRs, mean food group intakes (servings/day) were calculated for most food groups by the NDSR software (e.g., citrus fruits, deep-green vegetables). Serving sizes matched those used by the NDSR software, defined according to the *2000 Dietary Guidelines for Americans*(29), or for foods not covered by the Guidelines, the FDA(30). In general, one 'serving' was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy products, and 1 ounce for most meats and grains [**Table 2.2.1**]. Other food groups of interest on the FFQ (e.g., garlic) were matched to the 24HRs by searching relevant fields across all 24HRs, using codes included in **Table 2.2.1**. For the FFQ, line items were matched to NDSR food group codes, and summed to obtain the total servings/day for each food group. FFQ line items with multiple foods (e.g., grapefruit or grapefruit juice) were weighted according to standards from Harvard, and mixed dishes (e.g., pizza) were grouped according to the primary ingredient (e.g., pizza was considered refined grain). When serving definitions varied across methods, FFQ servings were converted to match those for the 24HRs using gram weight assumptions based on data from the US Department of Agriculture (USDA) Food Composition Database (31).

Diet Quality

A diet quality score was calculated for the FFQs and the mean of the 24HRs to represent a dietary pattern in accordance with ACS guidelines on nutrition for cancer prevention(16), which recommended: 1) consuming 5+ servings (or 2 ½ cups) per day of a variety of fruits and vegetables; 2) choosing whole grains in preference to processed, refined grains; and 3) limiting consumption of red and processed meats. The extent to which a person's diet was consistent with recommendations was quantified, as described in **Table 2.2.2**, using previously published methods as a guide(32). For each recommendation, the highest score represented optimal adherence to the recommendation. The total score (range: 0-9) is the sum of the three above subdomains (fruit and vegetables, whole grain, and low red and processed meat consumption), with higher scores indicating greater concordance with recommendations and better diet quality.

Statistical Analysis

All analyses were evaluated within strata defined by sex and race/ethnicity. The estimated food group servings per day were tabulated for both the repeated 24HRs and the FFQs and energy adjusted within sex strata using the residual method(33). Residuals were added to the predicted food group intake at the sex-specific mean energy intake. To examine the presence, direction, and extent of bias in measuring absolute intake at the group level, we calculated the mean differences between intake of food groups (servings/day) estimated by the FFQs, as well as between FFQ2 and the 24HRs, and calculated Bland-Altman limits of agreement(34).

For food groups, the 1-year reproducibility of the CPS-3 FFQ was assessed by comparing energy-adjusted food group intake (servings/day) estimated by FFQ1 with those estimated by FFQ2 using Spearman rank correlation coefficients. Validity was assessed by comparing energy-adjusted food group intakes estimated by the FFQs with repeated 24HRs, assuming the repeated recalls represent the construct of usual dietary intake, using two methods. First, we calculated energy-adjusted, deattenuated Spearman rank correlation coefficients (r_s). Consistent with previously described methods(35), data were probit transformed, and correlation coefficients were deattenuated to account for day-to-day variation (within-individual random error) in dietary intake from 24HRs; 95% confidence intervals (95% CI) were constructed using a SAS macro for corrected Spearman correlation estimates(36). Second, we tested agreement between FFQ2 and the mean of the 24HRs by comparing quartile classification for energy-adjusted food group intakes. We focused on FFQ2 for this analysis, as it covered the same time period as the 24HRs.The proportion of those with exact agreement, adjacent quartile, deviation by 2 quartiles, and deviation by 3 quartiles (gross misclassification), as well as the weighted Kappa coefficient, was calculated for each food group. The weighted Kappa coefficient is a summary measure of the level of agreement at the individual-level, taking chance agreement into account and ranging from -1 to 1, where values close to 0 indicate agreement similar to what could be expected due to chance alone and values greater than 0 indicate agreement greater than can be expected by chance alone(37).

We also calculated attenuation factors (γ) to estimate the degree to which diet-disease relationships may be underestimated due to measurement error in the FFQ, with factors close to 1 indicating minimal attenuation and factors close to 0 indicating maximal attenuation. The attenuation factors were obtained from linear regression analysis of the 24HRs (*i.e.,* the dependent variable) on the FFQ (*i.e.,* the independent variable) for the same energy-adjusted, log-transformed food groups and additionally adjusted for age(38,39).

Reproducibility and validity of the diet quality score were evaluated in a similar manner, except that the food groups comprising the score were not energy-adjusted and the score was normally distributed; thus Pearson correlation coefficients were used (r_p). As diet quality scores were calculated based on the mean of the 24HRs (not for each of the 24HRs), correlation coefficients were not deattenuated for day-to-day variability. Second, validity was examined through cross-classification of categories of diet quality (low concordance: 0-2, moderate concordance: 3-5, high concordance: 6-9) estimated by FFQ2 and the 24HRs. Weighted Kappa coefficients, mean differences, Bland-Altman limits of agreement, and attenuation factors were also obtained for the diet quality score.

Results

DAS participants were similar to those in the larger CPS-3 cohort with respect to age but were more likely to have a graduate degree and less likely to be married than the overall study population **[Table 2.1.1]**. As designed, the DAS had a higher proportion of minority participants and men compared to the overall cohort. All participants included in this study completed at least four 24HRs, and most participants completed all six [**Table 2.2.3**].

Food Groups

The unadjusted food group intakes (servings/day) estimated by FFQ1 were similar to those estimated by FFQ2 **[Table 2.2.2]**. With some exceptions, food group intakes assessed by the FFQs were higher than those from the 24HRs. Men reported consuming larger amounts of grains, and slightly more red meat and alcoholic beverages than women. Estimated food group intake appeared similar among racial/ethnic subgroups, with some exceptions. For example, African American participants tended to consume less coffee and alcohol than white and Hispanic participants **[Table 2.2.4]**. Mean differences between energy-adjusted food groups estimated by the FFQs and 24HRs and Bland-Altman limits of agreement are presented according to sex in **Table 2.2.5** and race/ethnicity in **Table 2.2.6**. In general, all subgroups tended to over-report fruits, whole grains, legumes, and seafood and under-report refined grains, breads, poultry products, cheeses, and sugar-sweetened beverages on the FFQ relative to the 24HRs.

Reproducibility correlations for repeated FFQs were $\geq$ 0.50 for 89% and 95% of the 63 food groups among men (median: r_s= 0.68, range = –0.25 to 0.92) and women (median: r_s= 0.66, range = 0.05 to 0.89), respectively **[Table 2.2.3]**. Results were mostly similar among men and women, with some exceptions. For example, vegetable juice intake appeared to have good reproducibility among men (r_s= 0.68) but was lower for women (r_s= 0.41), while alternative milk products had good reproducibility among women (r_s= 0.68) but not men (r_s= 0.15). Similar results were found among racial/ethnic subgroups, though reproducibility correlations tended to be lower among African Americans (median: r_s= 0.61) and Hispanics (median: r_s= 0.62) than white participants (median: r_s= 0.68) **[Table 2.2.7]**. Regardless of sex or race, low-fat cheeses and crackers generally had low reproducibility correlations, while alcoholic beverages and coffee had among the highest correlations.

Validity correlations between the intake of each food group estimated by the FFQs and the 24HRs varied substantially by food group **[Table 2.1.3]**. Deattenuated Spearman correlations ranged from 0.05 for decaffeinated tea and dark meat fish to 0.82 for coffee in men, and from 0.14 for crackers to 0.80 for coffee in women. Overall, correlations were similar between men (median deattenuated r_s=0.50) and women (median deattenuated r_s=0.52); however, men had substantially higher correlations for legumes, whole grains, and beer, whereas women had higher correlations for hot cereals, tomato products, and teas. Among men and women, few food groups had deattenuated validity correlations <0.20, and included groups such as full-fat yogurt, dark meat seafood (men only), pasta (men only), decaffeinated tea (men only), and crackers (women only). In our subgroup analysis by race/ethnicity, food group validity tended to be lower among African American (median deattenuated r_s=0.45) and Hispanic (median deattenuated r_s=0.49) participants compared to white participants (median deattenuated r_s=0.54), but varied by food group **[Table 2.2.8]**. For example, African American participants had substantially lower validity correlations for alcoholic beverages and cold cereals than white participants, but had higher correlations for white/fried potatoes and sugar-sweetened beverages. Validity correlations were < 0.20 for food groups such as, decaffeinated teas, beer, nuts and seeds, low-fat cheeses, and vegetable juice among African Americans, “light meat” seafood and snack bars among Hispanics, and for full-fat yogurt products, pasta, chocolate candy, and red processed meats among both African Americans and Hispanics. Among white participants, the only food group with a validity correlation <0.20 was bread. Food groups with validity correlations $\geq$ 0.60 among all racial/ethnic and gender subgroups included total coffee, caffeinated coffee, fruits excluding juices, dairy products, low-fat milk, and nuts. Validity correlations were also $\geq$ 0.60 for wine, total alcohol, non-citrus fruits excluding juices, and total fruits among all subgroups except African Americans as well as cruciferous vegetables and total processed meats except among women. Although generally similar, validity correlations were somewhat lower when comparing 24HRs to FFQ1 than FFQ2, for all subgroups.

Cross-classification of food groups estimated by FFQ2 and the mean of the 24HRs are presented by sex in **Table 2.1.4**. Of the 63 predefined food groups, 25 food groups estimated by the FFQ had ≥80% of men and women classified into the correct or adjacent distribution in quartiles based on the 24HRs. The number of food groups that had ≥10% of participants grossly misclassified was 2 among women, and 4 among men, and included foods/groups such as full-fat yogurt, vegetable juice (women only), as well as low-fat cheese, “light meat” seafood, and decaffeinated teas (men only). African Americans had fewer food groups with ≥80% of participants classified into the correct or adjacent quartile distribution (n=18) compared to white (n=31) or Hispanic participants (n=28) **[Table 2.2.9]**. Coffee and alcoholic beverages estimated by FFQ2 were most likely to be correctly classified into distribution quartiles according to 24HRs for all subgroups. Among all racial/ethnic groups, five or fewer food groups had ≥ 10% of participants grossly misclassified, with full-fat yogurt and low-fat cheeses as the food groups most likely to be grossly misclassified. Among all subgroups, weighted Kappa coefficients were ≥ 0.20 for most food groups, but were <0.20 for food groups such as low-fat cheese, full-fat yogurt, “light meat” seafood, fresh garlic (except among African Americans), crackers (except among Hispanics), deep-yellow vegetables (except among African Americans), and legumes (except among whites).

Attenuation factors representing the degree to which food group-disease relationships may be underestimated due to measurement error in the FFQ are presented in **Table 2.2.10**. The median attenuation factor was 0.51 among men (range: 0.09 – 0.92) and women (range: 0.11 – 0.93), after adjusting for energy and age. The median attenuation factors by race/ethnicity were 0.54, 0.44, and 0.43 among white, African American, and Hispanic participants, respectively.

Diet Quality

Diet quality scores estimated by the 24HRs tended to be slightly lower than those estimated by FFQ2 among both men and women [**Table 2.1.2, Table 2.2.6**] and all races, except among white participants **[Table 2.2.4, Table 2.2.6].** The reproducibility correlation comparing diet quality scores estimated by FFQ1 and FFQ2 was higher among men (r_p=0.76) than women (r_p=0.71) [**Table 2.1.3**], and highest among Hispanic participants (r_p=0.82) followed by white (r_p=0.72) and African American (r_p=0.70) participants **[Table 2.2.7]**.

The validity correlation comparing the diet quality score estimated by FFQ2 and the 24HRs was higher among men (r_p=0.69) than women (r_p=0.61) **[Table 2.1.3]**, and highest among African American participants (r_p=0.73) followed by Hispanic (r_p=0.64) and white (r_p=0.62) participants **[Table 2.2.8]**. Similar, albeit attenuated, correlations were found when comparing diet quality scores estimated by FFQ1 to the mean of the 24HRs.

The cross-classification of the ACS diet quality score categories (0-2, 3-4, 6-9) estimated by FFQ2 and the 24HRs is presented by sex in **Table 2.1.5** and by race/ethnicity in **Table 2.2.11**. Most individuals (>50%) had exact agreement and few were grossly misclassified (<3%). Overall, the percent of individuals with correctly classified diet quality scores increased as the diet quality score increased.

After adjusting for age, the attenuation factor for the diet quality score was higher, indicating less potential attenuation of risk estimates, among men (γ=0.75) than women (γ=0.65), and lower among white participants (γ=0.66) than Hispanic (γ=0.68) or African American (γ=0.79) participants **[Table 2.2.10]**.

Discussion

Foods, food groups, and dietary patterns are often the subject of epidemiological studies of diet and chronic disease risk. This study evaluated the performance of the CPS-3 FFQ in assessing food group intakes and diet quality in accordance with the ACS nutrition guidelines for cancer prevention. The CPS-3 FFQ was adapted from the Willett FFQ to include additional commonly consumed foods reported by a diverse sample of the study population, and select questions of scientific interest. Reproducibility and validity of the CPS-3 FFQ (compared to approximately six interviewer-based 24HRs) were acceptable for most, but not all, of the of the 63 food groups examined, including among men and women, and by race/ethnicity (white, African American, and Hispanic). The diet quality score performed well among the entire study population and the aforementioned subgroups.

Overall, participants tended to over-report fruits and whole grains and under-report refined grains on the FFQs compared to the 24HRs. This may be a reflection of the number of food items comprising the groups (e.g., 21 fruit items) or difficulties in estimating serving sizes. Another possible explanation for these findings could be social desirability bias, where participants respond to questions in a manner that is viewed favorably by others(40). The tendency of the FFQ to overestimate fruit and vegetable intake has been observed previously (27,41–44).

Reproducibility correlations comparing food group intakes assessed by repeat administration of the CPS-3 FFQ, approximately 1-year apart, were good (≥0.50) for 89% and 95% of the 63 food groups assessed among men and women, respectively, which indicates that the CPS-3 FFQ would be completed similarly over time for those food groups. This is conservative because these estimates ignore potential changes in diet over the course of the study year, which would tend to underestimate reproducibility. Among men and women, correlations were lowest (<0.40) for crackers and low-fat cheese, and among men, for alternative milk products, possibly because they are consumed infrequently and may have been missed on the 24HRs. Previous studies reported similar FFQ reproducibility correlations for foods or food groups, ranging from 0.50 to 0.90 (26,44–46). FFQ reproducibility was generally similar across racial/ethnic subgroups, but was somewhat lower among minority participants. Nevertheless, regardless of race/ethnicity, correlations were adequate (≥0.50) for food groups that are commonly of interest in investigations of chronic disease risk, including fruits, vegetables, whole grains, milk, red and processed meat, and alcoholic beverages.

Intakes of food groups assessed by the second CPS-3 FFQ and multiple 24HRs were at least moderately correlated (≥0.40) for approximately 70% of the food groups, and highly correlated (≥0.60) for 29% and 25% of food groups among men and women, respectively, after energy adjustment and deattenuation of 24HRs. Among both men and women, beverages, such as coffee (including caffeinated coffee) and alcohol, tended to have the highest validity correlations and the highest percent agreement in ranking intake according to quartiles of the distribution, similar to previous studies (26,27,41–43,45,47). This may be explained by the habitual (e.g. daily) nature of coffee consumption(48). In general, validity of food group intakes assessed by the FFQ, relative to the 24HRs, tended to be higher among broader food groups (e.g., non-starchy vegetables, total fruits) than more specific food groups (e.g., deep-yellow vegetables, citrus fruits). This may be because people are able to recall what they consume overall (e.g., alcohol, total yogurt) better than specific types (e.g., beer, wine, full-fat yogurt, low-fat yogurt). Food groups with low validity correlations (<0.40) included white processed poultry products, crackers, decaffeinated teas, and seafood subgroups. These foods tend to be consumed less frequently, and it is possible that six 24HRs were not enough to accurately capture true usual intake. In addition, the FFQ line-item on bacon did not differentiate between white processed poultry bacon (e.g., turkey bacon) and regular, red processed bacon, limited our ability to correctly categorize some food items. Validity correlations were largely similar among men and women, with some exceptions. For example, the FFQ appeared to have reasonable validity (≥0.50) in ranking fruit juices and beer in men, but not in women, potentially due to lower consumption among women. Similar FFQ performance in ranking food or food group-level intake among men and women has been previously observed (45,49), though fewer food groups were analyzed. For example, in a previous study, after energy adjustment, the mean validity correlation comparing 30 food groups estimated by the Diet History Questionnaire, a 124-item FFQ, with up to four 24HRs was 0.62 for women and 0.63 for men(49).

Validity of the FFQ tended to be lower among African American and Hispanic participants, relative to white participants. For example, only 60% of food groups had validity correlations ≥0.40 among minority participants compared to 80% of food groups among white participants. African Americans had lower validity correlations than whites for many foods less commonly consumed, such as alcoholic beverages (total and subtypes), cold cereal, and chocolate. To our knowledge, only one previous study examined food- or food group-level performance of a FFQ within strata of race/ethnicity(41). Similar to the present study, the authors reported higher FFQ validity among white than black participants in the Adventist Health Study-2 (mean energy-adjusted deattenuated correlation coefficients were 0.59 and 0.43, respectively)(41). Previous studies evaluating nutrient-level FFQ validity generally observed higher correlations among white participants than minority participants (50–53), though one study did suggest that the FFQ performed similarly in white and Hispanic participants(51), which largely supports our findings. Indeed, several food groups had high correlations (≥0.60) for validity among all racial/ethnic subgroups (white, African American, Hispanic), including those commonly of interest in studies of chronic disease risk (e.g. low-fat milk, fruit, and processed meat). Despite efforts to be comprehensive, FFQs intended for multiple racial/ethnic subgroups may be missing some staple items (including mixed dishes) for certain population subgroups, resulting in lower validity for those items. We collected 24HRs within a sample of CPS-3 participants to inform FFQ modification, conducted analyses in NHANES to identify commonly consumed foods and important sources of key nutrients by race/ethnicity, and held focus groups to test and discuss the instrument(54), but may have still missed some relevant foods and beverages.

Our results also support the ability of the CPS-3 FFQ to reliably and validly estimate diet quality in accordance with the ACS dietary guidelines for cancer prevention overall, and within strata defined by sex and race/ethnicity. The diet quality score tended to be somewhat overestimated by the FFQ, relative to the 24HRs, consistent with our observed over-reporting of fruits and whole grains, and under-reporting of refined grains. Validity correlations for the diet quality score were good (≥0.60), and higher among men (r=0.69) than women (r=0.61). Few studies have validated diet quality measures assessed by FFQs with 24HRs or diet records. A previous study compared the alternate healthy eating index (AHEI) estimated by a 125-item semi-quantitative FFQ with those estimated by up to three 24HRs, which suggested better performance among women (r=0.55) than men (r=0.46)(55). In a similar study, Olendzki and colleagues found lower correlations between AHEI scores calculated by an FFQ and three 24HRs among black participants (r=0.35) compared to their white counterparts (r=0.57)(56). This is in contrast to our results, which suggested a somewhat similar ability of the CPS-3 FFQ to rank diet quality among white (r=0.62), African American (r=0.73), and Hispanic (r=0.64) participants. The AHEI score differs from the diet quality score in the present study as it includes several other components, including fatty acids and alcohol, but is similar in that higher scores are characterized by diets high in fruits and vegetables, whole grains, and low in red and processed meats(57).

The attenuation factors produced in this study could enable researchers to correct for measurement error in future CPS-3 analyses involving continuous FFQ estimates of food group intake or the ACS diet quality score. Most attenuation factors (γ coefficients) were between 0.30-0.90, indicating that measures of association for diet-disease relations would be attenuated due to measurement error in the FFQ. Regression calibration of logistic models relies on certain assumptions: 1)linear probability of disease on the logit scale, given the imperfectly measured 24HR and other perfectly measured covariates; 2) linear conditional mean of the 24HR exposure, given the FFQ exposure and other perfectly measured covariates; and 3) constant variance(39). For Cox proportional hazards models, additional assumptions are required including rare disease, a low relative risk, and small measurement error(39). Therefore, potential violations of these assumptions should be considered before using these results to correct for measurement error. For example, our results indicate a high degree of measurement error for some food groups; therefore, researchers should exercise caution in using these coefficients, depending on the exposure.

Strengths of this study include its size and diverse sample, which enabled sex- and race-specific analyses. Second, we reduced potential bias due to within-person variability in the 24HRs by using deattenuated correlation coefficients. Third, potential bias due to extraneous variation in intake due to energy was mitigated by adjusting food groups for total energy intake.

Limitations of the study should be noted. First, 24HRs are also subject to systematic error, so we were not able to compare the FFQ performance to an unbiased measure of true intake. Attenuation factors presented in this study are likely biased but may still be useful in reducing bias, although they cannot eliminate it completely(58). Second, a greater number of 24HRs may be needed to assess usual intake of less commonly consumed items (such as decaffeinated teas). Third, because 24HRs and FFQs both rely on participant memory and serving size perceptions, errors between the two methods could be correlated, which would artificially inflate correlations. Finally, results of this study may not be generalizable to less educated participants in the CPS-3 cohort, who were less likely to participate in this validation sub-study. However, other characteristics were mostly similar between the DAS and the larger CPS-3 cohort, suggesting reasonable generalizability to most CPS-3 cohort members.

In summary, these results indicate good reproducibility and validity of the CPS-3 FFQ, relative to the 24HRs, for most food groups examined, although not for all. The CPS-3 FFQ performed reasonably well for most food groups within strata of sex and race/ethnicity, although validity tended to be lower for minority groups. In addition, the CPS-3 FFQ appeared to be a valid instrument for measuring diet quality in accordance with the ACS guidelines for cancer prevention in both sexes and all race/ethnicities included in this study. Future iterations of the CPS-3 FFQ should consider removing options for participants to differentiate between low-fat and full-fat cheeses and yogurts, as the results of this study suggest participants may not accurately recall the fat-type of these products. Also, differentiating "white" from "red" processed meat from all processed meat line-items (e.g., bacon, other sausages) may improve the ability of the CPS-3 FFQ to estimate consumption of these groups. Less commonly consumed items may be deleted or combined with similar foods to limit over-estimation of some items. Our findings highlight the importance of considering differences in the validity of dietary exposures by sex and race, as differential misclassification by these factors could underestimate gender and racial disparities in diet and disease relationships. The CPS-3 FFQ is of comparable quality with FFQs of other major cohorts for prospective investigation into relationships between food groups and disease risk. Researchers should exercise caution in using food groups estimated by the CPS-3 FFQ that have relatively poor validity (e.g., full-fat yogurt products, “light meat” seafood, bread), and consider alternate methods to assess these food groups.

Acknowledgements and statement of authors’ contributions to manuscript

MLM, ANT, YW, and TJH designed the research; ANT analyzed data and wrote the paper; WDF provided statistical consult; ANT, WDF, TJH, YW, MLM, LEM, DCM, RAH, LS, and AVP contributed to interpretation of data and editing of the manuscript; MLM had primary responsibility for final content. All authors have read and approved the final manuscript.

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Table 2.1.1. Participant Characteristics in the Cancer Prevention Study-3 (CPS-3) Diet Assessment Sub-Study (*n*=677) and the CPS-3 Cohort (*n*=176,672)[a]

Characteristic	Value	Validation Substudy *n* =677	CPS-3 Cohort[b] *n* =176,672
Age, years		52.3 ± 9.6	52.1 ±9.7
Gender			
	Men	244 (36.0)	36176 (20.5)
	Women	433 (64.0)	140496 (79.5)
Race			
	White	417 (61.6)	150945 (91.4)
	African American	159 (23.5)	4579 (2.8)
	Hispanic	101 (14.9)	9576 (5.8)
Body mass index, kg/m^2			
	Underweight (<18.5)	10 (1.5)	3931 (2.2)
	Healthy Weight (18.5-25)	272 (40.2)	66934 (37.9)
	Overweight (25-30)	204 (30.1)	56093 (31.8)
	Obese (30+)	191 (28.2)	49714 (28.1)
Highest education level			
	Some high school	4 (0.6)	602 (0.4)
	High school degree	18 (2.7)	12284 (7.5)
	Some college	75 (11.5)	22209 (13.5)
	2-year college	59 (9.0)	23228 (14.1)
	4-year college	224 (34.2)	56444 (34.3)
	Graduate degree	275 (42)	49990 (30.3)
Current smoking			
	No	655 (97.0)	170852 (97.0)
	Yes	20 (3.0)	5204 (3.0)
Household income			
	<$15,000	17 (2.5)	3046 (1.8)
	$15,000-$24,000	16 (2.4)	5010 (2.9)
	$25,000-$49,000	87 (13.0)	21077 (12.1)
	$50,000-$74,000	117 (17.4)	31366 (18.1)
	$75,000-$99,000	94 (14.0)	30700 (17.7)
	$100,000-$124,000	98 (14.6)	27701 (16.0)
	$125,000-$149,000	59 (8.8)	17167 (9.9)
	$150,000+	183 (27.3)	37460 (21.6)
Marital status			
	Married	460 (68.1)	129527 (74.2)
	Living with partner	19 (2.8)	4779 (2.7)
	Never married	85 (12.6)	13239 (7.6)
	Divorced	81 (12.0)	19480 (11.2)
	Separated	12 (1.8)	1850 (1.1)
	Widowed	18 (2.7)	5685 (3.3)
Work status			

Characteristic	Value	Validation Substudy *n* =677	CPS-3 Cohort[b] *n* =176,672
	Full-time	442 (67.4)	117475 (67.9)
	Part-time	73 (11.1)	21045 (12.2)
	Homemaker	98 (14.9)	21598 (12.5)
	Student	17 (2.6)	6799 (3.9)
	Unemployed	18 (2.7)	2684 (1.6)
	Retired	5 (0.8)	2132 (1.2)
	Volunteer	3 (0.5)	513 (0.3)
	Disabled	0 (0.0)	864 (0.5)

[a] Values are means ± SD or frequency (percentages).
[b] CPS-3 participants completed the CPS-3 food frequency questionnaire in 2015 and includes those who participated in the validation substudy.

Table 2.1.2. Sex-specific, mean food group intake (servings/day)[a] and diet quality score (0-9) estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire (FFQ) and up to six repeated 24-hour dietary recalls (24HR) among participants in the CPS-3 Diet Assessment Substudy (*n* =677)[b].

Food Group	Men (*n*=244)			Women (*n* =433)		
	FFQ1	FFQ2	24HR	FFQ1	FFQ2	24HR
Fruits & Juices, total, svg/d	3.3 ± 2.4	3.1 ± 2.2	1.9 ± 1.4	3.2 ± 2.6	3.0 ± 2.0	1.7 ± 1.3
Whole Fruits, total (excluding juices), svg/d	2.3 ± 1.8	2.3 ± 1.7	1.4 ± 1.2	2.7 ± 2.4	2.6 ± 1.7	1.5 ± 1.2
Citrus Fruits (excluding juices), svg/d	0.3 ± 0.4	0.2 ± 0.3	0.2 ± 0.3	0.2 ± 0.4	0.2 ± 0.3	0.2 ± 0.3
Non-Citrus Fruits (excluding juices), svg/d	2.1 ± 1.7	2.1 ± 1.6	1.2 ± 1.1	2.4 ± 2.2	2.3 ± 1.6	1.3 ± 1.1
Berries, svg/d	0.4 ± 0.5	0.4 ± 0.5	0.1 ± 0.2	0.6 ± 0.7	0.6 ± 0.7	0.2 ± 0.2
Fruit Juices, svg/d	0.5 ± 0.8	0.5 ± 0.8	0.5 ± 0.7	0.3 ± 0.6	0.2 ± 0.6	0.2 ± 0.4
Vegetables						
Starchy vegetables, svg/d	0.7 ± 0.6	0.7 ± 0.5	0.7 ± 0.6	0.6 ± 0.5	0.6 ± 0.5	0.5 ± 0.5
White/fried potatoes, svg/d	0.5 ± 0.6	0.5 ± 0.4	0.5 ± 0.5	0.4 ± 0.4	0.4 ± 0.4	0.4 ± 0.4
Non-starchy vegetables, svg/d	2.8 ± 1.7	2.8 ± 1.7	2.9 ± 1.6	3.3 ± 2.6	3.2 ± 2.1	2.7 ± 1.6
Tomato products, svg/d	0.6 ± 0.7	0.6 ± 0.5	0.6 ± 0.5	0.5 ± 0.5	0.5 ± 0.5	0.5 ± 0.4
Cruciferous vegetables, svg/d	0.5 ± 0.4	0.5 ± 0.5	0.3 ± 0.4	0.6 ± 0.7	0.6 ± 0.5	0.3 ± 0.4
Dark green vegetables, svg/d	0.7 ± 0.6	0.7 ± 0.5	0.7 ± 0.7	1.0 ± 1.0	1.0 ± 0.9	0.7 ± 0.7
Deep-yellow vegetables, svg/d	0.1 ± 0.2	0.1 ± 0.2	0.3 ± 0.3	0.1 ± 0.2	0.1 ± 0.2	0.3 ± 0.3
Legumes, svg/d	0.6 ± 1.0	0.7 ± 1.6	0.3 ± 0.3	0.6 ± 1.3	0.7 ± 1.6	0.2 ± 0.3
Garlic, fresh, svg/d	0.2 ± 0.4	0.2 ± 0.4	0.1 ± 0.2	0.3 ± 0.4	0.3 ± 0.5	0.1 ± 0.1
Vegetable juice, svg/d	0.1 ± 0.5	0.1 ± 0.4	0.1 ± 0.3	0.0 ± 0.2	0.0 ± 0.2	0.0 ± 0.1
Meats, Dairy, & Alternatives						
Dairy, total, svg/d	2.0 ± 1.4	1.9 ± 1.4	2.0 ± 1.2	1.8 ± 1.3	1.6 ± 1.2	1.7 ± 1.0
Dairy, low-fat, svg/d	0.9 ± 0.9	0.8 ± 0.8	1.0 ± 0.9	0.7 ± 0.9	0.6 ± 0.7	0.8 ± 0.8
Dairy, regular, svg/d	0.8 ± 1.0	0.9 ± 1.0	0.8 ± 0.6	0.7 ± 0.8	0.7 ± 0.8	0.6 ± 0.5
Yogurt, total, svg/d	0.2 ± 0.3	0.2 ± 0.4	0.1 ± 0.2	0.3 ± 0.3	0.2 ± 0.3	0.1 ± 0.2
Yogurt, low-fat , svg/d	0.2 ± 0.3	0.2 ± 0.3	0.1 ± 0.2	0.2 ± 0.3	0.2 ± 0.3	0.1 ± 0.2
Yogurt, regular, svg/d	0.0 ± 0.1	0.1 ± 0.2	0.0 ± 0.1	0.1 ± 0.2	0.1 ± 0.2	0.0 ± 0.0
Cheese, low-fat, svg/d	0.0 ± 0.2	0.0 ± 0.1	0.2 ± 0.2	0.1 ± 0.4	0.1 ± 0.2	0.2 ± 0.2

Food Group	Men (*n*=244)			Women (*n* =433)		
	FFQ1	FFQ2	24HR	FFQ1	FFQ2	24HR
Cheese, regular, svg/d	0.4 ± 0.5	0.4 ± 0.4	0.6 ± 0.5	0.4 ± 0.4	0.3 ± 0.4	0.5 ± 0.3
Milk, low-fat, svg/d	0.7 ± 0.9	0.6 ± 0.8	0.5 ± 0.7	0.4 ± 0.7	0.4 ± 0.6	0.3 ± 0.6
Frozen dessert, svg/d	0.3 ± 0.3	0.3 ± 0.4	0.2 ± 0.4	0.3 ± 0.4	0.3 ± 0.4	0.2 ± 0.3
Milk alternative[c], svg/d	0.2 ± 0.5	0.1 ± 0.4	0.1 ± 0.3	0.2 ± 0.4	0.2 ± 0.6	0.1 ± 0.3
Soy products[d], svg/d	0.1 ± 0.4	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.2
Eggs, svg/d	0.4 ± 0.6	0.4 ± 0.4	0.5 ± 0.5	0.4 ± 0.5	0.4 ± 0.5	0.5 ± 0.5
Poultry, svg/d	1.5 ± 1.4	1.4 ± 1.2	2.1 ± 1.6	1.7 ± 1.3	1.6 ± 1.4	1.6 ± 1.4
Red meat, svg/d	1.7 ± 1.5	1.7 ± 1.4	1.6 ± 1.6	1.6 ± 1.4	1.5 ± 1.3	1.0 ± 0.9
Processed Meat, Total, svg/d	0.9 ± 0.9	0.9 ± 1.0	0.9 ± 0.8	0.7 ± 0.7	0.6 ± 0.6	0.7 ± 0.7
Red processed meat, svg/d	0.5 ± 0.6	0.5 ± 0.6	0.4 ± 0.4	0.4 ± 0.5	0.4 ± 0.4	0.3 ± 0.3
White processed meat, svg/d	0.4 ± 0.6	0.4 ± 0.7	0.1 ± 0.3	0.3 ± 0.4	0.3 ± 0.3	0.1 ± 0.3
Total seafood, svg/d	1.0 ± 1.2	1.0 ± 0.9	0.9 ± 1.1	0.9 ± 1.0	0.9 ± 0.9	0.7 ± 0.9
Light meat seafood, svg/d	0.4 ± 0.5	0.4 ± 0.4	0.1 ± 0.2	0.4 ± 0.5	0.3 ± 0.4	0.1 ± 0.2
Dark meat seafood, svg/d	0.6 ± 0.9	0.6 ± 0.7	0.1 ± 0.3	0.5 ± 0.6	0.5 ± 0.6	0.1 ± 0.2
Nuts and seeds, svg/d	1.0 ± 1.2	0.9 ± 1.2	0.9 ± 1.5	1.2 ± 1.5	1.2 ± 1.4	0.9 ± 1.2
Nut and seed butters, svg/d	0.3 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	0.3 ± 0.4	0.3 ± 0.5	0.2 ± 0.4
Grains, total, svg/d	5.2 ± 2.7	5.1 ± 2.4	6.3 ± 2.3	4.4 ± 2.4	4.3 ± 2.3	4.5 ± 1.9
Whole grains, svg/d	2.6 ± 2.1	2.5 ± 1.8	1.8 ± 1.4	2.2 ± 1.6	2.2 ± 1.7	1.2 ± 1.0
Refined grains, svg/d	2.1 ± 1.5	2.1 ± 1.4	4.0 ± 2.1	1.7 ± 1.3	1.6 ± 1.2	2.7 ± 1.5
Cold Cereal, svg/d	0.5 ± 0.6	0.5 ± 0.5	0.5 ± 0.7	0.3 ± 0.5	0.3 ± 0.5	0.3 ± 0.5
Hot Cereal, svg/d	0.4 ± 0.5	0.4 ± 0.6	0.2 ± 0.3	0.5 ± 0.6	0.4 ± 0.6	0.2 ± 0.3
Bread, svg/d	1.7 ± 1.5	1.6 ± 1.3	2.0 ± 1.2	1.3 ± 1.3	1.3 ± 1.2	1.4 ± 0.9
Pasta, svg/d	0.5 ± 0.4	0.4 ± 0.4	0.5 ± 0.7	0.4 ± 0.4	0.4 ± 0.4	0.3 ± 0.4
Crackers, svg/d	0.1 ± 0.4	0.1 ± 0.5	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.2	0.2 ± 0.2
Snack bars, svg/d	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.3	0.2 ± 0.4	0.1 ± 0.2
Miscellaneous						
Baked goods, svg/d	0.5 ± 0.7	0.5 ± 0.7	0.5 ± 0.6	0.4 ± 0.5	0.4 ± 0.4	0.4 ± 0.5
Snack Chips, svg/d	0.5 ± 0.6	0.5 ± 0.6	0.6 ± 0.7	0.6 ± 0.7	0.5 ± 0.5	0.5 ± 0.6
Chocolate candy, svg/d	0.3 ± 0.4	0.3 ± 0.4	0.1 ± 0.2	0.3 ± 0.5	0.3 ± 0.4	0.1 ± 0.2

Food Group	Men (*n*=244)			Women (*n* =433)		
	FFQ1	FFQ2	24HR	FFQ1	FFQ2	24HR
Beverages						
Sugar sweetened beverages, svg/d	0.9 ± 1.3	0.8 ± 1.3	1.0 ± 1.2	0.5 ± 1.0	0.6 ± 1.0	0.8 ± 1.1
Coffee, total, svg/d	1.4 ± 1.6	1.4 ± 1.5	1.3 ± 1.4	1.1 ± 1.4	1.2 ± 1.4	1.0 ± 1.2
Decaffeinated coffee, svg/d	0.2 ± 0.6	0.1 ± 0.5	0.2 ± 0.6	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.4
Caffeinated coffee, svg/d	1.2 ± 1.4	1.2 ± 1.4	1.2 ± 1.3	1.0 ± 1.3	1.1 ± 1.3	0.9 ± 1.1
Tea, total, svg/d	0.7 ± 1.1	0.7 ± 1.0	0.6 ± 1.1	1.1 ± 1.8	1.2 ± 2.6	0.7 ± 1.3
Decaffeinated tea, svg/d	0.2 ± 0.5	0.2 ± 0.5	0.1 ± 0.5	0.4 ± 0.7	0.4 ± 1.1	0.2 ± 0.4
Caffeinated tea, svg/d	0.5 ± 0.9	0.5 ± 0.9	0.5 ± 0.9	0.8 ± 1.5	0.8 ± 1.8	0.6 ± 1.1
Alcohol, total, svg/d	0.8 ± 1.1	0.8 ± 1.1	0.8 ± 1.1	0.5 ± 0.8	0.5 ± 1.0	0.5 ± 0.7
Beer, svg/d	0.3 ± 0.6	0.3 ± 0.6	0.3 ± 0.6	0.1 ± 0.4	0.2 ± 0.6	0.1 ± 0.3
Wine, total, svg/d	0.3 ± 0.6	0.3 ± 0.5	0.3 ± 0.6	0.3 ± 0.6	0.3 ± 0.6	0.3 ± 0.5
Wine, white, svg/d	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.4	0.1 ± 0.4	0.2 ± 0.4
Wine, red, svg/d	0.2 ± 0.5	0.2 ± 0.4	0.2 ± 0.5	0.2 ± 0.4	0.2 ± 0.5	0.2 ± 0.5
ACS Diet Quality Score[e]	4.8 ± 2.2	4.7 ± 2.2	4.7 ± 2.4	4.9 ± 2.1	4.9 ± 2.0	4.6 ± 2.2

[a] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Supplemental Table S1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.

[b] Values presented are means ± SD. Not all groups/subgroups are mutually exclusive so all subgroups might not add up to equal the total group.

[c] Includes soy milk; almond milk or rice milk (servings defined as approximately equivalent to the amount of calcium in 1 cup of milk).

[d] Includes soy beans/edamame (1 ounce) or soy nuts (1/2 ounce); tofu (1 ounce) or tofu burgers; fermented soy, tempeh, miso (1 ounce); soy milk (servings defined as approximately equivalent to the amount of calcium in 1 cup of milk).

[e] Refer to **Supplemental Table S2** and methods for additional details on score calculation (range:0-9).

Table 2.1.3. Sex-specific correlation coefficients[a] for reproducibility and validity of energy-adjusted[b] food group intake (servings/day)[c] and a diet quality score (0-9) estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire (FFQ) among participants in the CPS-3 Diet Assessment Substudy (*n* =677).

Food Group	Men (*n*=244)				Women (*n*=433)			
	Repro-ducibility	Validity			Repro-ducibility	Validity		
	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)
Fruits & Juices, total, svg/d	0.71	0.55	0.6	0.70 (0.59, 0.78)	0.62	0.46	0.51	0.60 (0.51, 0.67)
Fruits, total (excluding juices), svg/d	0.77	0.61	0.64	0.74 (0.63, 0.82)	0.64	0.50	0.56	0.64 (0.56, 0.71)
Citrus Fruits (excluding juices), svg/d	0.68	0.38	0.38	0.45 (0.31, 0.57)	0.67	0.27	0.31	0.40 (0.29, 0.50)
Non-Citrus Fruits (excluding juices), svg/d	0.75	0.59	0.61	0.72 (0.60, 0.80)	0.63	0.50	0.55	0.65 (0.56, 0.72)
Berries, svg/d	0.71	0.17	0.32	0.37 (0.24, 0.49)	0.65	0.37	0.38	0.47 (0.37, 0.57)
Fruit Juices, svg/d	0.69	0.45	0.44	0.53 (0.40, 0.63)	0.66	0.31	0.27	0.35 (0.23, 0.45)
Vegetables								
Starchy vegetables, svg/d	0.55	0.34	0.36	0.61 (-0.49, 0.96)	0.57	0.32	0.36	0.61 (0.43, 0.75)
White/fried potatoes, svg/d	0.56	0.25	0.28	0.37 (0.20, 0.52)	0.64	0.29	0.3	0.42 (0.30, 0.53)
Non-starchy vegetables, svg/d	0.65	0.42	0.44	0.56 (0.42, 0.68)	0.71	0.48	0.51	0.63 (0.54, 0.71)
Tomato products, svg/d	0.69	0.31	0.33	0.50 (0.31, 0.65)	0.65	0.36	0.41	0.67 (0.39, 0.84)
Cruciferous vegetables, svg/d	0.63	0.47	0.49	0.68 (0.51, 0.80)	0.70	0.40	0.40	0.59 (0.45, 0.70)
Dark green vegetables, svg/d	0.64	0.43	0.40	0.51 (0.36, 0.64)	0.67	0.45	0.49	0.64 (0.54, 0.73)
Deep-yellow vegetables, svg/d	0.68	0.29	0.23	0.31 (0.15, 0.45)	0.64	0.21	0.23	0.33 (0.20, 0.46)

Food Group	Men (n=244) Repro-ducibility r_s (FFQ1 vs. FFQ2)	Men Validity r_s (FFQ1 vs. 24HR)	Men Validity r_s (FFQ2 vs. 24HR)	Men Validity Deattenuated r_s (FFQ2 vs. 24HR)	Women (n=433) Repro-ducibility r_s (FFQ1 vs. FFQ2)	Women Validity r_s (FFQ1 vs. 24HR)	Women Validity r_s (FFQ2 vs. 24HR)	Women Validity Deattenuated r_s (FFQ2 vs. 24HR)
Legumes, svg/d	0.54	0.37	0.44	0.57 (0.42, 0.69)	0.57	0.24	0.29	0.39 (0.27, 0.49)
Garlic, fresh, svg/d	0.79	0.31	0.26	0.35 (0.18, 0.50)	0.73	0.34	0.30	0.42 (0.29, 0.53)
Vegetable juice, svg/d	0.68	0.39	0.38	0.43 (0.31, 0.55)	0.41	0.22	0.2	0.23 (0.13, 0.33)
Meats, Dairy, & Alternatives								
Dairy, total, svg/d	0.69	0.61	0.64	0.76 (0.65, 0.84)	0.66	0.53	0.60	0.74 (0.64, 0.81)
Dairy, low-fat, svg/d	0.71	0.60	0.62	0.69 (0.59, 0.77)	0.71	0.46	0.52	0.59 (0.51, 0.66)
Dairy, regular, svg/d	0.76	0.46	0.44	0.54 (0.40, 0.66)	0.62	0.32	0.37	0.52 (0.39, 0.63)
Yogurt, total, svg/d	0.69	0.43	0.43	0.51 (0.38, 0.62)	0.64	0.41	0.42	0.50 (0.41, 0.59)
Yogurt, low-fat, svg/d	0.65	0.42	0.40	0.48 (0.35, 0.59)	0.59	0.34	0.36	0.43 (0.33, 0.52)
Yogurt, regular, svg/d	0.48	0.24	0.17	0.18 (0.05, 0.31)	0.51	0.10	0.14	0.16 (0.06, 0.26)
Cheese, low-fat, svg/d	-0.25	-0.14	0.22	0.29 (0.13, 0.44)	0.05	0.02	0.28	0.39 (0.24, 0.52)
Cheese, regular, svg/d	0.69	0.43	0.44	0.57 (0.42, 0.69)	0.54	0.42	0.43	0.62 (0.49, 0.72)
Milk, low-fat, svg/d	0.74	0.65	0.69	0.76 (0.68, 0.82)	0.76	0.53	0.59	0.67 (0.60, 0.74)
Frozen dessert, svg/d	0.57	0.20	0.21	0.26 (0.10, 0.40)	0.52	0.13	0.21	0.27 (0.15, 0.37)
Milk alternative[c], svg/d	0.15	0.14	0.48	0.54 (0.42, 0.63)	0.68	0.49	0.53	0.61 (0.53, 0.68)
Soy products[d], svg/d	0.65	0.31	0.30	0.33 (0.20, 0.45)	0.67	0.32	0.34	0.39 (0.29, 0.47)
Eggs, svg/d	0.66	0.45	0.48	0.60 (0.46, 0.71)	0.66	0.38	0.44	0.55 (0.45, 0.64)

Food Group	Men (n=244) Repro-ducibility r_s (FFQ1 vs. FFQ2)	Men Validity r_s (FFQ1 vs. 24HR)	Men Validity r_s (FFQ2 vs. 24HR)	Men Validity Deattenuated r_s (FFQ2 vs. 24HR)	Women (n=433) Repro-ducibility r_s (FFQ1 vs. FFQ2)	Women Validity r_s (FFQ1 vs. 24HR)	Women Validity r_s (FFQ2 vs. 24HR)	Women Validity Deattenuated r_s (FFQ2 vs. 24HR)
Poultry, svg/d	0.52	0.41	0.45	0.63 (0.47, 0.75)	0.55	0.38	0.37	0.52 (0.24, 0.72)
Red meat, svg/d	0.71	0.42	0.39	0.51 (0.36, 0.64)	0.72	0.37	0.40	0.57 (0.43, 0.68)
Processed Meat, Total, svg/d	0.65	0.41	0.48	0.67 (0.50, 0.79)	0.69	0.40	0.41	0.54 (0.43, 0.64)
Red processed meat, svg/d	0.65	0.32	0.38	0.50 (0.34, 0.63)	0.73	0.39	0.36	0.48 (0.36, 0.59)
White processed meat, svg/d	0.60	0.20	0.17	0.21 (0.07, 0.35)	0.64	0.21	0.22	0.28 (0.16, 0.38)
Total seafood, svg/d	0.71	0.38	0.33	0.45 (0.27, 0.59)	0.70	0.38	0.37	0.48 (0.36, 0.58)
Light meat seafood, svg/d	0.61	0.23	0.2	0.23 (0.09, 0.36)	0.62	0.27	0.24	0.29 (0.18, 0.38)
Dark meat seafood, svg/d	0.69	0.04	0.05	0.05 (-.09, 0.19)	0.67	0.33	0.32	0.39 (0.29, 0.49)
Nuts and seeds, svg/d	0.60	0.44	0.51	0.61 (0.49, 0.71)	0.68	0.47	0.54	0.67 (0.58, 0.75)
Nut and seed butters, svg/d	0.64	0.35	0.33	0.39 (0.26, 0.51)	0.66	0.27	0.21	0.26 (0.15, 0.36)
Grains, total, svg/d	0.58	0.38	0.36	0.45 (0.31, 0.58)	0.59	0.45	0.48	0.59 (0.50, 0.68)
Whole grains, svg/d	0.58	0.50	0.61	0.72 (0.61, 0.80)	0.59	0.40	0.43	0.52 (0.42, 0.61)
Refined grains, svg/d	0.70	0.46	0.37	0.48 (0.32, 0.61)	0.62	0.38	0.45	0.59 (0.48, 0.68)
Cold Cereal, svg/d	0.73	0.52	0.54	0.61 (0.50, 0.70)	0.70	0.43	0.45	0.54 (0.45, 0.63)
Hot Cereal, svg/d	0.65	0.19	0.28	0.33 (0.19, 0.46)	0.70	0.36	0.43	0.52 (0.42, 0.61)
Bread, svg/d	0.46	0.27	0.29	0.41 (0.12, 0.64)	0.57	0.41	0.41	0.57 (0.44, 0.67)
Pasta, svg/d	0.45	0.10	0.10	0.12 (-.05, 0.27)	0.59	0.09	0.15	0.22 (0.08, 0.34)

Food Group	Men (*n*=244)				Women (*n*=433)			
	Repro-ducibility	Validity			Repro-ducibility	Validity		
	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)
Crackers, svg/d	0.35	0.20	0.23	0.26 (0.13, 0.39)	0.30	0.11	0.10	0.14 (0.02, 0.25)
Snack bars, svg/d	0.66	0.42	0.38	0.44 (0.31, 0.55)	0.65	0.32	0.33	0.40 (0.18, 0.59)
Miscellaneous								
Baked goods, svg/d	0.60	0.27	0.27	0.36 (0.19, 0.50)	0.58	0.29	0.35	0.47 (0.35, 0.57)
Snack Chips, svg/d	0.69	0.45	0.43	0.55 (0.40, 0.68)	0.63	0.36	0.34	0.53 (0.01, 0.83)
Chocolate candy, svg/d	0.65	0.19	0.19	0.24 (0.09, 0.38)	0.59	0.26	0.26	0.35 (0.23, 0.46)
Beverages								
Sugar sweetened beverages, svg/d	0.74	0.28	0.32	0.36 (0.23, 0.47)	0.72	0.26	0.26	0.28 (0.19, 0.38)
Coffee, total, svg/d	0.89	0.76	0.79	0.82 (0.76, 0.86)	0.86	0.77	0.77	0.80 (0.76, 0.84)
Decaffeinated coffee, svg/d	0.64	0.52	0.46	0.50 (0.39, 0.60)	0.63	0.38	0.38	0.42 (0.33, 0.50)
Caffeinated coffee, svg/d	0.89	0.74	0.77	0.81 (0.75, 0.86)	0.84	0.75	0.74	0.78 (0.73, 0.82)
Tea, total, svg/d	0.80	0.43	0.46	0.51 (0.40, 0.61)	0.79	0.57	0.60	0.68 (0.61, 0.74)
Decaffeinated tea, svg/d	0.40	0.23	0.04	0.05 (-.09, 0.18)	0.71	0.32	0.30	0.36 (0.26, 0.45)
Caffeinated tea, svg/d	0.72	0.36	0.40	0.45 (0.33, 0.56)	0.76	0.49	0.52	0.59 (0.51, 0.66)
Alcohol, total, svg/d	0.92	0.67	0.72	0.78 (0.70, 0.84)	0.89	0.64	0.65	0.71 (0.65, 0.77)
Beer, svg/d	0.87	0.53	0.51	0.59 (0.47, 0.68)	0.77	0.22	0.24	0.28 (0.18, 0.38)
Wine, total, svg/d	0.86	0.56	0.59	0.67 (0.57, 0.76)	0.86	0.57	0.54	0.61 (0.53, 0.68)

Food Group		Men (n=244) Reproducibility r_s (FFQ1 vs. FFQ2)	Men Validity r_s (FFQ1 vs. 24HR)	Men Validity r_s (FFQ2 vs. 24HR)	Men Validity Deattenuated r_s (FFQ2 vs. 24HR)	Women (n=433) Reproducibility r_s (FFQ1 vs. FFQ2)	Women Validity r_s (FFQ1 vs. 24HR)	Women Validity r_s (FFQ2 vs. 24HR)	Women Validity Deattenuated r_s (FFQ2 vs. 24HR)
	Wine, white, svg/d	0.78	0.36	0.38	0.43 (0.31, 0.55)	0.77	0.34	0.34	0.39 (0.29, 0.48)
	Wine, red, svg/d	0.81	0.43	0.46	0.51 (0.39, 0.61)	0.81	0.42	0.40	0.45 (0.36, 0.54)
Median		0.68	0.41	0.40	0.50	0.66	0.37	0.38	0.52
		r_p (FFQ1 vs. FFQ2)	**r_p (FFQ1 vs. 24HR)**	**r_p (FFQ2 vs. 24HR)**		**r_p (FFQ1 vs. FFQ2)**	**r_p (FFQ1 vs. 24HR)**	**r_p (FFQ2 vs. 24HR)**	
ACS Diet Quality Score[f]		0.76	0.65	0.69	--	0.71	0.54	0.61	--

[a] Spearman (r_s) and Pearson (r_p) correlation coefficients were used to describe food group and diet quality score analyses, respectively.
[b] Food groups were energy-adjusted according to the residual method.
[c] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Supplemental Table S1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[d] Includes soy milk; almond milk or rice milk.
[e] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.
[f] Refer to **Supplemental Table S2** and methods for additional details on score calculation (range:0-9).

Table 2.1.4. Percent agreement between energy-adjusted [a] food groups (servings/day) [b] estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire [c] and the mean of the 24-hour dietary recalls among participants in the CPS-3 Diet Validation Study (*n* =677)[d].

Food Group	Men (*n* =244) Level of Agreement					Women (*n* =433) Level of Agreement				
	Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa	Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa
Fruits & Juices, total, svg/d	101 (41.4)	99 (40.6)	39 (16.0)	5 (2.0)	0.37	171 (39.5)	185 (42.7)	60 (13.9)	17 (3.9)	0.34
Fruits, total (excluding juices), svg/d	114 (46.7)	97 (39.8)	28 (11.5)	5 (2.0)	0.45	189 (43.6)	177 (40.9)	52 (12.0)	15 (3.5)	0.40
Citrus Fruits (excluding juices), svg/d	83 (34.0)	102 (41.8)	47 (19.3)	12 (4.9)	0.24	168 (38.8)	185 (42.7)	63 (14.5)	17 (3.9)	0.33
Non-Citrus Fruits (excluding juices), svg/d	102 (41.8)	106 (43.4)	30 (12.3)	6 (2.5)	0.40	180 (41.6)	188 (43.4)	51 (11.8)	14 (3.2)	0.39
Berries, svg/d	94 (38.5)	112 (45.9)	30 (12.3)	8 (3.3)	0.36	181 (41.8)	156 (36.0)	72 (16.6)	24 (5.5)	0.31
Fruit Juice, svg/d	91 (37.3)	101 (41.4)	39 (16.0)	15 (5.3)	0.29	150 (34.6)	167 (38.6)	90 (20.8)	26 (6.0)	0.21
Vegetables										
Starchy vegetables, svg/d	87 (35.7)	94 (38.5)	51 (20.9)	12 (4.9)	0.24	182 (42.0)	162 (37.4)	63 (14.5)	26 (6.0)	0.32
White/fried potatoes, svg/d	86 (35.2)	96 (39.3)	46 (18.9)	16 (6.6)	0.23	157 (36.3)	177 (40.9)	78 (18.0)	21 (4.8)	0.27
Non-starchy vegetables, svg/d	100 (41.0)	95 (38.9)	40 (16.4)	9 (3.7)	0.34	165 (38.1)	179 (41.3)	74 (17.1)	15 (3.50)	0.31
Tomato products, svg/d	80 (32.8)	95 (38.9)	52 (21.3)	17 (7.0)	0.18	156 (36.0)	170 (39.3)	89 (20.6)	18 (4.20)	0.26
Cruciferous vegetables, svg/d	92 (37.7)	99 (40.6)	44 (18.0)	9 (3.7)	0.30	165 (38.1)	181 (41.8)	70 (16.2)	17 (3.90)	0.31

Food Group	Men (*n* =244) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa	Women (*n* =433) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa
Dark green vegetables, svg/d	95 (38.9)	110 (45.1)	33 (13.5)	6 (2.5)	0.36	152 (35.1)	179 (41.3)	81 (18.7)	21 (4.80)	0.25
Deep-yellow vegetables, svg/d	84 (34.4)	82 (33.6)	58 (23.8)	20 (8.2)	0.15	133 (30.7)	190 (43.9)	70 (16.2)	40 (9.20)	0.17
Legumes, svg/d	77 (31.6)	100 (41.0)	55 (22.5)	12 (4.9)	0.19	139 (32.1)	172 (39.7)	94 (21.7)	28 (6.50)	0.18
Garlic, fresh, svg/d	65 (26.6)	108 (44.3)	53 (21.7)	18 (7.4)	0.12	151 (34.9)	158 (36.5)	90 (20.8)	34 (7.90)	0.19
Vegetable juice, svg/d	107 (43.9)	73 (29.9)	51 (20.9)	13 (5.3)	0.30	150 (34.6)	157 (36.3)	81 (18.7)	45 (10.4)	0.16
Meats, Dairy, & Alternatives										
Dairy, total, svg/d	117 (48.0)	93 (38.1)	27 (11.1)	7 (2.9)	0.45	179 (41.3)	180 (41.6)	64 (14.8)	10 (2.30)	0.37
Dairy, low-fat, svg/d	112 (45.9)	105 (43.0)	22 (9.00)	5 (2.0)	0.46	180 (41.6)	174 (40.2)	61 (14.1)	18 (4.20)	0.35
Dairy, regular, svg/d	84 (34.4)	111 (45.5)	42 (17.2)	7 (2.9)	0.29	150 (34.6)	170 (39.3)	85 (19.6)	28 (6.50)	0.22
Yogurt, total, svg/d	106 (43.4)	104 (42.6)	30 (12.3)	4 (1.6)	0.42	194 (44.8)	168 (38.8)	59 (13.6)	12 (2.80)	0.40
Yogurt, low-fat, svg/d	102 (41.8)	90 (36.9)	44 (18.0)	8 (3.3)	0.34	176 (40.6)	164 (37.9)	71 (16.4)	22 (5.10)	0.31
Yogurt, regular, svg/d	89 (36.5)	82 (33.6)	47 (19.3)	26 (10.7)	0.17	130 (30.0)	174 (40.2)	83 (19.2)	46 (10.6)	0.12
Cheese, low-fat, svg/d	60 (24.6)	93 (38.1)	64 (26.2)	27 (11.1)	0.01	111 (25.6)	184 (42.5)	100 (23.1)	38 (8.80)	0.08
Cheese, regular, svg/d	104 (42.6)	93 (38.1)	36 (14.8)	11 (4.5)	0.35	160 (37.0)	178 (41.1)	75 (17.3)	20 (4.60)	0.28
Milk, low-fat, svg/d	133 (54.5)	94 (38.5)	15 (6.10)	2 (0.8)	0.57	201 (46.4)	181 (41.8)	40 (9.20)	11 (2.50)	0.46

Food Group	Men (*n* =244) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa	Women (*n* =433) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa
Frozen Dairy Dessert, svg/d	79 (32.4)	104 (42.6)	51 (20.9)	10 (4.1)	0.23	155 (35.8)	162 (37.4)	88 (20.3)	28 (6.50)	0.22
Milk alternative [e], svg/d	118 (48.4)	73 (29.9)	42 (17.2)	11 (4.5)	0.38	208 (48.0)	151 (34.9)	63 (14.5)	11 (2.50)	0.43
Soy products [f], svg/d	80 (32.8)	107 (43.9)	43 (17.6)	14 (5.7)	0.23	167 (38.6)	153 (35.3)	83 (19.2)	30 (6.90)	0.24
Eggs, svg/d	111 (45.5)	96 (39.3)	29 (11.9)	8 (3.3)	0.42	183 (42.3)	175 (40.4)	64 (14.8)	11 (2.50)	0.38
Poultry, svg/d	92 (37.7)	98 (40.2)	42 (17.2)	12 (4.9)	0.29	155 (35.8)	174 (40.2)	82 (18.9)	22 (5.10)	0.25
Red meat, svg/d	98 (40.2)	87 (35.7)	48 (19.7)	11 (4.5)	0.29	173 (40.0)	179 (41.3)	72 (16.6)	9 (2.10)	0.35
Processed Meat, Total, svg/d	100 (41.0)	97 (39.8)	44 (18.0)	3 (1.2)	0.36	172 (39.7)	170 (39.3)	79 (18.2)	12 (2.80)	0.33
Red processed meat, svg/d	83 (34.0)	112 (45.9)	41 (16.8)	8 (3.3)	0.29	176 (40.6)	174 (40.2)	71 (16.4)	12 (2.80)	0.35
White processed meat, svg/d	82 (33.6)	101 (41.4)	46 (18.9)	15 (6.1)	0.22	162 (37.4)	168 (38.8)	79 (18.2)	24 (5.50)	0.26
Total seafood, svg/d	86 (35.2)	94 (38.5)	52 (21.3)	12 (4.9)	0.23	163 (37.6)	190 (43.9)	62 (14.3)	18 (4.20)	0.32
Light meat seafood, svg/d	66 (27.0)	110 (45.1)	42 (17.2)	26 (10.7)	0.11	129 (29.8)	175 (40.4)	108 (24.9)	21 (4.80)	0.16
Dark meat seafood, svg/d	82 (33.6)	91 (37.3)	50 (20.5)	21 (8.6)	0.17	156 (36.0)	182 (42.0)	81 (18.7)	14 (3.20)	0.29
Nuts and seeds, svg/d	114 (46.7)	99 (40.6)	24 (9.80)	7 (2.9)	0.45	185 (42.7)	168 (38.8)	68 (15.7)	12 (2.80)	0.37
Nut and seed butters, svg/d	89 (36.5)	101 (41.4)	41 (16.8)	13 (5.3)	0.27	145 (33.5)	172 (39.7)	90 (20.8)	26 (6.00)	0.20
Grains, total, svg/d	86 (35.2)	86 (35.2)	54 (22.1)	18 (7.4)	0.19	169 (39.0)	168 (38.8)	78 (18.0)	18 (4.20)	0.30
Whole grains, svg/d	113 (46.3)	105 (43.0)	21 (8.60)	5 (2.0)	0.47	181 (41.8)	175 (40.4)	64 (14.8)	13 (3.00)	0.37

Food Group	Men (*n* =244) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa	Women (*n* =433) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa
Refined grains, svg/d	83 (34.0)	97 (39.8)	45 (18.4)	19 (7.8)	0.20	157 (36.3)	184 (42.5)	74 (17.1)	18 (4.20)	0.29
Cold Cereal, svg/d	107 (43.9)	107 (43.9)	27 (11.1)	3 (1.2)	0.44	199 (46.0)	163 (37.6)	62 (14.3)	9 (2.10)	0.42
Hot Cereal, svg/d	93 (38.1)	100 (41.0)	45 (18.4)	6 (2.5)	0.32	195 (45.0)	167 (38.6)	62 (14.3)	9 (2.10)	0.41
Bread, svg/d	82 (33.6)	92 (37.7)	46 (18.9)	24 (9.8)	0.16	173 (40.0)	172 (39.7)	62 (14.3)	26 (6.00)	0.31
Pasta, svg/d	72 (29.5)	91 (37.3)	60 (24.6)	21 (8.6)	0.10	147 (33.9)	171 (39.5)	92 (21.2)	23 (5.30)	0.22
Crackers, svg/d	74 (30.3)	104 (42.6)	46 (18.9)	20 (8.2)	0.16	151 (34.9)	161 (37.2)	82 (18.9)	39 (9.00)	0.18
Snack bars, svg/d	99 (40.6)	94 (38.5)	41 (16.8)	10 (4.1)	0.32	177 (40.9)	166 (38.3)	80 (18.5)	10 (2.30)	0.34
Miscellaneous										
Baked goods, svg/d	87 (35.7)	98 (40.2)	47 (19.3)	12 (4.9)	0.25	157 (36.3)	177 (40.9)	86 (19.9)	13 (3.00)	0.28
Snack Chips, svg/d	94 (38.5)	100 (41.0)	44 (18.0)	6 (2.5)	0.32	169 (39.0)	172 (39.7)	70 (16.2)	22 (5.10)	0.30
Chocolate candy, svg/d	77 (31.6)	101 (41.4)	53 (21.7)	13 (5.3)	0.19	146 (33.7)	188 (43.4)	73 (16.9)	26 (6.00)	0.24
Beverages										
Sugar sweetened beverages, svg/d	90 (36.9)	96 (39.3)	44 (18.0)	14 (5.7)	0.26	162 (37.4)	168 (38.8)	77 (17.8)	26 (6.0)	0.26
Coffee, total, svg/d	158 (64.8)	77 (31.6)	8 (3.30)	1 (0.4)	0.69	277 (64.0)	146 (33.7)	10 (2.30)	0 (0.0)	0.69
Decaffeinated coffee, svg/d	108 (44.3)	75 (30.7)	44 (18.0)	17 (7.0)	0.30	189 (43.6)	146 (33.7)	70 (16.2)	28 (6.50)	0.32
Caffeinated coffee, svg/d	155 (63.5)	81 (33.2)	7 (2.90)	1 (0.4)	0.68	264 (61.0)	158 (36.5)	9 (2.10)	2 (0.50)	0.66
Tea, total, svg/d	119 (48.8)	104 (42.6)	17 (7.00)	4 (1.6)	0.51	214 (49.4)	173 (40.0)	39 (9.00)	7 (1.60)	0.50

Food Group	Men (*n* =244) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa	Women (*n* =433) Level of Agreement Exact	Deviation by 1 Quartile	Deviation by 2 Quartiles	Grossly Misclass-ified	Weighted Kappa
Decaffeinated tea, svg/d	70 (28.7)	85 (34.8)	64 (26.2)	25 (10.2)	0.06	172 (39.7)	176 (40.6)	69 (15.9)	16 (3.70)	0.33
Caffeinated tea, svg/d	107 (43.9)	101 (41.4)	31 (12.7)	5 (2.0)	0.42	196 (45.3)	173 (40.0)	51 (11.8)	13 (3.00)	0.42
Alcohol, total, svg/d	143 (58.6)	91 (37.3)	9 (3.70)	1 (0.4)	0.63	235 (54.3)	170 (39.3)	24 (5.50)	4 (0.90)	0.57
Beer, svg/d	120 (49.2)	92 (37.7)	26 (10.7)	6 (2.5)	0.47	175 (40.4)	153 (35.3)	84 (19.4)	21 (4.80)	0.29
Wine, total, svg/d	124 (50.8)	90 (36.9)	28 (11.5)	2 (0.8)	0.50	205 (47.3)	173 (40.0)	52 (12.0)	3 (0.70)	0.47
Wine, white, svg/d	103 (42.2)	93 (38.1)	37 (15.2)	11 (4.5)	0.34	162 (37.4)	166 (38.3)	87 (20.1)	18 (4.20)	0.27
Wine, red, svg/d	106 (43.4)	101 (41.4)	30 (12.3)	7 (2.9)	0.40	170 (39.3)	169 (39.0)	81 (18.7)	13 (3.00)	0.32

[a] Food groups were energy-adjusted based on the residual method.

[b] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Supplemental Table S1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.

[c] FFQ2.

[d] Values are frequencies (percentages) except for the weighted Kappa coefficient.

[e] Includes soy milk; almond milk or rice milk.

[f] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.

Table 2.1.5. Cross-classification of a diet quality score [a] in concordance with the *American Cancer Society's Dietary Guidelines for Cancer Prevention* estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire and the mean of the 24-hour dietary recalls among participants in the CPS-3 Diet Validation Study (*n*=677) [b].

Diet Quality Score from Dietary Recalls	**Men (*n*=244)** Diet Quality Score from CPS-3 FFQ **0-2**	**3-5**	**6-9**	**Weighted Kappa**	**Women (*n*=433)** Diet Quality Score from CPS-3 FFQ **0-2**	**3-5**	**6-9**	**Weighted Kappa**
0-2	19 (7.8%)	30 (12.3%)	1 (0.4%)	0.42	25 (5.8%)	45 (10.4%)	7 (1.6%)	0.38
3-5	18 (7.4%)	56 (23.0%)	27 (11.1%)		25 (5.8%)	121 (28.0%)	55 (12.7%)	
6-9	1 (0.4%)	29 (11.9%)	63 (25.8%)		5 (1.2%)	45 (10.4%)	105 (24.3%)	

[a] Refer to Supplemental Table S2 and methods for additional details.
[b] Values are frequencies (percentages) except for the weighted Kappa coefficient.

Table 2.2.1. Food groups defined according to the Cancer Prevention Study-3 food frequency questionnaire (FFQ) and foods assessed by the 24-hour dietary recalls (24HR) along with definitions for serving sizes analyzed.

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
Fruits & Juices, total	Grapes; raisins or dried cranberries; prunes or prune juice; mixed or other dried fruit; banana; avocado or guacamole; apples or pears; apple juice or cider; oranges or clementines; regular OJ; fortified OJ; grapefruit or juice; other fruit juices; watermelon; cantaloupe; mango or papaya; strawberries; blueberries; raspberries; peaches or plums; pineapple; plantains	All fruits and 100% fruit juice consumed separately (plain) and in fruit salads Excludes: fruit in baked goods; trail mix; fruit roll-ups; jam, jelly, marmalade; pickled fruit relishes	1 medium piece of fruit; ½ cup of chopped, cooked, or canned fruit; ¼ cup of dried fruit; 4 fluid ounces of juice
Fruits, total (excluding juices)	Grapes; raisins or dried cranberries; prunes or prune juice (100% weight for dried prunes); mixed or other dried fruit; banana; avocado or guacamole; apples or pears; oranges or clementines; grapefruit or juice (70% weight to only count grapefruit); watermelon; cantaloupe; mango or papaya; strawberries; blueberries; raspberries; peaches or plums; pineapple; plantains	All fruits consumed separately (plain) and in fruit salads Excludes: fruit juices; fruit in baked goods; trail mix; fruit roll-ups; jam, jelly, marmalade; pickled fruit relishes	1 medium piece of fruit; ½ cup of chopped cooked, or canned fruit; ¼ cup of dried fruit
Citrus Fruits (excluding juices)	Oranges or clementines; grapefruit or grapefruit juice (70% weight to only count grapefruit)	Citrus fruits (e.g., oranges, grapefruit, tangerines, lemons) Excludes: fruit juices; fruit in baked goods; trail mix; fruit roll-ups; jam, jelly, marmalade; pickled fruit relishes	1 medium piece of fruit; ½ cup of chopped cooked, or canned fruit; ¼ cup of dried fruit
Non-Citrus Fruits (excluding juices)	Grapes; banana; apples or pears; watermelon; cantaloupe; mango or papaya; strawberries; blueberries; raspberries; peaches or plums; pineapple; raisins or dried cranberries; prunes or prune juice (100% weight for dried	Non-citrus fruits (e.g., strawberries, peaches, apples) Excludes: fruit juices; fruit in baked goods; trail mix; fruit roll-ups; jam, jelly, marmalade; pickled fruit relishes	1 medium piece; ½ cup of chopped cooked, or canned fruit; ¼ cup of dried fruit

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
	prunes); mixed or other dried fruit; plantains		
Berries	Strawberries; blueberries; raspberries	All berries (e.g., strawberries, cranberries, blackberries) consumed separately (plain) or in fruit salads This food group was manually created for the 24HRs using the following NDSR Food Codes: 5645, 5006, 30212, 5014, 14171, 5019, 110385, 5017, 5025, 5027, 5026, 5028, 27377, 5085, 14174, 5162, 12702, 110388, 5329, 5328, 5330, 5338, 5340, 5339, 5368, 5364, 5363, 5370, 5372, 5371, 5374, 5022, 5332, 5335, 5365	½ cup; ¼ cup of dried fruit
Fruit Juices	Regular OJ; fortified OJ	100% fruit juices (sweetened or unsweetened)	4 fluid ounces
Vegetables			
Starchy vegetables	Peas or lima beans; corn; French fries and hash browns; potatoes, baked, boiled or mashed; plantains; sweet potatoes or yams	Starchy vegetables (e.g., cassava, corn, green peas, jicama) in raw, cooked, or canned form; starchy vegetables in recipes; vegetables with more starch than peas; baked, boiled, and canned white potatoes; potatoes in recipes (e.g., stew); fried potatoes (e.g., French fries, hash browns, pan fried potatoes, potato tots) We also included the following NDSR food codes for sweet potatoes or yams: 3150, 6151, 6184, 7647, 11018, 11019, 12662, 31450,111304, 113643	½ cup, 1 medium baked potato, 70g French fries
White/fried potatoes	French fries or hash browns; potatoes, baked, boiled or mashed	Baked, boiled, and canned white potatoes; potatoes in recipes (e.g., stew);	½ cup

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		fried potatoes (e.g., French fries, hash browns, pan fried potatoes, potato tots)	
Non-starchy vegetables	Tomatoes; tomato or v-8 juice; tomato sauce; tomato soup ; salsa, picante or taco sauce; asparagus; dark orange (winter) squash, e.g., acorn, pumpkin; zucchini, eggplant, other summer squash; broccoli; cauliflower; cabbage or cole slaw; brussels sprouts; carrots, raw; carrots, cooked or carrot juice; spinach, cooked; spinach, raw as in salad; kale, chard, greens, e.g., turnip, collards; iceberg or head lettuce; romaine or leaf lettuce, mixed greens; celery; peppers: green, yellow, red, chile; onion as a garnish or in salad; onions as a cooked vegetable or rings; cucumber; string (green) beans; mixed vegetables, e.g., in stir fry, soup	Includes tomato products, dark-green vegetables, deep-yellow vegetables (except sweet potatoes or yams), vegetable juice (all described below), as well as other non-starchy vegetables, including fried and breaded vegetables. Includes non-starchy vegetables in raw, cooked, or canned form; non-starchy vegetables in recipes Excludes legumes (described below) and sweet potato/yams The deep-yellow vegetable group that excluded sweet potatoes or yams was manually created using the following NDSR food codes: 2963, 2964, 2965, 3099, 7396, 9626, 7628, 7630, 7641, 11806	1 cup of raw leafy vegetables or ½ cup of other cooked or raw vegetables
Tomato products	Tomatoes; tomato or v-8 juice; tomato sauce; tomato soup; salsa, picante or taco sauce	Raw, cooked, or canned tomato; salsa; tomato sauce or paste; spaghetti sauce; tomato-based sauce or puree; tomatoes in recipes Excludes: Ketchup; cocktail sauce	½ cup chopped or default form; ½ cup tomato sauce; ¼ cup tomato puree; ¼ cup tomato paste
Cruciferous vegetables	Broccoli; brussels sprouts; cabbage or cole slaw; cauliflower; kale, chard, greens, e.g., turnip, collards	Includes: arugula; bok choy; broccoli; brussels sprouts; cabbage; cauliflower; collard greens; horseradish; kale; radishes; rutabaga; turnips; watercress; kohlrabi; cruciferous vegetables from mixed dishes	1 cup of raw leafy vegetables or ½ cup of other cooked or raw vegetables

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		This food group was manually created for the 24HRs using the following NDSR Food Codes: 590, 14745, 114487, 116415, 114898, 115964, 107881, 114284, 32831, 115118, 27242, 20237, 108350, 108351, 108359, 113082, 27765, 9967, 27691, 27713, 27693, 116480, 27694, 9970, 113100, 18450, 2949, 11949, 17109, 2951, 2952, 2950, 2953, 15140, 7328, 2954, 2955, 2956, 15141, 2972, 2973, 7404, 2971, 2974, 7403, 30047, 2982, 2983, 2984, 11961, 3012, 3013, 3011, 11967, 3014, 3016, 15170, 21652, 7607, 3104, 7623, 3173, 3174, 3175, 3177, 3176, 7688, 7727, 2948, 2957, 2958, 2959, 2960, 2961, 2962, 2977, 2978, 2980, 3028, 3029, 7335, 11113, 11379, 11380	
Dark green vegetables	Broccoli; spinach, cooked; spinach, raw as in salad; kale, chard, greens; romaine or leaf lettuce, mixed greens	Dark-green vegetables (e.g., broccoli, spinach, romaine, collards) in raw, cooked, or canned form; dark-green vegetables in recipes	1 cup of raw leafy vegetables or ½ cup of other cooked or raw vegetables
Deep-yellow vegetables	Dark orange (winter) squash, e.g., acorn, pumpkin; carrots, raw; carrots, cooked or carrot juice; sweet potatoes or yams	Deep-yellow vegetables (e.g., carrots, pumpkin, sweet potatoes, winter squash) in raw, cooked, or canned form; deep-yellow vegetables in recipes	1 cup of raw leafy vegetables or ½ cup of other cooked or raw vegetables
Legumes	Peas or lima beans; chick peas, or hummus; lentils; refried beans; baked beans with sauce; beans eaten with rice, soup, chili or other recipe; soy beans	Cooked dried beans; mature lima beans; refried beans; beans in sauce (e.g., pork and beans); beans in recipes (e.g., stew, soup)	½ cup
Garlic, fresh	Garlic fresh, eaten raw; fresh, cooked	Garlic eaten fresh or cooked. This food group was manually created for the 24HRs using the following NDSR Food Codes: 19259, 12061	4 grams

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
Vegetable juice	Tomato or V-8 juice	100% vegetable juice	4 fluid ounces (~118.3mL)
Meats, Dairy, & Alternatives			
Dairy, total	Skim milk; 1 or 2% milk; whole milk; frozen yogurt, sherbet, sorbet or low-fat ice cream; regular ice cream; Yogurt-plain; light; fruit or other flavoring; ricotta or cottage cheese; cream cheese; soft cheese; other cheese; cream	Includes low-fat dairy, full-fat dairy, and frozen dairy desserts (as described below) Servings include dairy consumed separately and in recipes containing dairy (e.g., soup)	1 cup fluid or dry, ½ cup evaporated, 1 ½ ounces of natural cheese, 2 ounces of processed cheese, 2 cups cottage cheese, ½ cup ricotta cheese, 2 ounces of cheese spread or food
Dairy, low-fat	Skim milk; 1 or 2% milk; yogurt-light; low-fat or non-fat ricotta or cottage cheese; low-fat or non-fat soft cheese; low-fat or non-fat other cheese	Includes low-fat yogurt, low-fat cheese, and low-fat milk (described below); cream, including sour cream (reduced fat)	1 cup fluid or dry, ½ cup evaporated, 1 ½ ounces of natural cheese, 2 ounces of processed cheese, 2 cups cottage cheese, ½ cup ricotta cheese, 2 ounces of cheese spread or food
Dairy, full-fat	Whole milk; cream; Yogurt- plain; full-fat ricotta or cottage cheese; full-fat cream cheese; full-fat soft cheese; full-fat other cheese	Includes full-fat yogurt and full-fat cheese (described below); whole milk, including dry, with or without added flavors; cream, including sour cream	1 cup fluid or dry, ½ cup evaporated, 1 ½ ounces of natural cheese, 2 ounces of processed cheese, 2 cups cottage cheese, ½ cup ricotta cheese, 2 ounces of cheese spread or food
Yogurt, total	Regular yogurt-plain; Regular yogurt-light (artificially sweetened); Regular yogurt-fruit or other flavoring; Low-fat or non-fat yogurt-plain; Low-fat or non-fat yogurt-	Yogurt, with or without artificial sweetener	1 cup

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
	light; Low-fat or non-fat yogurt-fruit or other flavoring		
Yogurt, low-fat	Low-fat or non-fat yogurt-plain; Low-fat or non-fat yogurt-light (artificially sweetened); Low-fat or non-fat yogurt-fruit or other flavoring	Yogurt (<1 – 2% fat), with or without artificial sweetener	1 cup
Yogurt, full-fat	Regular yogurt-plain; Regular yogurt-light (artificially sweetened); Regular yogurt-fruit or other flavoring	Yogurt (3-4% fat), with or without artificial sweetener	1 cup
Cheese, low-fat	Low-fat or non-fat ricotta or cottage cheese; low-fat or non-fat cream cheese; low-fat or non-fat soft cheese; or low-fat or non-fat other cheese	Low-fat and fat-free cheeses (skim – 1%); natural and processed cheeses (8-16%); part skim mozzarella; 2% cottage cheese	1 ½ ounces of natural cheese, 2 ounces of processed cheese, 2 cups cottage cheese, ½ cup ricotta cheese, 2 ounces of cheese spread or food
Cheese, regular	Regular ricotta or cottage cheese; regular cream cheese; regular soft cheese; or regular other cheese	Natural and processed (24-33%) cheeses; regular cottage cheese (4%); cheese powder for macaroni and cheese	1 ½ ounces of natural cheese, 2 ounces of processed cheese, 2 cups cottage cheese, ½ cup ricotta cheese, 2 ounces of cheese spread or food
Milk, low-fat	Skim milk; 1 or 2% milk	Reduced fat (2%), low-fat (1%) and fat-free milk (skim, including nonfat dry milk) consumed separately (plain) and in recipes, with and without added flavors	1 cup
Frozen dairy dessert	Frozen yogurt, sherbet, sorbet or low-fat ice cream; regular ice cream	Frozen dairy-based desserts including, ice cream, frozen yogurt, and ice cream treats, sugar and artificially sweetened	½ cup
Milk alternative[b]	Soy milk; almond milk or rice milk	Soy, rice, or grain based alternative milk product consumed separately (plain) and in recipes	1 cup

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
Soy products[c]	Soy beans/edamame or soy nuts; tofu or tofu burger; fermented soy, tempeh, miso; soy milk	Includes soy milk, soy cheese, soy yogurt, soy ice cream, soybeans, soy nuts, tofu, soy meat substitutes, miso (broth and paste) This food group was manually created for the 24HRs using the following NDSR Food Codes: 103463, 103464, 4886, 18416, 107651, 103539, 103540, 114246, 114245, 103537, 4704, 103568, 114247, 114248, 114249, 114255, 114253, 114254, 103542, 103543, 114252, 114256, 13619, 103093, 9936, 2925, 28966, 109162, 109163, 106603, 103660, 18415, 103775, 103776, 103766, 103764, 103765, 103767, 2929, 103769, 103772, 11006, 29182, 23775	½ ounce of soy nuts, 1 cup of milk alternative products, 1 ounce for all others
Eggs	Eggs, regular including yolk; omega-3 fortified including yolk; egg whites or egg substitute	Eggs or egg substitutes	1 large egg, 2 large egg whites, 2 large egg yolks
Poultry	Chicken thighs, drumsticks, wings; other chicken or turkey, with skin or ground; chicken or turkey, no skin, main dish; other chicken or turkey in a mixed dish, e.g., soup, with pasta, frozen dinners, burrito, quesadilla, etc.	Poultry, including domestic and wild fowl; fried chicken Servings include meat consumed separately and in recipes containing meat	1 ounce (~28.35 g)
Red meat	Hamburger, regular; hamburger, lean; pork main dish, e.g., ribs, ham, chops; beef or lamb as a main dish, e.g., steak, roast; beef, pork, or lamb in a sandwich or mixed dish, e.g., stew, taco, lasagna, frozen dinners, meat pie, etc.	Beef; veal; lamb; pork (fresh) Servings include meat consumed separately and in recipes containing meat	1 ounce (~28.35 g)
Processed Meat, Total	Bacon; chicken or turkey sausage or hot dogs; beef hot dogs or pork hot dogs; other sausage, chorizo, or kielbasa; ham	Cured pork; cold cuts and sausages	1 ounce (~28.35 g)

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
	lunch meat; turkey breast lunch meat; salami, bologna, or other processed meat	Servings include meat consumed separately and in recipes containing meat	
Red processed meat	Bacon; beef or pork hot dogs; other sausage, chorizo, or kielbasa; ham lunch meat; salami, bologna, or other processed meat	Bacon; sausages (pork or beef); red meat lunch meats (e.g., ham, pastrami, salami, bologna) This food group was manually created for the 24HRs using the following NDSR Food Codes: 2279, 2280, 2283, 7176, 12704, 15119, 28167, 31090, 103732, 116413, 7246, 9704, 12868, 31499, 31500, 113385, 114816, 116997, 9725, 9730, 12874, 17910, 17916, 17917, 31538, 31540, 31509, 31527, 116783, 116784, 9551, 9556, 9579, 6404, 9723, 11375, 12858, 12860, 22043, 31494, 31510, 31511, 31513, 31517, 8608, 9800, 9810, 9812, 9813, 9814, 9819, 9822, 9823, 9824, 9830, 9834, 9835, 9837, 9839, 9840, 9841, 9850, 9854, 9858, 9859, 11372, 12880, 12934, 31571, 31574, 31579, 31582, 31583, 31587, 31588, 31594, 103734, 114817, 114818	1 ounce (~28.35 g)
White processed meat	Chicken or turkey sausage or hot dogs; turkey breast lunchmeat	Bacon (turkey); sausages (turkey or chicken); white meat lunch meats (e.g., turkey, turkey pastrami, chicken bologna) This food group was manually created for the 24HRs using the following NDSR Food Codes: 17677, 31687, 9734, 12873, 31544, 9816, 9978, 12936, 17976, 31521, 31524, 31572, 31589, 31596, 31599, 31600, 17868, 17875, 27410, 31502,	1 ounce (~28.35 g)

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		31515, 116430, 116432, 12937, 12862, 9541	
Total seafood	canned tuna fish; breaded fish cakes, pieces, or fish sticks; shrimp, lobster, scallops as main dish; dark meat fish, e.g. salmon, tuna steak, mackerel, sardines, swordfish, trout; other fish, e.g. tilapia, cod, halibut	Fish (fresh and smoked); fried fish; shellfish; fried shellfish Servings include fish consumed separately and in recipes containing fish	1 ounce (~28.35 g)
Light meat seafood	Breaded fish cakes, pieces, or fish sticks; other fish, e.g. tilapia, cod, halibut	Light meat fish (e.g., tilapia, yellowtail, bass), included breaded This food group was manually created for the 24HRs using the following NDSR Food Codes: 9027, 9061, 9086, 9097, 9099, 9141, 9143, 9156, 9166, 1478, 9232, 9424, 9586, 9607, 9678, 9681, 9682, 9683, 11360, 12722, 12757, 12769, 14841, 17304, 17887, 17888, 18249, 18252, 18279, 18303, 18304, 110335, 114105, 116524, 116526, 116527	1 ounce (~28.35 g)
Dark meat seafood	Dark meat fish, e.g., salmon, tuna steak, mackerel, sardines, swordfish, trout; canned tuna fish	Dark meat fish (e.g., salmon, tuna, mackerel). This food group was manually created for the 24HRs using the following NDSR Food Codes: 9444, 9445, 9447, 9449, 9450, 9452, 9453, 9455, 109181, 109186, 110469, 114106, 114107, 116364, 116366, 116367, 116528, 9640, 9641, 9642, 9644, 9646, 9647, 9654, 9655, 9657, 9658, 9660, 15200, 114461, 114469, 114470, 114472, 114473, 114475, 9459, 9460, 16487, 9623, 9632, 9633, 9634, 114163, 9053, 9461, 9055,	1 ounce (~28.35 g)

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		9127, 9130, 9134, 9178, 9191, 9417, 9420, 9604, 9616, 9686, 11356	
Nuts and seeds	peanuts; walnuts; almonds; other nuts; sunflower, pumpkin or other seeds; flaxseed, ground, seeds or oil	All nuts and seeds	½ ounce (~14.17g)
Nut and seed butters	Peanut butter	All nut and seed butters	1 tablespoon
Grains, total	cooked oatmeal/oat bran; grits or other cooked breakfast cereal; cold breakfast cereal; white bread, including pita; rye/pumpernickel; whole wheat, oatmeal or other whole grain bread; corn tortillas, arepas, pupusas, eaten plain or with other foods; flour tortillas eaten plain or with other foods, including quesadillas, burritos, etc; tamales; corn muffins or bread; other muffins or biscuits; whole grain/whole wheat crackers; other crackers; white bagels, English muffins, buns or rolls; whole wheat bagels, English muffins or rolls; pancakes or waffles; brown rice or quinoa; white rice; whole grain pasta; macaroni and cheese; other pasta; pizza; oat bran, wheat bran, dry, added to food; popcorn; corn chips; pretzels	Grains consumed separately (plain) and in recipes containing grains (e.g., lasagna, casseroles) Excludes: grains from baked goods (cakes, cookies, doughnuts, etc.)	1 slice of bread, 1 ounce (~28.35 g) ready-to-eat cereal, ½ cup of cooked cereal, rice or pasta, 45g muffins and quick breads, 45g cornbread, popovers, 1 ounce Croissant, 1 ounce tortilla.
Whole grains	whole wheat; whole wheat bagels, English muffins or rolls; rye/pumpernickel; cooked oatmeal/oat bran; whole grain breakfast cereals; brown rice or quinoa; corn tortillas; corn muffins or bread; tamales; whole grain pasta; whole grain cereal; oat bran	Whole grain grains, flour, and dry mixes (e.g., cooked cereal rains, rice); whole grain breads and rolls; other whole grain breads (e.g., quick breads, corn muffins, tortillas). In addition, a 50% weight was applied to all partial whole grain grains, flour, and dry mixes; partial whole grain breads and rolls; and other partial whole grain breads	1 slice of bread, 1 ounce (~28.35 g) ready-to-eat cereal, ½ cup of cooked cereal, rice or pasta, 45g muffins and quick breads, 45g cornbread, popovers, 1 ounce (~28.35 g) Croissant, 1

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		Whole grain foods are those in which the first ingredient on the food label is a whole grain ingredient; partial whole grain foods are those in which a whole grain ingredient appears anywhere else on the label	ounce (~28.35 g) tortilla.
Refined grains	white bread, including pita; ; regular cereal; white bagels; macaroni and cheese; other pasta; flour tortillas; other muffins; pancakes or waffles; white rice; grits; pizza	Refined grain grains, flour, and dry mixes (e.g., cooked cereal rains, rice); refined grain breads and rolls; other refined grain breads (e.g., quick breads, corn muffins, tortillas). In addition, a 50% weight was applied to all partial whole grain grains, flour, and dry mixes; partial whole grain breads and rolls; and other partial whole grain breads Partial whole grain foods are those in which a whole grain ingredient appears anywhere else on the label	1 slice of bread, 1 ounce (~28.35 g) ready-to-eat cereal, ½ cup of cooked cereal, rice or pasta, 45g muffins and quick breads, 45g cornbread, popovers, 1 ounce Croissant, 1 ounce (~28.35 g) tortilla.
Cold Cereal	Cold breakfast cereal	Ready-to-eat breakfast cereals This food group was manually created for the 24HRs using the following NDSR Food Codes: 103840, 103875, 108446, 14964, 29353, 381, 103845, 108498, 108500, 113022, 115201, 385, 389, 397, 398, 430, 7054, 377, 495, 29340, 377, 378, 385, 400, 401, 404, 407, 431, 438, 454, 455, 462, 469, 470, 471, 494, 496, 513, 514, 517, 521, 5658, 7016, 7020, 7021, 7037, 7054, 7058, 7077, 10399, 12699, 14211, 14223, 15053, 15546, 16311, 17483, 17493, 17496, 22056, 22123, 22143, 22144, 22150, 22156,	1 ounce (~28.35 g)

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		22160, 22168, 22186, 22207, 27405, 29340, 29341, 29349, 29357, 29375, 29388, 103840, 103841, 103842, 103844, 106069, 106077, 106108, 106109, 106110, 106111, 108493, 108498, 108499, 108507, 108508, 108509, 108512, 108513, 108532, 108619, 108621, 108622, 112878, 112879, 112886, 112900, 112901, 112902, 112907, 112908, 112916, 112920, 112921, 112987, 113010, 113012, 113014, 113026, 113211,113212, 113222, 113223, 113233, 113234, 113236, 113272, 114333, 114334, 114335, 114343, 115030, 115033, 115072, 115073, 115134, 115168, 115169, 115170, 115171, 115173, 115174, 115175, 115176, 115178, 115183, 115197, 115204, 115206, 115207, 115209, 115748, 402, 403, 417, 419, 436, 498, 500, 5670, 7030, 7723, 11689, 106153, 113271, 115131, 115184	
Hot Cereal	Cooked oatmeal/oat bran; grits or other cooked breakfast cereal	Hot breakfast cereals, including oatmeal and grits This food group was manually created for the 24HRs using the following NDSR Food Codes: 10447, 10481, 10496, 10504, 10507, 10510, 10513, 10515, 108406, 115232, 12732, 13141, 21476, 24259, 30052, 10547, 106143, 106144, 10661, 11271, 10556, 10563, 10570, 10579, 108394, 10991, 110454, 113391, 15256, 115263, 115264, 115266, 115269, 116848, 12480, 24187, 24215, 24225,	½ cup

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		24281, 24382, 8461, 8464, 10660, 10664, 10778, 15077, 108404, 108405, 115229, 1895, 24381, 113390, 115212, 115225, 115228, 115239, 115246, 115248, 115251, 115252	
Bread	white bread, including pita; rye/pumpernickel; whole wheat, oatmeal, other whole grain; white bagels, English muffins, buns or rolls; whole wheat bagels, English muffins or rolls	Loaf-type breads and plain rolls (e.g., bread, buns, bagel, English muffins); all grain types (whole grain, partial whole grain, and refined grain)	1 slice of bread, 45g muffins and quick breads
Pasta	whole grain pasta; macaroni and cheese; other pasta	Pasta, all grain types (whole grain, partial whole grain, and refined grain)	½ cup
Crackers	whole grain/whole wheat crackers; other crackers	Crackers, all grain types (whole grain, partial whole grain, and refined grain)	1 ounce (~28.35 g)
Snack bars	breakfast bars, e.g., granola, fiber one; energy bars, e.g., luna, clif, powerbar; high protein bars	Granola bars, energy bars, meal replacement bars; all grain types (whole grain, partial whole grain, and refined grain)	40 grams (approximately 1 bar)
Miscellaneous			
Baked goods	cookies or brownies; cakes or cupcakes; pie, fruit crisp or turnover; sweet or cinnamon roll, donut, pan dulce, pastry	Cakes, cookies, pies, pastries, Danish, doughnuts, cobblers; all grain types (whole grain, partial whole grain, and refined grain)	1 ounce (~28.35 g) of popcorn, all others 40 grams
Snack Chips	popcorn, regular; pretzels; potato chips; corn/tortilla chips; popcorn, fat free or light	Snack chips; vegetable based savory snacks (e.g., potato chips); popcorn; pork rinds	1 ounce (~28.35 g) of popcorn, all others 40 grams
Chocolate candy	Milk chocolate; dark chocolate; candy bars	Chocolate candy	40 grams
Beverages			
Sugar sweetened beverages	Regular carbonated beverages with and without caffeine; other sugared beverages; sugar sweetened iced tea; grapefruit or juice (30% weight to only count juice); other fruit juices	Sweetened soft drinks; sweetened fruit drinks <100% fruit juice (e.g., kool aid); sweetened tea	8 fluid ounces (~236.59 mL)

Food Group	**Included line items from FFQ**	**24HR Definitions**	**Definition of 1 serving (for analysis)** [a]
Coffee, total	Decaffeinated coffee; coffee with caffeine; dairy coffee drink	Sweetened or unsweetened coffee	8 fluid ounces (~236.59 mL)
Decaffeinated coffee	Decaffeinated coffee	Decaffeinated coffee. This food group was manually created for the 24HRs using the following NDSR Food Codes: 7782, 7800, 17429, 7823	8 fluid ounces (~236.59 mL)
Caffeinated coffee	Caffeinated coffee; dairy coffee drink	Caffeinated coffee This food group was manually created for the 24HRs using the following NDSR Food Codes: 7772, 7776, 7799, 7806, 18234, 7822, 25366, 110501, 110502	8 fluid ounces (~236.59 mL)
Tea, total	Herbal tea; green tea, decaffeinated; green tea with caffeine; black tea, decaffeinated; black tea with caffeine; iced tea	Sweetened or unsweetened tea	8 fluid ounces (~236.59 mL)
Decaffeinated tea	Herbal tea; green tea, decaffeinated; black tea, decaffeinated	Decaffeinated and herbal teas This food group was manually created for the 24HRs using the following NDSR Food Codes: 251, 17542, 252, 8241, 11095, 11096, 11099, 107857	8 fluid ounces (~236.59 mL)
Caffeinated tea	Green tea with caffeine; black tea with caffeine; iced tea	Teas with caffeine This food group was manually created for the 24HRs using the following NDSR Food Codes: 8255, 250, 11097, 13197, 19662, 25386, 25388, 25396, 25404, 25416, 113146, 113147, 113149, 113150, 113153, 113157, 113160, 113161, 113163, 113164, 113166, 113167, 113202, 113262, 113263, 113317, 8262, 17406, 17408, 25439, 25440, 25441,	8 fluid ounces (~236.59 mL)

Food Group	Included line items from FFQ	24HR Definitions	Definition of 1 serving (for analysis) [a]
		8255, 8256, 8257, 25390, 25434, 25435, 25436, 103673, 103683	
Alcohol, total	Beer, regular; light beer; red wine; white wine; liquor	Beers and ales; cordial and liqueur; distilled liquor; wine	5 fluid ounces (~147.89 mL) of table wine, 3 fluid ounces (~88.72 mL) of dessert wine, 12 fluid ounces (~354.88 mL) of beer, 1 ½ fluid ounces (~44.36 mL) of liquor
Beer	Beer, regular; light beer	Beers and ales	12 fluid ounces (~354.88 mL)
Wine, total	Red wine; white wine	Wine, including wine coolers	5 fluid ounces (~147.89 mL) of table wine, 3 fluid ounces (~88.72 mL) of dessert wine
Wine, white	White wine	White wines (e.g., sauvignon blanc, Riesling), including sparkling and rose wines This food group was manually created for the 24HRs using the following NDSR Food Codes: 117, 133, 136, 140, 8304, 8308, 103900, 106142, 8305, 137, 148, 118, 131, 247	5 fluid ounces (~147.89 mL) of table wine, 3 fluid ounces (~88.72 mL) of dessert wine
Wine, red	Red wine	Red wine (e.g., pinot noir, cabernet sauvignon, merlot) This food group was manually created for the 24HRs using the following NDSR Food Codes: 120, 127, 132, 147, 249, 268, 269, 8279, 8296, 8298, 8299, 103902, 106138	5 fluid ounces (~147.89 mL) of table wine, 3 fluid ounces (~88.72 mL) of dessert wine

*NDSR codes are included for food groups that were manually created and not already included in the NDSR system, to link with 24HRs.

[a] Serving sizes, as defined in this analysis, were based on the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the Food and Drug Administration. Servings were originally defined differently for some foods in the CPS-3 FFQ but converted to the equivalent of the above definitions.

Table 2.2.2. Quantification of the American Cancer Society's dietary guidelines for cancer prevention.

Recommendation	Quantification	Scoring
1) Consume 5+ servings per day of a *variety* of fruits and vegetables	Both *quantity* and *variety* of fruits/vegetables considered. For quantity: Calculate total servings/day of fruit and vegetables For variety: Individuals receive 1 point for consuming foods in each of the following groups: citrus fruits, non-citrus fruits, avocado and similar, dark-green vegetables, deep-yellow vegetables, tomatoes, starchy vegetables, legumes, and other vegetables. *Fruit juices, white potatoes, and French fries were not included in these calculations	The total score (range: 0-3) is the sum of the "quantity" and "variety components", as scored below. Quantity: • 1 point: $\geq$ 5 servings/day • 0 points: < 5 servings/day Variety: • 2 points: highest sex-specific tertile of distribution • 1 point: middle sex-specific tertile of distribution • 0 points: lowest sex-specific tertile of distribution
2) Chose whole grains in preference to processed, refined grains	% whole grains = whole grains (servings/day)/ total grains (servings/day)	0 points for the lowest sex-specific quartile of distribution and 3 points for the highest quartile of distribution.
3) Limit consumption of red and processed meats	Total servings/day of red and processed meats	0 points for the highest sex-specific quartile of distribution and 3 points for the lowest quartile of distribution.

Table 2.2.3. Number of repeated 24-hour dietary recalls (24HR) completed among participants in the Cancer Prevention Study-3 Diet Assessment Substudy (*n*=677) according to sex and race/ethnicity [a].

	Number of 24HRs Completed			
	4	**5**	**6**	**Mean ± SD**
Sex				
Men	7 (2.9)	16 (6.6)	221 (90.6)	5.9 ± 0.4
Women	10 (2.3)	29 (6.7)	394 (91.0)	5.9 ± 0.4
Race/Ethnicity				
White	12 (2.9)	21 (5.0)	384 (92.1)	5.9 ± 0.4
African American	2 (1.3)	13 (8.2)	144 (90.6)	5.9 ± 0.3
Hispanic	3 (3.0)	11 (10.9)	87 (86.1)	5.8 ± 0.4

[a] All values are frequencies and row percentages unless otherwise indicated. N=10 participants completed fewer than four 24HRs and were excluded from all analyses (see methods).

Table 2.2.4. Race-specific, mean food group intake (servings/day) [a] and diet quality score (0-9) estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire (FFQ) and up to six repeated 24-hour dietary recalls (24HR) among participants in the CPS-3 Diet Assessment Substudy (*n* =677) [b].

	White (*n*=417)			African American (*n*=159)			Hispanic (*n*=101)		
Food Group	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**
Fruits & Juices, total, svg/d	3.0 (2.0)	3.0 (2.0)	1.8 (1.3)	3.5 (3.6)	3.2 (2.4)	1.7 (1.4)	3.7 (2.4)	3.4 (1.9)	1.9 (1.4)
Whole Fruits, total (excluding juices), svg/d	2.5 (1.7)	2.4 (1.7)	1.5 (1.2)	2.6 (3.2)	2.4 (1.8)	1.3 (1.2)	2.9 (1.9)	2.7 (1.7)	1.6 (1.3)
Citrus Fruits (excluding juices), svg/d	0.2 (0.4)	0.2 (0.3)	0.2 (0.3)	0.2 (0.3)	0.2 (0.3)	0.1 (0.2)	0.3 (0.5)	0.2 (0.3)	0.2 (0.3)
Non-Citrus Fruits (excluding juices), svg/d	2.2 (1.6)	2.2 (1.6)	1.3 (1.1)	2.4 (3.0)	2.2 (1.7)	1.2 (1.1)	2.6 (1.6)	2.4 (1.6)	1.3 (1.1)
Berries, svg/d	0.5 (0.6)	0.5 (0.6)	0.2 (0.3)	0.4 (0.7)	0.4 (0.5)	0.1 (0.2)	0.4 (0.4)	0.5 (0.6)	0.1 (0.2)
Fruit Juice, svg/d	0.3 (0.6)	0.3 (0.7)	0.3 (0.6)	0.5 (0.7)	0.4 (0.6)	0.4 (0.5)	0.5 (0.9)	0.4 (0.7)	0.4 (0.6)
Vegetables									
Starchy vegetables, svg/d	0.7 (0.6)	0.7 (0.5)	0.6 (0.5)	0.8 (0.7)	0.8 (0.6)	0.7 (0.5)	0.7 (0.6)	0.7 (0.5)	0.5 (0.5)
White/fried potatoes, svg/d	0.4 (0.5)	0.5 (0.4)	0.4 (0.4)	0.5 (0.5)	0.5 (0.4)	0.4 (0.5)	0.4 (0.4)	0.4 (0.4)	0.4 (0.4)
Non-starchy vegetables, svg/d	3.0 (2.3)	2.9 (1.7)	2.9 (1.6)	2.8 (2.2)	2.9 (2.1)	2.5 (1.5)	3.4 (2.2)	3.2 (2.2)	2.7 (1.4)
Tomato products, svg/d	0.6 (0.6)	0.6 (0.5)	0.6 (0.4)	0.4 (0.5)	0.4 (0.4)	0.4 (0.3)	0.7 (0.5)	0.6 (0.6)	0.6 (0.4)
Cruciferous vegetables, svg/d	0.6 (0.7)	0.5 (0.5)	0.3 (0.4)	0.6 (0.7)	0.7 (0.6)	0.4 (0.5)	0.6 (0.6)	0.6 (0.5)	0.3 (0.4)
Dark green vegetables, svg/d	0.9 (0.9)	0.9 (0.8)	0.7 (0.7)	0.9 (0.9)	1.0 (0.8)	0.7 (0.7)	0.9 (0.7)	0.9 (0.8)	0.7 (0.6)
Deep-yellow vegetables, svg/d	0.1 (0.2)	0.1 (0.2)	0.3 (0.3)	0.1 (0.2)	0.1 (0.2)	0.2 (0.3)	0.1 (0.2)	0.1 (0.2)	0.2 (0.3)

	White (*n*=417)			African American (*n*=159)			Hispanic (*n*=101)		
Food Group	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**
Legumes, svg/d	0.5 (1.1)	0.7 (1.5)	0.2 (0.3)	0.4 (0.8)	0.7 (1.8)	0.2 (0.3)	1.1 (1.8)	1.0 (1.7)	0.3 (0.4)
Garlic, fresh, svg/d	0.3 (0.4)	0.2 (0.4)	0.1 (0.1)	0.2 (0.3)	0.2 (0.4)	0.1 (0.1)	0.4 (0.5)	0.5 (0.7)	0.1 (0.2)
Vegetable juice, svg/d	0.1 (0.4)	0.1 (0.3)	0.1 (0.3)	0.1 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)
Meats, Dairy, & Alternatives									
Dairy, total, svg/d	2.0 (1.3)	2.0 (1.3)	2.0 (1.2)	1.4 (1.3)	1.1 (0.9)	1.3 (0.9)	2.1 (1.7)	1.8 (1.4)	1.8 (0.9)
Dairy, low-fat, svg/d	0.8 (0.9)	0.8 (0.8)	1.0 (0.9)	0.6 (0.9)	0.4 (0.5)	0.6 (0.7)	1.0 (1.0)	0.8 (0.9)	0.9 (0.7)
Dairy, regular, svg/d	0.8 (0.8)	0.9 (0.9)	0.7 (0.5)	0.6 (0.6)	0.5 (0.6)	0.5 (0.5)	0.9 (1.1)	0.8 (1.0)	0.7 (0.6)
Yogurt, total, svg/d	0.3 (0.3)	0.2 (0.3)	0.2 (0.2)	0.2 (0.4)	0.2 (0.3)	0.1 (0.1)	0.3 (0.3)	0.2 (0.3)	0.1 (0.2)
Yogurt, low-fat, svg/d	0.2 (0.3)	0.2 (0.3)	0.1 (0.2)	0.1 (0.4)	0.1 (0.2)	0.1 (0.1)	0.2 (0.3)	0.2 (0.3)	0.1 (0.2)
Yogurt, regular, svg/d	0.1 (0.2)	0.1 (0.1)	0.0 (0.1)	0.0 (0.1)	0.1 (0.3)	0.0 (0.1)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)
Cheese, low-fat, svg/d	0.1 (0.2)	0.1 (0.2)	0.2 (0.2)	0.1 (0.6)	0.0 (0.1)	0.1 (0.2)	0.1 (0.2)	0.1 (0.1)	0.2 (0.3)
Cheese, regular, svg/d	0.4 (0.4)	0.4 (0.4)	0.5 (0.4)	0.3 (0.4)	0.2 (0.3)	0.4 (0.4)	0.4 (0.7)	0.3 (0.3)	0.5 (0.4)
Milk, low-fat, svg/d	0.6 (0.8)	0.5 (0.7)	0.5 (0.7)	0.3 (0.6)	0.3 (0.5)	0.2 (0.5)	0.7 (1.0)	0.6 (0.8)	0.5 (0.5)
Frozen Dairy Dessert, svg/d	0.3 (0.4)	0.3 (0.5)	0.2 (0.4)	0.3 (0.4)	0.2 (0.3)	0.2 (0.3)	0.3 (0.4)	0.2 (0.3)	0.2 (0.3)
Milk alternative [c], svg/d	0.1 (0.4)	0.2 (0.5)	0.1 (0.3)	0.2 (0.4)	0.2 (0.3)	0.1 (0.2)	0.4 (0.7)	0.3 (0.9)	0.1 (0.3)
Soy products [d], svg/d	0.1 (0.3)	0.1 (0.3)	0.1 (0.3)	0.1 (0.2)	0.1 (0.2)	0.0 (0.2)	0.2 (0.5)	0.2 (0.5)	0.1 (0.2)
Eggs, svg/d	0.4 (0.5)	0.4 (0.5)	0.5 (0.5)	0.4 (0.6)	0.4 (0.3)	0.5 (0.5)	0.5 (0.5)	0.5 (0.6)	0.6 (0.5)
Poultry, svg/d	1.4 (1.1)	1.4 (1.1)	1.6 (1.3)	2.0 (1.8)	2.0 (1.7)	2.3 (1.7)	1.7 (1.4)	1.6 (1.4)	1.8 (1.6)
Red meat, svg/d	1.7 (1.3)	1.8 (1.3)	1.2 (1.1)	1.2 (1.5)	1.2 (1.3)	1.1 (1.4)	1.6 (1.5)	1.5 (1.2)	1.6 (1.5)
Processed Meat, Total, svg/d	0.8 (0.8)	0.7 (0.7)	0.7 (0.7)	0.8 (0.8)	0.7 (1.0)	0.9 (0.9)	0.8 (0.9)	0.8 (0.8)	0.7 (0.7)
Red processed meat, svg/d	0.4 (0.5)	0.4 (0.5)	0.3 (0.4)	0.4 (0.5)	0.4 (0.5)	0.4 (0.4)	0.5 (0.6)	0.5 (0.5)	0.3 (0.3)

	White (*n*=417)			African American (*n*=159)			Hispanic (*n*=101)		
Food Group	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**
White processed meat, svg/d	0.4 (0.4)	0.3 (0.4)	0.1 (0.2)	0.3 (0.4)	0.4 (0.8)	0.2 (0.3)	0.3 (0.6)	0.3 (0.4)	0.1 (0.3)
Total seafood, svg/d	0.8 (0.9)	0.8 (0.8)	0.7 (1.0)	1.2 (1.4)	1.2 (1.2)	1.0 (1.1)	0.9 (1.1)	0.9 (1.0)	0.7 (0.9)
Light meat seafood, svg/d	0.3 (0.4)	0.3 (0.3)	0.1 (0.2)	0.5 (0.7)	0.5 (0.5)	0.1 (0.2)	0.4 (0.6)	0.4 (0.5)	0.1 (0.2)
Dark meat seafood, svg/d	0.5 (0.7)	0.5 (0.6)	0.1 (0.2)	0.7 (0.8)	0.7 (0.8)	0.1 (0.2)	0.5 (0.6)	0.5 (0.7)	0.1 (0.2)
Nuts and seeds, svg/d	1.1 (1.3)	1.1 (1.3)	1.0 (1.5)	1.2 (1.8)	1.2 (1.5)	0.8 (1.1)	1.0 (1.3)	0.9 (0.9)	0.8 (1.3)
Nut and seed butters, svg/d	0.3 (0.4)	0.3 (0.4)	0.3 (0.4)	0.2 (0.5)	0.2 (0.5)	0.2 (0.3)	0.2 (0.3)	0.2 (0.2)	0.2 (0.3)
Grains, total, svg/d	4.6 (2.4)	4.7 (2.3)	5.2 (2.2)	4.8 (2.8)	4.5 (2.4)	5.0 (2.3)	4.9 (2.6)	4.7 (2.4)	5.4 (2.3)
Whole grains, svg/d	2.3 (1.7)	2.3 (1.7)	1.5 (1.2)	2.3 (2.1)	2.2 (1.9)	1.2 (1.1)	2.6 (1.6)	2.4 (1.7)	1.7 (1.1)
Refined grains, svg/d	1.8 (1.4)	1.8 (1.3)	3.1 (1.8)	1.8 (1.4)	1.7 (1.1)	3.2 (1.7)	1.9 (1.5)	1.9 (1.3)	3.3 (2.0)
Cold Cereal, svg/d	0.4 (0.6)	0.4 (0.6)	0.4 (0.7)	0.3 (0.5)	0.3 (0.4)	0.2 (0.4)	0.3 (0.4)	0.3 (0.7)	0.3 (0.4)
Hot Cereal, svg/d	0.4 (0.5)	0.4 (0.5)	0.2 (0.3)	0.6 (0.7)	0.6 (0.7)	0.2 (0.3)	0.5 (0.6)	0.4 (0.6)	0.2 (0.3)
Bread, svg/d	1.5 (1.4)	1.6 (1.4)	1.7 (1.1)	1.3 (1.4)	1.2 (1.3)	1.5 (1.1)	1.3 (1.3)	1.1 (0.9)	1.6 (1.2)
Pasta, svg/d	0.4 (0.3)	0.4 (0.4)	0.4 (0.5)	0.4 (0.5)	0.4 (0.3)	0.3 (0.4)	0.5 (0.5)	0.4 (0.4)	0.5 (0.7)
Crackers, svg/d	0.1 (0.4)	0.1 (0.4)	0.2 (0.3)	0.1 (0.2)	0.1 (0.1)	0.2 (0.3)	0.1 (0.1)	0.1 (0.4)	0.1 (0.2)
Snack bars, svg/d	0.2 (0.4)	0.3 (0.4)	0.2 (0.3)	0.2 (0.3)	0.1 (0.3)	0.1 (0.2)	0.2 (0.3)	0.2 (0.4)	0.2 (0.3)
Miscellaneous									
Baked goods, svg/d	0.4 (0.6)	0.4 (0.6)	0.5 (0.5)	0.4 (0.4)	0.3 (0.3)	0.4 (0.5)	0.4 (0.4)	0.4 (0.6)	0.4 (0.4)
Snack Chips, svg/d	0.5 (0.6)	0.5 (0.5)	0.6 (0.6)	0.7 (0.9)	0.7 (0.7)	0.7 (0.8)	0.4 (0.4)	0.4 (0.3)	0.4 (0.5)
Chocolate candy, svg/d	0.4 (0.5)	0.4 (0.5)	0.2 (0.2)	0.2 (0.3)	0.2 (0.2)	0.1 (0.2)	0.3 (0.3)	0.3 (0.4)	0.1 (0.2)
Beverages									
Sugar sweetened beverages, svg/d	0.6 (1.1)	0.6 (1.1)	0.9 (1.3)	0.8 (1.0)	0.9 (1.1)	0.9 (1.0)	0.7 (1.4)	0.7 (1.4)	0.8 (1.0)
Coffee, total, svg/d	1.5 (1.5)	1.4 (1.5)	1.4 (1.3)	0.6 (1.0)	0.7 (1.1)	0.6 (0.9)	1.2 (1.4)	1.3 (1.3)	1.2 (1.1)
Decaffeinated coffee, svg/d	0.1 (0.5)	0.1 (0.5)	0.2 (0.6)	0.1 (0.3)	0.1 (0.3)	0.1 (0.3)	0.1 (0.4)	0.1 (0.4)	0.1 (0.5)
Caffeinated coffee, svg/d	1.3 (1.4)	1.3 (1.4)	1.2 (1.3)	0.5 (0.9)	0.6 (1.1)	0.5 (0.9)	1.1 (1.3)	1.1 (1.3)	1.0 (1.0)
Tea, total, svg/d	1.0 (1.6)	1.0 (1.7)	0.7 (1.3)	0.8 (1.2)	0.9 (1.3)	0.6 (0.8)	1.0 (1.8)	1.3 (4.1)	0.7 (1.2)
Decaffeinated tea, svg/d	0.3 (0.6)	0.3 (0.6)	0.1 (0.5)	0.3 (0.7)	0.3 (0.8)	0.1 (0.2)	0.4 (0.8)	0.5 (1.9)	0.2 (0.7)

	White (*n*=417)			African American (*n*=159)			Hispanic (*n*=101)		
Food Group	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**	**FFQ1**	**FFQ2**	**24HR**
Caffeinated tea, svg/d	0.7 (1.4)	0.7 (1.4)	0.5 (1.2)	0.5 (0.8)	0.6 (0.8)	0.5 (0.7)	0.7 (1.5)	0.8 (2.5)	0.5 (0.9)
Alcohol, total, svg/d	0.8 (1.0)	0.8 (1.1)	0.7 (1.0)	0.3 (0.7)	0.3 (0.7)	0.3 (0.6)	0.5 (0.8)	0.5 (1.0)	0.5 (0.8)
Beer, svg/d	0.3 (0.6)	0.3 (0.6)	0.2 (0.5)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.2 (0.4)	0.2 (0.9)	0.2 (0.5)
Wine, total, svg/d	0.4 (0.7)	0.4 (0.6)	0.4 (0.6)	0.2 (0.5)	0.2 (0.6)	0.1 (0.4)	0.2 (0.4)	0.2 (0.4)	0.2 (0.3)
Wine, white, svg/d	0.2 (0.4)	0.2 (0.5)	0.2 (0.5)	0.1 (0.3)	0.1 (0.2)	0.1 (0.3)	0.1 (0.1)	0.1 (0.1)	0.1 (0.2)
Wine, red, svg/d	0.2 (0.5)	0.2 (0.4)	0.3 (0.6)	0.1 (0.3)	0.1 (0.5)	0.1 (0.4)	0.2 (0.3)	0.1 (0.3)	0.1 (0.3)
ACS Diet Quality Score [e]	4.7 (2.0)	4.7 (2.1)	4.7 (2.2)	5.0 (2.2)	5.0 (2.2)	4.2 (2.4)	5.2 (2.0)	5.1 (2.1)	4.9 (2.2)

[a] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Table 2.2.1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[b] Values presented are means ± SD. Not all groups/subgroups are mutually exclusive so all subgroups might not add up to equal the total group.
[c] Includes soy milk; almond milk or rice milk (servings defined as approximately equivalent to the amount of calcium in 1 cup of milk).
[d] Includes soy beans/edamame (1 ounce) or soy nuts (1/2 ounce); tofu (1 ounce) or tofu burgers; fermented soy, tempeh, miso (1 ounce); soy milk (servings defined as approximately equivalent to the amount of calcium in 1 cup of milk).
[e] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.5. Average mean differences and Bland-Altman limits of agreement between food group intakes (servings/day)[a] and diet quality scores estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaires (FFQ) and repeated 24-hour dietary recalls (24HR) among men and women participating in the CPS-3 Diet Assessment Sub-study (*n*=677).

Food Group	Men (*n*=244)				Women (*n*=433)			
	Comparison: FFQ1 - FFQ2		Comparison: 24HR – FFQ2		Comparison: FFQ1 - FFQ2		Comparison: 24HR – FFQ2	
	Mean Difference	Limits of Agreement	Mean Difference	Limits of Agreement	Mean Difference	Limits of Agreement	Mean Difference	Limits of Agreement
Fruits & Juices, total, svg/d	-0.03	-2.87, 2.82	-1.23	-4.25, 1.78	0.15	-3.44, 3.73	-1.24	-4.34, 1.85
Whole Fruits, total (excluding juices), svg/d	-0.04	-2.03, 1.94	-0.86	-3.29, 1.57	0.10	-3.12, 3.32	-1.02	-3.69, 1.64
Citrus Fruits (excluding juices), svg/d	0.03	-0.52, 0.59	-0.06	-0.63, 0.51	0.02	-0.61, 0.66	-0.04	-0.56, 0.48
Non-Citrus Fruits (excluding juices) , svg/d	-0.08	-1.94, 1.78	-0.79	-3.11, 1.53	0.08	-2.93, 3.08	-0.98	-3.54, 1.58
Berries, svg/d	-0.02	-0.74, 0.71	-0.25	-1.06, 0.57	-0.01	-1.31, 1.29	-0.37	-1.55, 0.81
Fruit Juice, svg/d	-0.04	-1.37, 1.3	-0.09	-1.68, 1.5	0.04	-0.81, 0.89	0.01	-0.84, 0.87
Vegetables								
Starchy vegetables, svg/d	-0.06	-0.97, 0.85	-0.13	-1.34, 1.08	-0.02	-0.8, 0.76	-0.17	-1.09, 0.76
White/fried potatoes, svg/d	-0.04	-0.78, 0.69	-0.01	-1.02, 0.99	-0.01	-0.59, 0.57	-0.04	-0.83, 0.75
Non-starchy vegetables, svg/d	-0.03	-2.64, 2.58	0.22	-3.09, 3.52	0.02	-3.74, 3.79	-0.32	-3.67, 3.03
Tomato products, svg/d	0.01	-1, 1.02	0.01	-1.19, 1.2	0.01	-0.84, 0.86	0.00	-0.94, 0.93
Cruciferous vegetables, svg/d	-0.04	-0.9, 0.83	-0.19	-1.15, 0.77	0.01	-0.94, 0.96	-0.25	-1.25, 0.75
Dark green vegetables, svg/d	-0.03	-1.05, 0.99	-0.06	-1.29, 1.18	-0.05	-1.64, 1.55	-0.26	-2, 1.48
Deep-yellow vegetables, svg/d	0.00	-0.28, 0.28	0.16	-0.49, 0.8	-0.01	-0.34, 0.31	0.13	-0.54, 0.79

Legumes, svg/d	-0.10	-2.13, 1.93	-0.32	-2.17, 1.54	-0.05	-2.04, 1.93	-0.37	-2.02, 1.28
Garlic, fresh, svg/d	0.01	-0.51, 0.52	-0.09	-0.69, 0.5	-0.03	-0.84, 0.78	-0.20	-1.2, 0.8
Vegetable juice, svg/d	0.01	-0.65, 0.66	-0.03	-0.56, 0.49	0.01	-0.34, 0.36	-0.01	-0.3, 0.28
Meats, Dairy, & Alternatives								
Dairy, total, svg/d	-0.01	-2.1, 2.09	0.01	-2.26, 2.27	0.12	-1.99, 2.22	0.03	-2.02, 2.08
Dairy, low-fat, svg/d	0.11	-1.25, 1.46	0.25	-1.27, 1.76	0.11	-1.2, 1.42	0.22	-1.41, 1.85
Dairy, regular, svg/d	-0.10	-1.74, 1.55	-0.17	-2.32, 1.99	-0.04	-1.54, 1.46	-0.15	-1.87, 1.57
Yogurt, total, svg/d	-0.01	-0.54, 0.52	-0.09	-0.61, 0.42	0.03	-0.61, 0.66	-0.09	-0.58, 0.39
Yogurt, low-fat, svg/d	0.01	-0.51, 0.53	-0.05	-0.57, 0.48	0.02	-0.53, 0.58	-0.05	-0.5, 0.41
Yogurt, regular, svg/d	-0.02	-0.3, 0.26	-0.04	-0.31, 0.22	0.00	-0.43, 0.43	-0.05	-0.43, 0.34
Cheese, low-fat, svg/d	0.01	-0.31, 0.33	0.17	-0.32, 0.65	0.04	-0.77, 0.85	0.12	-0.41, 0.66
Cheese, regular, svg/d	0.00	-0.86, 0.85	0.19	-0.72, 1.09	0.00	-0.89, 0.9	0.11	-0.76, 0.98
Milk, low-fat, svg/d	0.08	-1.19, 1.36	-0.05	-1.1, 1	0.05	-0.88, 0.98	-0.05	-0.98, 0.88
Frozen Dairy Dessert, svg/d	-0.03	-0.67, 0.62	-0.12	-0.95, 0.72	0.04	-0.71, 0.78	-0.06	-0.75, 0.63
Milk alternative, svg/d	0.03	-0.63, 0.68	-0.04	-0.62, 0.54	-0.01	-0.95, 0.93	-0.06	-0.75, 0.63
Soy products, svg/d	0.02	-0.41, 0.46	-0.04	-0.56, 0.49	0.00	-0.4, 0.41	-0.06	-0.59, 0.47
Eggs, svg/d	0.04	-0.82, 0.89	0.14	-0.69, 0.97	-0.02	-0.92, 0.87	0.06	-0.84, 0.96
Poultry, svg/d	-0.04	-2.24, 2.15	0.67	-2.24, 3.58	0.05	-2.33, 2.43	0.03	-2.76, 2.83
Red meat, svg/d	-0.10	-2.36, 2.16	-0.25	-3.49, 2.99	0.02	-2.01, 2.05	-0.47	-2.67, 1.73
Processed Meat, Total, svg/d	0.01	-1.45, 1.47	0.01	-1.56, 1.58	0.06	-1.37, 1.48	0.05	-1.32, 1.42
Red processed meat, svg/d	0.00	-0.93, 0.93	-0.10	-1.28, 1.07	0.03	-0.87, 0.93	-0.04	-0.82, 0.75
White processed meat, svg/d	0.00	-0.97, 0.97	-0.24	-1.14, 0.65	0.03	-0.76, 0.81	-0.14	-0.89, 0.61
Total seafood, svg/d	-0.02	-1.68, 1.65	-0.08	-2.34, 2.19	0.00	-1.67, 1.66	-0.19	-2.08, 1.7
Light meat seafood, svg/d	0.00	-0.84, 0.84	-0.30	-1.14, 0.54	0.03	-0.81, 0.87	-0.28	-1.06, 0.5
Dark meat seafood, svg/d	-0.02	-1.24, 1.2	-0.44	-1.65, 0.78	-0.04	-1.16, 1.09	-0.42	-1.69, 0.85
Nuts and seeds, svg/d	0.12	-1.95, 2.19	-0.01	-2.12, 2.11	-0.08	-2.28, 2.13	-0.31	-2.92, 2.3

Nut and seed butters, svg/d	0.01	-0.67, 0.69	-0.01	-0.73, 0.71	-0.01	-0.69, 0.68	-0.02	-0.82, 0.78
Grains, total, svg/d	-0.09	-3.68, 3.49	1.01	-3.54, 5.57	0.03	-3.18, 3.25	0.23	-3.4, 3.86
Whole grains, svg/d	0.05	-3.14, 3.24	-0.71	-3.42, 2.01	0.01	-2.69, 2.7	-0.86	-3.59, 1.87
Refined grains, svg/d	-0.12	-1.87, 1.64	1.89	-3.8, 7.57	0.00	-2.02, 2.01	1.06	-1.84, 3.96
Cold Cereal, svg/d	-0.01	-0.79, 0.77	-0.01	-0.96, 0.94	0.00	-0.96, 0.96	-0.04	-0.87, 0.79
Hot Cereal, svg/d	-0.06	-1.01, 0.89	-0.23	-1.14, 0.69	0.04	-1.08, 1.16	-0.25	-1.18, 0.68
Bread, svg/d	0.03	-2.66, 2.71	0.41	-2.55, 3.36	-0.03	-2.42, 2.37	0.16	-2.29, 2.6
Pasta, svg/d	0.01	-0.71, 0.74	0.05	-1.17, 1.28	0.02	-0.62, 0.66	-0.06	-0.87, 0.75
Crackers, svg/d	-0.02	-0.72, 0.69	0.01	-0.77, 0.8	0.00	-0.37, 0.38	0.06	-0.63, 0.74
Snack bars, svg/d	-0.02	-0.69, 0.65	-0.07	-0.7, 0.55	-0.01	-0.68, 0.65	-0.07	-0.71, 0.57
Miscellaneous								
Baked goods, svg/d	0.02	-0.92, 0.96	0.02	-1.1, 1.14	0.00	-0.78, 0.77	0.04	-0.88, 0.97
Snack Chips, svg/d	-0.01	-0.84, 0.82	0.01	-1.12, 1.13	0.02	-1.01, 1.04	-0.02	-1.08, 1.04
Chocolate candy, svg/d	-0.03	-0.67, 0.61	-0.16	-0.89, 0.57	0.02	-0.7, 0.75	-0.15	-0.82, 0.51
Beverages								
Sugar sweetened beverages, svg/d	0.03	-1.82, 1.87	0.25	-2.54, 3.04	-0.03	-1.59, 1.53	0.20	-2.32, 2.73
Coffee, total, svg/d	-0.10	-2.45, 2.25	-0.17	-3.08, 2.74	-0.02	-2.04, 2.01	-0.11	-2.04, 1.82
Decaffeinated coffee, svg/d	0.01	-0.76, 0.78	0.03	-0.92, 0.98	0.00	-0.61, 0.6	0.02	-0.71, 0.74
Caffeinated coffee, svg/d	-0.13	-2.47, 2.21	-0.21	-3.08, 2.66	-0.02	-2.02, 1.99	-0.13	-2.08, 1.81
Tea, total, svg/d	-0.01	-1.37, 1.35	-0.13	-1.75, 1.48	-0.07	-3.31, 3.18	-0.47	-4.4, 3.46
Decaffeinated tea, svg/d	0.00	-0.69, 0.69	-0.07	-0.72, 0.58	-0.03	-1.93, 1.88	-0.24	-2.35, 1.88
Caffeinated tea, svg/d	-0.01	-1.13, 1.1	-0.06	-1.53, 1.42	-0.05	-2.28, 2.17	-0.23	-2.8, 2.34
Alcohol, total, svg/d	0.04	-1.06, 1.13	-0.03	-1.48, 1.42	-0.02	-1.01, 0.96	-0.06	-1.29, 1.16
Beer, svg/d	-0.01	-0.62, 0.6	-0.05	-0.77, 0.67	-0.02	-0.67, 0.63	-0.05	-0.78, 0.69
Wine, total, svg/d	0.05	-0.7, 0.79	0.01	-0.74, 0.76	-0.01	-0.71, 0.69	-0.03	-0.83, 0.77
Wine, white, svg/d	0.00	-0.39, 0.39	0.03	-0.5, 0.55	0.00	-0.57, 0.56	0.02	-0.6, 0.64
Wine, red, svg/d	0.05	-0.48, 0.58	0.06	-0.63, 0.74	0.00	-0.44, 0.43	0.01	-0.59, 0.61
ACS Diet Quality Score[b]	-0.01	-3.00, 2.98	-0.07	-3.64, 3.5	-0.04	-3.15, 3.07	-0.26	-4, 3.47

[a] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Table 2.2.1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[b] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.6. Average mean differences (Mean Diff.) and Bland-Altman limits of agreement (LOA) between food group intakes (servings/day)[a] and diet quality scores estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaires (FFQ) and repeated 24-hour dietary recalls (24HR) among participants in the CPS-3 Diet Assessment Substudy (*n*=677), by race/ethnicity.

Food Group	White (*n*=244)				African American (*n*=433)				Hispanic (*n*=101)			
	Comparison: FFQ1 - FFQ2		Comparison: 24HR – FFQ2		Comparison: FFQ1 - FFQ2		Comparison: 24HR – FFQ2		Comparison: FFQ1 - FFQ2		Comparison: 24HR – FFQ2	
	Mean Diff.	LOA	Mean Diff.	LOA	Mean Diff.	LOA	Mean Diff.	LOA	Mean Diff.	LOA	Mean Diff.	LOA
Fruits & Juices, total, svg/d	0.04	-2.87, 2.94	-1.15	-3.97, 1.67	0.17	-4.16, 4.51	-1.48	-5.05, 2.1	0.13	-3.11, 3.37	-1.23	-4.32, 1.87
Whole Fruits, total (excluding juices), svg/d	0.02	-2.55, 2.58	-0.93	-3.44, 1.59	0.15	-3.51, 3.82	-1.05	-3.75, 1.65	0.02	-2.4, 2.45	-0.97	-3.67, 1.73
Citrus Fruits (excluding juices), svg/d	0.03	-0.63, 0.68	-0.05	-0.56, 0.47	0.01	-0.48, 0.51	-0.08	-0.6, 0.45	0.05	-0.51, 0.6	0.00	-0.62, 0.63
Non-Citrus Fruits (excluding juices) , svg/d	-0.01	-2.34, 2.32	-0.88	-3.25, 1.5	0.14	-3.37, 3.65	-0.98	-3.57, 1.62	-0.03	-2.37, 2.31	-0.97	-3.7, 1.76
Berries, svg/d	0.00	-1.19, 1.19	-0.34	-1.46, 0.78	0.01	-1.05, 1.07	-0.28	-1.26, 0.7	-0.08	-1, 0.83	-0.35	-1.33, 0.63
Fruit Juice, svg/d	-0.02	-0.91, 0.88	-0.02	-1.07, 1.03	0.09	-1.34, 1.52	-0.01	-1.3, 1.29	0.01	-0.9, 0.93	-0.06	-1.5, 1.38
Vegetables												
Starchy vegetables, svg/d	-0.03	-0.81, 0.74	-0.13	-1.16, 0.89	-0.02	-1, 0.95	-0.20	-1.26, 0.86	-0.07	-0.9, 0.77	-0.15	-1.22, 0.93
White/fried potatoes, svg/d	-0.02	-0.65, 0.6	-0.02	-0.9, 0.86	0.00	-0.71, 0.72	-0.07	-0.89, 0.75	-0.06	-0.62, 0.51	-0.02	-0.92, 0.89
Non-starchy vegetables, svg/d	0.03	-3.5, 3.55	0.03	-3.13, 3.19	-0.09	-3.43, 3.25	-0.33	-4.01, 3.35	0.07	-2.88, 3.02	-0.44	-4.02, 3.15

Tomato products, svg/d	0.00	-0.89, 0.89	0.02	-1.06, 1.09	0.01	-0.79, 0.8	0.00	-0.82, 0.82	0.05	-1.08, 1.19	-0.07	-1.21, 1.07
Cruciferous vegetables, svg/d	-0.01	-0.86, 0.84	-0.24	-1.18, 0.7	0.00	-1.12, 1.11	-0.19	-1.34, 0.95	0.00	-0.89, 0.88	-0.24	-1.15, 0.66
Dark green vegetables, svg/d	-0.03	-1.42, 1.36	-0.16	-1.58, 1.26	-0.07	-1.6, 1.46	-0.23	-2.24, 1.77	-0.03	-1.38, 1.31	-0.23	-1.74, 1.28
Deep-yellow vegetables, svg/d	-0.01	-0.25, 0.24	0.16	-0.52, 0.85	-0.01	-0.43, 0.4	0.09	-0.55, 0.74	-0.01	-0.36, 0.35	0.11	-0.44, 0.66
Legumes, svg/d	-0.04	-1.92, 1.83	-0.30	-1.88, 1.28	-0.21	-2.24, 1.82	-0.45	-2.53, 1.62	0.04	-2.37, 2.44	-0.40	-2.08, 1.28
Garlic, fresh, svg/d	-0.01	-0.64, 0.62	-0.14	-1.01, 0.74	0.00	-0.89, 0.9	-0.16	-0.83, 0.52	-0.08	-0.84, 0.69	-0.28	-1.43, 0.87
Vegetable juice, svg/d	0.00	-0.51, 0.52	-0.14	-1.01, 0.74	0.00	-0.89, 0.9	0.00	-0.27, 0.27	-0.02	-0.48, 0.45	-0.03	-0.5, 0.45
Meats, Dairy, & Alternatives												
Dairy, total, svg/d	-0.01	-1.84, 1.81	-0.01	-2.16, 2.14	0.21	-1.97, 2.39	0.08	-1.79, 1.95	0.21	-2.68, 3.1	0.04	-2.36, 2.44
Dairy, low-fat, svg/d	0.09	-1.1, 1.29	0.29	-1.42, 1.99	0.13	-1.36, 1.62	0.13	-1.18, 1.44	0.13	-1.41, 1.68	0.16	-1.28, 1.6
Dairy, regular, svg/d	-0.10	-1.48, 1.29	-0.21	-2.25, 1.82	0.01	-1.3, 1.32	0.00	-1.38, 1.39	0.13	-1.41, 1.68	-0.17	-2.06, 1.73
Yogurt, total, svg/d	0.02	-0.54, 0.59	-0.08	-0.56, 0.40	-0.03	-0.71, 0.65	-0.12	-0.67, 0.43	0.04	-0.55, 0.63	-0.09	-0.56, 0.38
Yogurt, low-fat, svg/d	0.02	-0.51, 0.55	-0.05	-0.56, 0.47	0.01	-0.53, 0.55	-0.05	-0.37, 0.28	0.03	-0.56, 0.62	-0.05	-0.6, 0.49
Yogurt, regular, svg/d	0.00	-0.32, 0.33	-0.04	-0.3, 0.22	-0.04	-0.59, 0.51	-0.07	-0.62, 0.48	0.00	-0.28, 0.28	-0.04	-0.28, 0.2
Cheese, low-fat, svg/d	0.02	-0.44, 0.47	0.15	-0.39, 0.68	0.06	-1.06, 1.18	0.10	-0.35, 0.56	0.03	-0.45, 0.51	0.16	-0.37, 0.7
Cheese, regular, svg/d	-0.03	-0.76, 0.7	0.11	-0.8, 1.03	0.03	-1.00, 1.05	0.17	-0.74, 1.08	0.09	-1.05, 1.24	0.19	-0.54, 0.92

Milk, low-fat, svg/d	0.06	-0.96, 1.07	-0.03	-1.06, 1.00	0.05	-0.92, 1.02	-0.07	-0.87, 0.73	0.08	-1.3, 1.46	-0.10	-1.11, 0.91
Frozen Dairy Dessert, svg/d	-0.01	-0.7, 0.67	-0.10	-0.87, 0.67	0.05	-0.77, 0.87	-0.07	-0.77, 0.63	0.07	-0.56, 0.7	-0.02	-0.73, 0.7
Milk alternative, svg/d	-0.01	-0.7, 0.67	-0.05	-0.73, 0.63	0.04	-0.58, 0.66	-0.06	-0.55, 0.43	0.03	-1.46, 1.51	-0.20	-1.77, 1.38
Soy products, svg/d	0.00	-0.3, 0.3	-0.05	-0.52, 0.43	0.01	-0.30, 0.32	-0.05	-0.36, 0.27	0.05	-0.75, 0.86	-0.08	-0.96, 0.8
Eggs, svg/d	-0.01	-0.77, 0.75	0.06	-0.75, 0.88	0.02	-1.00, 1.04	0.14	-0.85, 1.13	-0.01	-1.11, 1.1	0.11	-0.84, 1.06
Poultry, svg/d	0.04	-1.86, 1.94	0.24	-2.26, 2.74	0.00	-3.04, 3.04	0.33	-3.09, 3.75	-0.06	-2.63, 2.52	0.23	-3.29, 3.75
Red meat, svg/d	-0.03	-2.08, 2.02	-0.53	-3.06, 1.99	0.00	-2.44, 2.44	-0.22	-3.1, 2.65	-0.02	-1.88, 1.84	-0.06	-2.55, 2.42
Processed Meat, Total, svg/d	0.05	-1.19, 1.3	0.03	-1.36, 1.42	0.02	-1.75, 1.79	0.09	-1.4, 1.58	0.02	-1.59, 1.64	-0.04	-1.6, 1.53
Red processed meat, svg/d	0.01	-0.83, 0.86	-0.06	-0.94, 0.82	0.05	-0.99, 1.08	-0.01	-0.97, 0.94	0.00	-0.96, 0.96	-0.15	-1.3, 0.99
White processed meat, svg/d	0.04	-0.69, 0.77	-0.18	-0.87, 0.5	-0.03	-1.09, 1.03	-0.16	-1.2, 0.89	0.01	-0.97, 0.98	-0.15	-1.3, 0.99
Total seafood, svg/d	0.00	-1.44, 1.43	-0.11	-1.9, 1.69	0.04	-2.22, 2.3	-0.23	-2.82, 2.36	-0.11	-1.55, 1.34	-0.17	-2.15, 1.8
Light meat seafood, svg/d	0.01	-0.66, 0.67	-0.24	-0.94, 0.45	0.07	-1.11, 1.26	-0.39	-1.35, 0.58	-0.03	-0.85, 0.79	-0.30	-1.19, 0.58
Dark meat seafood, svg/d	-0.01	-1.12, 1.09	-0.38	-1.53, 0.78	-0.04	-1.43, 1.34	-0.59	-2.14, 0.97	-0.07	-1.08, 0.93	-0.38	-1.37, 0.61
Nuts and seeds, svg/d	-0.01	-2.04, 2.01	-0.16	-2.72, 2.4	-0.04	-2.62, 2.53	-0.40	-2.78, 1.97	0.07	-1.97, 2.11	-0.07	-2.16, 2.03
Nut and seed butters, svg/d	-0.01	-0.69, 0.67	0.00	-0.79, 0.79	0.00	-0.78, 0.78	-0.09	-0.92, 0.73	0.05	-0.46, 0.55	0.03	-0.5, 0.57
Grains, total, svg/d	-0.01	-0.69, 0.67	0.44	-3.45, 4.32	0.12	-3.83, 4.06	0.45	-4.23, 5.12	-0.14	-3.52, 3.24	0.91	-2.7, 4.53

Whole grains, svg/d	0.00	-2.68, 2.67	-0.75	-3.43, 1.92	0.04	-3.35, 3.43	-1.10	-4.03, 1.83	0.09	-2.77, 2.94	-0.56	-3.01, 1.89
Refined grains, svg/d	-0.04	-1.86, 1.79	1.21	-2.69, 5.12	0.02	-2.26, 2.3	1.66	-3.66, 6.97	-0.18	-1.9, 1.53	1.48	-1.71, 4.66
Cold Cereal, svg/d	-0.04	-1.86, 1.79	-0.01	-0.81, 0.79	0.01	-0.87, 0.89	-0.07	-0.86, 0.72	-0.03	-1.11, 1.05	-0.03	-1.25, 1.19
Hot Cereal, svg/d	0.01	-0.95, 0.96	-0.19	-0.99, 0.61	-0.03	-1.37, 1.3	-0.39	-1.52, 0.73	0.06	-1, 1.11	-0.23	-1.21, 0.75
Bread, svg/d	-0.06	-2.38, 2.26	0.16	-2.55, 2.86	0.04	-3.12, 3.2	0.26	-2.38, 2.91	0.13	-1.9, 2.15	0.59	-1.72, 2.9
Pasta, svg/d	0.01	-0.58, 0.6	-0.01	-0.97, 0.94	0.07	-0.73, 0.87	-0.06	-0.93, 0.81	-0.02	-0.77, 0.72	0.03	-1.19, 1.25
Crackers, svg/d	-0.01	-0.57, 0.56	0.03	-0.78, 0.84	0.02	-0.32, 0.36	0.09	-0.45, 0.63	-0.03	-0.59, 0.53	0.01	-0.58, 0.59
Snack bars, svg/d	-0.02	-0.8, 0.75	-0.08	-0.81, 0.65	0.00	-0.43, 0.44	-0.05	-0.42, 0.31	-0.02	-0.47, 0.44	-0.05	-0.55, 0.45
Miscellaneous												
Baked goods, svg/d	0.02	-0.83, 0.88	0.05	-0.97, 1.07	-0.01	-0.76, 0.73	0.04	-0.88, 0.95	-0.05	-0.93, 0.83	-0.05	-0.55, 0.45
Snack Chips, svg/d	0.01	-0.93, 0.95	0.00	-1.1, 1.09	0.01	-1.16, 1.19	-0.05	-1.23, 1.12	0.00	-0.61, 0.6	0.02	-0.84, 0.89
Chocolate candy, svg/d	0.01	-0.75, 0.77	-0.17	-0.92, 0.58	-0.01	-0.48, 0.46	-0.12	-0.64, 0.4	0.02	-0.72, 0.76	-0.15	-0.81, 0.52
Beverages												
Sugar sweetened beverages, svg/d	0.00	-1.62, 1.63	0.31	-2.38, 3	0.02	-1.89, 1.93	-0.01	-2.44, 2.41	-0.10	-1.51, 1.32	0.21	-2.39, 2.81
Coffee, total, svg/d	-0.03	-2.2, 2.13	-0.15	-2.66, 2.36	-0.04	-1.8, 1.73	-0.06	-1.69, 1.56	-0.12	-2.72, 2.47	-0.18	-2.67, 2.31
Decaffeinated coffee, svg/d	0.00	-0.7, 0.69	0.04	-0.87, 0.94	0.01	-0.59, 0.6	-0.01	-0.55, 0.52	0.02	-0.65, 0.69	0.02	-0.75, 0.79
Caffeinated coffee, svg/d	-0.03	-2.2, 2.14	-0.18	-2.66, 2.3	-0.05	-1.65, 1.56	-0.05	-1.63, 1.53	-0.16	-2.81, 2.48	-0.24	-2.84, 2.37
Tea, total, svg/d	0.05	-2.01, 2.1	-0.31	-2.41, 1.78	-0.18	-2.6, 2.24	-0.31	-2.39, 1.78	-0.21	-4.99, 4.57	-0.55	-7.52, 6.41
Decaffeinated tea, svg/d	0.01	-1.26, 1.29	-0.13	-1.48, 1.21	-0.05	-1.45, 1.35	-0.23	-1.59, 1.12	-0.10	-2.73, 2.53	-0.27	-3.43, 2.88

Caffeinated tea, svg/d	0.01	-1.83, 1.86	-0.18	-1.93, 1.57	-0.12	-1.68, 1.44	-0.06	-1.52, 1.4	-0.13	-2.64, 2.38	-0.28	-4.5, 3.95
Alcohol, total, svg/d	-0.01	-1.07, 1.06	-0.06	-1.5, 1.38	0.01	-0.79, 0.8	-0.06	-1.12, 1	0.00	-1.18, 1.19	-0.02	-1.11, 1.06
Beer, svg/d	-0.01	-0.62, 0.59	-0.06	-0.83, 0.71	0.00	-0.19, 0.19	-0.01	-0.23, 0.2	-0.04	-1.12, 1.03	-0.05	-1.07, 0.97
Wine, total, svg/d	0.02	-0.81, 0.84	0.00	-0.82, 0.81	0.00	-0.57, 0.56	-0.07	-0.93, 0.79	0.02	-0.34, 0.38	0.00	-0.44, 0.44
Wine, white, svg/d	-0.01	-0.63, 0.62	0.03	-0.66, 0.73	0.01	-0.23, 0.25	0.00	-0.35, 0.35	0.00	-0.23, 0.23	0.03	-0.32, 0.38
Wine, red, svg/d	0.03	-0.48, 0.53	0.05	-0.57, 0.68	-0.01	-0.5, 0.48	-0.04	-0.78, 0.7	0.02	-0.24, 0.28	0.01	-0.44, 0.47
ACS Diet Quality Score[b]	-0.02	-3.08, 3.05	0.05	-3.65, 3.75	0.01	-3.40, 3.42	-0.86	-4.22, 2.49	-0.14	-2.59, 2.31	-0.15	-3.75, 3.46

[a] Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Table 2.2.1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[b] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.7. Race-specific correlation coefficients [a] for reproducibility of energy-adjusted [b] food group intake (servings/day)[c] and a diet quality score (0-9) estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire (FFQ) among participants in the CPS-3 Diet Assessment Substudy (*n*=660) [d].

	White (*n*=405)	African American (*n*=157)	Hispanic (*n*=98)
Food Group	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. FFQ2)	r_s (FFQ1 vs. FFQ2)
Fruits & Juices, total, svg/d	0.68	0.62	0.59
Whole Fruits, total (excluding juices), svg/d	0.71	0.65	0.73
Citrus Fruits (excluding juices), svg/d	0.71	0.63	0.59
Non-Citrus Fruits (excluding juices) , svg/d	0.70	0.64	0.69
Berries, svg/d	0.68	0.61	0.74
Fruit Juice, svg/d	0.73	0.53	0.74
Vegetables			
Starchy vegetables, svg/d	0.61	0.56	0.49
White/fried potatoes, svg/d	0.63	0.61	0.58
Non-starchy vegetables, svg/d	0.71	0.68	0.67
Tomato products, svg/d	0.65	0.70	0.57
Cruciferous vegetables, svg/d	0.69	0.61	0.71
Dark green vegetables, svg/d	0.68	0.64	0.63
Deep-yellow vegetables, svg/d	0.71	0.52	0.68
Legumes, svg/d	0.60	0.58	0.41
Garlic, fresh, svg/d	0.77	0.74	0.67
Vegetable juice, svg/d	0.55	0.59	0.41
Meats, Dairy, & Alternatives			
Dairy, total, svg/d	0.70	0.57	0.60
Dairy, low-fat, svg/d	0.73	0.64	0.66
Dairy, regular, svg/d	0.68	0.61	0.68
Yogurt, total, svg/d	0.70	0.57	0.54
Yogurt, low-fat, svg/d	0.64	0.53	0.56
Yogurt, regular, svg/d	0.55	0.47	0.45
Cheese, low-fat, svg/d	-0.02	-0.09	0.14

Cheese, regular, svg/d	0.60	0.52	0.58
Milk, low-fat, svg/d	0.78	0.70	0.74
Frozen Dairy Dessert, svg/d	0.59	0.44	0.49
Milk alternative[e], svg/d	0.59	0.71	0.65
Soy products[f], svg/d	0.64	0.70	0.68
Eggs, svg/d	0.69	0.61	0.57
Poultry, svg/d	0.55	0.58	0.36
Red meat, svg/d	0.69	0.73	0.76
Processed Meat, Total, svg/d	0.71	0.68	0.59
Red processed meat, svg/d	0.68	0.78	0.68
White processed meat, svg/d	0.67	0.60	0.50
Total seafood, svg/d	0.71	0.66	0.61
Light meat seafood, svg/d	0.63	0.59	0.48
Dark meat seafood, svg/d	0.69	0.61	0.67
Nuts and seeds, svg/d	0.68	0.63	0.55
Nut and seed butters, svg/d	0.69	0.59	0.58
Grains, total, svg/d	0.66	0.48	0.53
Whole grains, svg/d	0.63	0.49	0.60
Refined grains, svg/d	0.69	0.65	0.64
Cold Cereal, svg/d	0.74	0.63	0.76
Hot Cereal, svg/d	0.66	0.66	0.60
Bread, svg/d	0.61	0.32	0.57
Pasta, svg/d	0.57	0.56	0.40
Crackers, svg/d	0.33	0.28	0.37
Snack bars, svg/d	0.65	0.6	0.71
Miscellaneous			
Baked goods, svg/d	0.65	0.52	0.39
Snack Chips, svg/d	0.67	0.60	0.62
Chocolate candy, svg/d	0.64	0.51	0.60
Beverages			

Sugar sweetened beverages, svg/d	0.70	0.70	0.75
Coffee, total, svg/d	0.87	0.86	0.78
Decaffeinated coffee, svg/d	0.64	0.62	0.51
Caffeinated coffee, svg/d	0.87	0.82	0.74
Tea, total, svg/d	0.84	0.65	0.80
Decaffeinated tea, svg/d	0.68	0.61	0.64
Caffeinated tea, svg/d	0.80	0.60	0.70
Alcohol, total, svg/d	0.91	0.85	0.88
Beer, svg/d	0.85	0.72	0.79
Wine, total, svg/d	0.87	0.85	0.81
Wine, white, svg/d	0.78	0.77	0.72
Wine, red, svg/d	0.81	0.81	0.80
Median	0.68	0.61	0.62
	r_p (FFQ1 v FFQ2)	**r_p (FFQ1 v FFQ2)**	**r_p (FFQ1 v FFQ2)**
ACS Diet Quality Score [g]	0.72	0.70	0.82

[a] Spearman (r_s) and Pearson (r_p) correlation coefficients were used to describe food group and diet quality score analyses, respectively.
[b] Food groups were energy-adjusted according to the residual method.
[c] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Table 2.2.1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[d] Participants who completed fewer than five 24-hour dietary recalls were excluded from this analysis (n=17).
[e] Includes soy milk; almond milk or rice milk.
[f] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.
[g] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.8. Sex-specific correlation coefficients [a] for reproducibility and validity of energy-adjusted [b] food group intake (servings/day) [c] and a diet quality score (0-9) estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire (FFQ) among participants in the CPS-3 Diet Assessment Substudy (N=660) [d].

	White (*n*=405)			African American (*n* =157)			Hispanic (*n* =98)		
Food Group	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)	r_s (FFQ1 vs. 24HR)	r_s (FFQ2 vs. 24HR)	Deattenuated r_s (FFQ2 vs. 24HR)
Fruits & Juices, total, svg/d	0.55	0.60	0.70 (0.53, 0.82)	0.47	0.46	0.55 (0.39, 0.67)	0.39	0.54	0.65 (0.44, 0.79)
Whole Fruits, total (excluding juices), svg/d	0.57	0.62	0.73 (0.55, 0.84)	0.52	0.52	0.60 (0.45, 0.72)	0.50	0.60	0.71 (0.52, 0.84)
Citrus Fruits (excluding juices), svg/d	0.30	0.36	0.45 (0.34, 0.55)	0.32	0.28	0.34 (0.16, 0.50)	0.34	0.30	0.37 (0.13, 0.56)
Non-Citrus Fruits (excluding juices), svg/d	0.55	0.61	0.73 (0.52, 0.86)	0.51	0.51	0.59 (0.44, 0.71)	0.49	0.52	0.62 (0.42, 0.76)
Berries, svg/d	0.37	0.43	0.53 (0.42, 0.63)	0.23	0.24	0.29 (0.11, 0.45)	0.34	0.41	0.51 (0.26, 0.69)
Fruit Juice, svg/d	0.41	0.41	0.48 (0.38, 0.57)	0.32	0.25	0.30 (0.12, 0.46)	0.35	0.36	0.46 (0.21, 0.65)
Vegetables									
Starchy vegetables, svg/d	0.32	0.35	0.54 (0.39, 0.67)	0.32	0.39	0.65 (0.31, 0.84)	0.32	0.31	0.83 (-.96, 1.00)
White/fried potatoes, svg/d	0.28	0.27	0.39 (0.25, 0.50)	0.32	0.38	0.56 (0.32, 0.74)	0.19	0.23	0.31 (0.04, 0.54)
Non-starchy vegetables, svg/d	0.50	0.53	0.64 (0.55, 0.72)	0.39	0.45	0.57 (0.39, 0.71)	0.40	0.42	0.59 (0.27, 0.79)
Tomato products, svg/d	0.34	0.38	0.61 (0.44, 0.73)	0.27	0.37	0.67 (-.86, 0.99)	0.33	0.29	0.45 (0.11, 0.69)
Cruciferous vegetables, svg/d	0.43	0.41	0.62 (0.42, 0.77)	0.34	0.40	0.60 (0.36, 0.77)	0.52	0.45	0.64 (0.34, 0.83)
Dark green vegetables, svg/d	0.52	0.51	0.66 (0.55, 0.74)	0.32	0.38	0.49 (0.31, 0.64)	0.42	0.43	0.68 (0.27, 0.89)
Deep-yellow vegetables, svg/d	0.19	0.18	0.25 (0.12, 0.38)	0.23	0.26	0.38 (0.15, 0.56)	0.20	0.24	0.33 (0.06, 0.56)
Legumes, svg/d	0.27	0.32	0.45 (0.32, 0.56)	0.25	0.29	0.37 (0.19, 0.53)	0.20	0.36	0.53 (0.22, 0.74)
Garlic, fresh, svg/d	0.27	0.23	0.34 (0.20, 0.46)	0.39	0.29	0.37 (0.19, 0.53)	0.40	0.27	0.39 (0.11, 0.61)

Vegetable juice, svg/d	0.33	0.37	0.43 (0.33, 0.52)	0.27	0.13	0.17 (0.00, 0.33)	0.40	0.18	0.21 (-.01, 0.41)
Meats, Dairy, & Alternatives									
Dairy, total, svg/d	0.58	0.62	0.74 (0.65, 0.80)	0.47	0.50	0.65 (0.47, 0.78)	0.48	0.59	0.80 (0.47, 0.94)
Dairy, low-fat, svg/d	0.56	0.62	0.74 (0.65, 0.80)	0.47	0.50	0.65 (0.47, 0.78)	0.51	0.64	0.75 (0.57, 0.87)
Dairy, regular, svg/d	0.34	0.38	0.54 (0.40, 0.65)	0.38	0.35	0.43 (0.25, 0.59)	0.41	0.43	0.53 (0.30, 0.71)
Yogurt, total, svg/d	0.50	0.48	0.58 (0.48, 0.66)	0.26	0.34	0.41 (0.24, 0.56)	0.29	0.31	0.36 (0.14, 0.55)
Yogurt, low-fat, svg/d	0.40	0.42	0.50 (0.40, 0.58)	0.22	0.30	0.37 (0.19, 0.52)	0.33	0.29	0.34 (0.11, 0.54)
Yogurt, regular, svg/d	0.15	0.20	0.24 (0.13, 0.34)	0.12	0.08	0.09 (-.08, 0.25)	0.02	-0.03	-.04 (-.26, 0.19)
Cheese, low-fat, svg/d	-0.02	0.28	0.40 (0.26, 0.53)	-0.14	0.05	0.09 (-.09, 0.26)	0.08	0.30	0.42 (0.15, 0.63)
Cheese, regular, svg/d	0.43	0.42	0.63 (0.49, 0.74)	0.38	0.38	0.46 (0.29, 0.61)	0.39	0.43	0.58 (0.32, 0.76)
Milk, low-fat, svg/d	0.63	0.66	0.73 (0.66, 0.78)	0.46	0.51	0.62 (0.46, 0.74)	0.57	0.69	0.78 (0.62, 0.88)
Frozen Dairy Dessert, svg/d	0.37	0.51	0.58 (0.49, 0.65)	0.42	0.43	0.49 (0.33, 0.61)	0.52	0.52	0.58 (0.40, 0.72)
Milk alternative[e], svg/d	0.32	0.37	0.42 (0.32, 0.51)	0.34	0.25	0.29 (0.12, 0.44)	0.26	0.20	0.24 (0.02, 0.43)
Soy products[f], svg/d	0.43	0.50	0.61 (0.51, 0.69)	0.38	0.35	0.45 (0.26, 0.62)	0.41	0.45	0.57 (0.34, 0.73)
Eggs, svg/d	0.38	0.38	0.58 (-.10, 0.89)	0.29	0.39	0.53 (0.33, 0.68)	0.35	0.45	0.57 (0.34, 0.73)
Poultry, svg/d	0.38	0.41	0.58 (0.39, 0.72)	0.37	0.40	0.52 (0.33, 0.67)	0.47	0.53	0.78 (0.39, 0.93)
Red meat, svg/d	0.41	0.44	0.61 (0.49, 0.71)	0.49	0.47	0.63 (0.43, 0.77)	0.24	0.38	0.61 (0.22, 0.84)
Processed Meat, Total, svg/d	0.36	0.44	0.61 (0.49, 0.71)	0.46	0.41	0.50 (0.33, 0.64)	0.19	0.24	0.37 (0.06, 0.61)
Red processed meat, svg/d	0.25	0.27	0.34 (0.23, 0.44)	0.15	0.15	0.19 (0.00, 0.37)	0.31	0.16	0.19 (-.06, 0.42)
White processed meat, svg/d	0.33	0.33	0.44 (0.32, 0.54)	0.41	0.34	0.46 (0.28, 0.61)	0.39	0.37	0.46 (0.21, 0.66)
Total seafood, svg/d	0.19	0.21	0.25 (0.15, 0.35)	0.30	0.19	0.24 (0.07, 0.40)	0.25	0.20	0.22 (0.01, 0.42)

Light meat seafood, svg/d	0.18	0.19	0.24 (0.12, 0.34)	0.18	0.17	0.22 (0.03, 0.39)	0.13	0.12	0.12 (-.11, 0.33)
Dark meat seafood, svg/d	0.47	0.55	0.68 (0.59, 0.76)	0.43	0.56	0.67 (0.51, 0.78)	0.13	0.48	0.62 (0.38, 0.78)
Nuts and seeds, svg/d	0.32	0.34	0.43 (0.32, 0.53)	0.26	0.09	0.10 (-.08, 0.27)	0.35	0.22	0.26 (0.03, 0.47)
Nut and seed butters, svg/d	0.51	0.53	0.62 (0.53, 0.70)	0.43	0.37	0.44 (0.27, 0.58)	0.26	0.55	0.68 (0.46, 0.82)
Grains, total, svg/d	0.49	0.56	0.65 (0.57, 0.73)	0.39	0.41	0.49 (0.32, 0.64)	0.47	0.51	0.66 (0.41, 0.81)
Whole grains, svg/d	0.44	0.46	0.58 (0.47, 0.67)	0.42	0.39	0.50 (0.31, 0.65)	0.44	0.54	0.68 (0.45, 0.82)
Refined grains, svg/d	0.52	0.57	0.67 (0.58, 0.74)	0.36	0.27	0.32 (0.14, 0.48)	0.41	0.40	0.49 (0.27, 0.66)
Cold Cereal, svg/d	0.30	0.39	0.45 (0.35, 0.54)	0.33	0.44	0.54 (0.36, 0.69)	0.15	0.32	0.38 (0.14, 0.57)
Hot Cereal, svg/d	0.37	0.43	0.55 (0.43, 0.64)	0.44	0.31	0.46 (0.23, 0.64)	0.25	0.32	0.53 (0.14, 0.78)
Bread, svg/d	0.11	0.08	0.12 (-.01, 0.25)	0.12	0.17	0.21 (0.00, 0.39)	-0.05	0.20	0.28 (0.00, 0.52)
Pasta, svg/d	0.12	0.18	0.22 (0.11, 0.33)	0.19	0.03	0.02 (-.17, 0.21)	0.02	0.07	0.11 (-.15, 0.36)
Crackers, svg/d	0.42	0.40	0.46 (0.36, 0.55)	0.20	0.21	0.24 (0.07, 0.40)	0.29	0.31	0.39 (0.15, 0.59)
Snack bars, svg/d	0.16	0.26	0.33 (0.22, 0.44)	0.16	0.15	0.21 (0.01, 0.40)	0.09	0.05	0.07 (-.17, 0.30)
Miscellaneous									
Baked goods, svg/d	0.29	0.35	0.48 (0.35, 0.58)	0.26	0.28	0.36 (0.16, 0.53)	0.22	0.25	0.34 (0.08, 0.55)
Snack Chips, svg/d	0.43	0.34	0.49 (0.32, 0.62)	0.33	0.44	0.61 (0.38, 0.76)	0.28	0.35	0.49 (0.07, 0.77)
Chocolate candy, svg/d	0.25	0.32	0.41 (0.30, 0.52)	0.11	0.05	0.05 (-.15, 0.24)	0.23	0.01	0.02 (-.24, 0.28)
Beverages									
Sugar sweetened beverages, svg/d	0.21	0.24	0.27 (0.17, 0.36)	0.46	0.35	0.42 (0.25, 0.56)	0.26	0.36	0.42 (0.21, 0.59)
Coffee, total, svg/d	0.79	0.79	0.82 (0.78, 0.85)	0.67	0.67	0.75 (0.58, 0.86)	0.60	0.70	0.74 (0.62, 0.83)
Decaffeinated coffee, svg/d	0.49	0.47	0.52 (0.44, 0.60)	0.32	0.22	0.26 (0.09, 0.41)	0.44	0.30	0.34 (0.14, 0.52)
Caffeinated coffee, svg/d	0.76	0.76	0.79 (0.75, 0.83)	0.67	0.66	0.73 (0.62, 0.81)	0.44	0.65	0.70 (0.56, 0.80)
Tea, total, svg/d	0.76	0.56	0.62 (0.54, 0.69)	0.44	0.49	0.57 (0.42, 0.70)	0.53	0.51	0.57 (0.39, 0.72)
Decaffeinated tea, svg/d	0.30	0.24	0.28 (0.17, 0.37)	0.18	0.06	0.07 (-.11, 0.24)	0.07	0.16	0.24 (-.05, 0.49)
Caffeinated tea, svg/d	0.45	0.49	0.55 (0.47, 0.63)	0.44	0.45	0.52 (0.36, 0.65)	0.47	0.42	0.49 (0.29, 0.65)

Alcohol, total, svg/d	0.70	0.72	0.79 (0.73, 0.83)	0.52	0.50	0.56 (0.41, 0.68)	0.57	0.59	0.66 (0.49, 0.79)
Beer, svg/d	0.44	0.45	0.52 (0.42, 0.60)	0.25	0.16	0.19 (0.01, 0.35)	0.37	0.38	0.45 (0.24, 0.62)
Wine, total, svg/d	0.61	0.63	0.71 (0.63, 0.77)	0.44	0.39	0.45 (0.29, 0.58)	0.48	0.49	0.62 (0.38, 0.78)
Wine, white, svg/d	0.38	0.41	0.48 (0.38, 0.57)	0.24	0.19	0.23 (0.07, 0.38)	0.31	0.27	0.32 (0.10, 0.52)
Wine, red, svg/d	0.47	0.49	0.55 (0.46, 0.63)	0.31	0.29	0.33 (0.17, 0.48)	0.38	0.43	0.51 (0.30, 0.67)
Median	0.40	0.41	0.54	0.33	0.35	0.45	0.35	0.36	0.49
ACS Diet Quality Score[g]	0.58	0.62	--	0.63	0.73	--	0.52	0.64	--

[a] Spearman (r_s) and Pearson (r_p) correlation coefficients were used to describe food group and diet quality score analyses, respectively.
[b] Food groups were energy-adjusted according to the residual method.
[c] Servings/day (svg/d). Serving sizes were defined according to the *2000 Dietary Guidelines for Americans*, or for foods not covered by the guidelines, the FDA. Please refer to **Table 2.2.1** for all serving size definitions. In general, one serving was equivalent to ½ cup for most fruits and vegetables, 1 cup for most dairy, and 1 ounce for most meats and grains.
[d] Participants who completed fewer than five 24-hour dietary recalls were excluded from this analysis (n=17).
[e] Includes soy milk; almond milk or rice milk.
[f] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.
[g] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.9. Percent agreement between energy-adjusted[a] food groups estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire[b] and averaged 24-hour dietary recalls among participants in the CPS-3 Diet Validation Study (N=677) [c].

Food Group	White (n=417)					African American (n=159)					Hispanic (n=101)				
	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]
Fruits & Juices, total, svg/d	170 (40.8)	183 (43.9)	55 (13.2)	9 (2.20)	0.39	65 (40.9)	56 (35.2)	32 (20.1)	6 (3.80)	0.30	43 (42.6)	42 (41.6)	12 (11.9)	4 (4.00)	0.38
Whole Fruits, total (excluding juices), svg/d	193 (46.3)	164 (39.3)	48 (11.5)	12 (2.90)	0.43	67 (42.1)	61 (38.4)	28 (17.6)	3 (1.90)	0.36	45 (44.6)	42 (41.6)	12 (11.9)	2 (2.00)	0.43
Citrus Fruits (excluding juices), svg/d	164 (39.3)	177 (42.4)	63 (15.1)	13 (3.10)	0.34	55 (34.6)	61 (38.4)	36 (22.6)	7 (4.40)	0.22	31 (30.7)	43 (42.6)	18 (17.8)	9 (8.90)	0.16
Non-Citrus Fruits (excluding juices) , svg/d	179 (42.9)	178 (42.7)	48 (11.5)	12 (2.90)	0.40	64 (40.3)	63 (39.6)	29 (18.2)	3 (1.90)	0.34	39 (38.6)	46 (45.5)	12 (11.9)	4 (4.00)	0.35
Berries, svg/d	191 (45.8)	146 (35.0)	64 (15.3)	16 (3.80)	0.38	57 (35.8)	64 (40.3)	28 (17.6)	10 (6.30)	0.24	43 (42.6)	37 (36.6)	18 (17.8)	3 (3.00)	0.35
Fruit Juice, svg/d	159 (38.1)	144 (34.5)	93 (22.3)	21 (5.00)	0.24	58 (36.5)	71 (44.7)	21 (13.2)	9 (5.70)	0.29	35 (34.7)	41 (40.6)	18 (17.8)	7 (6.90)	0.22
Vegetables															
Starchy vegetables, svg/d	158 (37.9)	169 (40.5)	69 (16.5)	21 (5.00)	0.29	66 (41.5)	59 (37.1)	27 (17.0)	7 (4.40)	0.32	35 (34.7)	38 (37.6)	22 (21.8)	6 (5.90)	0.20
White/fried potatoes, svg/d	147 (35.3)	168 (40.3)	84 (20.1)	18 (4.30)	0.25	62 (39.0)	64 (40.3)	27 (17.0)	6 (3.80)	0.31	31 (30.7)	52 (51.5)	12 (11.9)	6 (5.90)	0.25
Non-starchy vegetables, svg/d	166 (39.8)	175 (42.0)	61 (14.6)	15 (3.60)	0.34	60 (37.7)	63 (39.6)	27 (17.0)	9 (5.70)	0.27	34 (33.7)	42 (41.6)	19 (18.8)	6 (5.90)	0.22
Tomato products, svg/d	146 (35.0)	167 (40.0)	81 (19.4)	23 (5.50)	0.24	58 (36.5)	63 (39.6)	31 (19.5)	7 (4.40)	0.26	27 (26.7)	47 (46.5)	18 (17.8)	9 (8.90)	0.13
Cruciferous vegetables, svg/d	153 (36.7)	172 (41.2)	76 (18.2)	16 (3.80)	0.29	67 (42.1)	59 (37.1)	26 (16.4)	7 (4.40)	0.33	36 (35.6)	44 (43.6)	17 (16.8)	4 (4.00)	0.28
Dark green vegetables, svg/d	168 (40.3)	166 (39.8)	67 (16.1)	16 (3.80)	0.33	60 (37.7)	63 (39.6)	31 (19.5)	5 (3.10)	0.29	39 (38.6)	42 (41.6)	16 (15.8)	4 (4.00)	0.32
Deep-yellow vegetables, svg/d	126 (30.2)	168 (40.3)	83 (19.9)	40 (9.60)	0.13	51 (32.1)	73 (45.9)	24 (15.1)	11 (6.90)	0.22	31 (30.7)	40 (39.6)	22 (21.8)	8 (7.90)	0.14
Legumes, svg/d	141 (33.8)	165 (39.6)	86 (20.6)	25 (6.00)	0.21	53 (33.3)	56 (35.2)	40 (25.2)	10 (6.30)	0.16	34 (33.7)	31 (30.7)	29 (28.7)	7 (6.90)	0.13
Garlic, fresh, svg/d	130 (31.2)	157 (37.6)	101 (24.2)	29 (7.00)	0.14	58 (36.5)	64 (40.3)	29 (18.2)	8 (5.00)	0.26	29 (28.7)	34 (33.7)	28 (27.7)	10 (9.90)	0.05

Food Group	White (n=417)					African American (n=159)					Hispanic (n=101)				
	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]
Vegetable juice, svg/d	178 (42.7)	141 (33.8)	62 (14.9)	36 (8.60)	0.28	51 (32.1)	57 (35.8)	32 (20.1)	19 (11.9)	0.10	32 (31.7)	40 (39.6)	18 (17.8)	11 (10.9)	0.13
Meats, Dairy, & Alternatives															
Dairy, total, svg/d	186 (44.6)	179 (42.9)	41 (9.80)	11 (2.60)	0.44	55 (34.6)	71 (44.7)	26 (16.4)	7 (4.40)	0.27	48 (47.5)	38 (37.6)	11 (10.9)	4 (4.00)	0.43
Dairy, low-fat, svg/d	182 (43.6)	167 (40.0)	55 (13.2)	13 (3.10)	0.39	61 (38.4)	61 (38.4)	28 (17.6)	9 (5.70)	0.27	51 (50.5)	37 (36.6)	8 (7.90)	5 (5.00)	0.46
Dairy, regular, svg/d	130 (31.2)	187 (44.8)	85 (20.4)	15 (3.60)	0.23	49 (30.8)	71 (44.7)	26 (16.4)	13 (8.20)	0.18	37 (36.6)	39 (38.6)	18 (17.8)	7 (6.90)	0.24
Yogurt, total, svg/d	191 (45.8)	175 (42.0)	44 (10.6)	7 (1.70)	0.45	66 (41.5)	61 (38.4)	27 (17.0)	5 (3.10)	0.34	36 (35.6)	45 (44.6)	17 (16.8)	3 (3.00)	0.30
Yogurt, low-fat, svg/d	190 (45.6)	150 (36.0)	60 (14.4)	17 (4.10)	0.38	59 (37.1)	64 (40.3)	30 (18.9)	6 (3.80)	0.28	37 (36.6)	32 (31.7)	28 (27.7)	4 (4.00)	0.20
Yogurt, regular, svg/d	139 (33.3)	156 (37.4)	88 (21.1)	34 (8.20)	0.17	47 (29.6)	58 (36.5)	32 (20.1)	22 (13.8)	0.05	29 (28.7)	42 (41.6)	14 (13.9)	16 (15.8)	0.06
Cheese, low-fat, svg/d	96 (23.0)	181 (43.4)	97 (23.3)	43 (10.3)	0.03	35 (22.0)	63 (39.6)	42 (26.4)	19 (11.9)	-0.03	29 (28.7)	45 (44.6)	18 (17.8)	9 (8.90)	0.14
Cheese, regular, svg/d	171 (41.0)	157 (37.6)	70 (16.8)	19 (4.60)	0.32	66 (41.5)	58 (36.5)	29 (18.2)	6 (3.80)	0.32	37 (36.6)	39 (38.6)	20 (19.8)	5 (5.00)	0.25
Milk, low-fat, svg/d	205 (49.2)	173 (41.5)	32 (7.70)	7 (1.70)	0.50	64 (40.3)	68 (42.8)	19 (11.9)	8 (5.00)	0.34	52 (51.5)	40 (39.6)	7 (6.90)	2 (2.00)	0.52
Frozen Dairy Dessert, svg/d	140 (33.6)	181 (43.4)	77 (18.5)	19 (4.60)	0.25	56 (35.2)	51 (32.1)	41 (25.8)	11 (6.90)	0.16	22 (21.8)	52 (51.5)	21 (20.8)	6 (5.90)	0.11
Milk alternative[e], svg/d	191 (45.8)	143 (34.3)	61 (14.6)	22 (5.30)	0.36	66 (41.5)	65 (40.9)	27 (17.0)	1 (0.60)	0.38	45 (44.6)	45 (44.6)	10 (9.90)	1 (1.00)	0.46
Soy products[f], svg/d	167 (40.0)	148 (35.5)	76 (18.2)	26 (6.20)	0.27	51 (32.1)	63 (39.6)	34 (21.4)	11 (6.90)	0.17	40 (39.6)	32 (31.7)	23 (22.8)	6 (5.90)	0.24
Eggs, svg/d	179 (42.9)	173 (41.5)	54 (12.9)	11 (2.60)	0.40	67 (42.1)	60 (37.7)	24 (15.1)	8 (5.00)	0.33	36 (35.6)	49 (48.5)	15 (14.9)	1 (1.00)	0.35
Poultry, svg/d	159 (38.1)	166 (39.8)	70 (16.8)	22 (5.30)	0.29	56 (35.2)	70 (44.0)	27 (17.0)	6 (3.80)	0.28	46 (45.5)	30 (29.7)	17 (16.8)	8 (7.90)	0.30
Red meat, svg/d	153 (36.7)	162 (38.8)	88 (21.1)	14 (3.40)	0.27	69 (43.4)	57 (35.8)	28 (17.6)	5 (3.10)	0.35	40 (39.6)	46 (45.5)	13 (12.9)	2 (2.00)	0.38
Processed Meat, Total, svg/d	161 (38.6)	181 (43.4)	62 (14.9)	13 (3.10)	0.34	68 (42.8)	57 (35.8)	31 (19.5)	3 (1.90)	0.35	42 (41.6)	42 (41.6)	13 (12.9)	4 (4.00)	0.36
Red processed meat, svg/d	165 (39.6)	169 (40.5)	64 (15.3)	19 (4.60)	0.32	67 (42.1)	69 (43.4)	20 (12.6)	3 (1.90)	0.40	39 (38.6)	44 (43.6)	18 (17.8)		0.36
White processed meat, svg/d	143 (34.3)	168 (40.3)	84 (20.1)	22 (5.30)	0.23	59 (37.1)	63 (39.6)	24 (15.1)	13 (8.20)	0.24	32 (31.7)	39 (38.6)	21 (20.8)	9 (8.90)	0.14

Food Group	White (n=417) Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ^d	African American (n=159) Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ^d	Hispanic (n=101) Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ^d
Total seafood, svg/d	143 (34.3)	182 (43.6)	72 (17.3)	20 (4.80)	0.26	68 (42.8)	60 (37.7)	19 (11.9)	12 (7.50)	0.32	38 (37.6)	38 (37.6)	21 (20.8)	4 (4.00)	0.27
Light meat seafood, svg/d	123 (29.5)	178 (42.7)	88 (21.1)	28 (6.70)	0.16	45 (28.3)	67 (42.1)	32 (20.1)	15 (9.40)	0.11	33 (32.7)	41 (40.6)	20 (19.8)	7 (6.90)	0.19
Dark meat seafood, svg/d	148 (35.5)	168 (40.3)	81 (19.4)	20 (4.80)	0.25	55 (34.6)	63 (39.6)	30 (18.9)	11 (6.90)	0.21	33 (32.7)	42 (41.6)	20 (19.8)	6 (5.90)	0.20
Nuts and seeds, svg/d	196 (47.0)	146 (35.0)	63 (15.1)	12 (2.90)	0.41	66 (41.5)	68 (42.8)	23 (14.5)	2 (1.30)	0.39	37 (36.6)	47 (46.5)	16 (15.8)	1 (1.00)	0.35
Nut and seed butters, svg/d	158 (37.9)	157 (37.6)	81 (19.4)	21 (5.00)	0.27	51 (32.1)	63 (39.6)	34 (21.4)	11 (6.90)	0.17	33 (32.7)	37 (36.6)	26 (25.7)	5 (5.00)	0.17
Grains, total, svg/d	159 (38.1)	180 (43.2)	66 (15.8)	12 (2.90)	0.33	64 (40.3)	50 (31.4)	29 (18.2)	16 (10.1)	0.21	37 (36.6)	48 (47.5)	14 (13.9)	2 (2.00)	0.35
Whole grains, svg/d	178 (42.7)	179 (42.9)	47 (11.3)	13 (3.10)	0.40	77 (48.4)	52 (32.7)	26 (16.4)	4 (2.50)	0.41	47 (46.5)	44 (43.6)	6 (5.90)	4 (4.00)	0.46
Refined grains, svg/d	150 (36.0)	172 (41.2)	77 (18.5)	18 (4.30)	0.27	63 (39.6)	53 (33.3)	34 (21.4)	9 (5.70)	0.25	41 (40.6)	40 (39.6)	18 (17.8)	2 (2.00)	0.35
Cold Cereal, svg/d	201 (48.2)	169 (40.5)	42 (10.1)	5 (1.20)	0.27	62 (39.0)	74 (46.5)	19 (11.9)	4 (2.50)	0.37	40 (39.6)	40 (39.6)	17 (16.8)	4 (4.00)	0.32
Hot Cereal, svg/d	154 (36.9)	173 (41.5)	79 (18.9)	11 (2.60)	0.30	63 (39.6)	73 (45.9)	20 (12.6)	3 (1.90)	0.38	44 (43.6)	40 (39.6)	13 (12.9)	4 (4.00)	0.38
Bread, svg/d	160 (38.4)	160 (38.4)	73 (17.5)	24 (5.80)	0.27	55 (34.6)	65 (40.9)	28 (17.6)	11 (6.90)	0.22	37 (36.6)	29 (28.7)	30 (29.7)	5 (5.00)	0.17
Pasta, svg/d	130 (31.2)	169 (40.5)	91 (21.8)	27 (6.50)	0.17	55 (34.6)	65 (40.9)	32 (20.1)	7 (4.40)	0.24	27 (26.7)	34 (33.7)	34 (33.7)	6 (5.90)	0.05
Crackers, svg/d	135 (32.4)	168 (40.3)	82 (19.7)	32 (7.70)	0.18	50 (31.4)	56 (35.2)	37 (23.3)	16 (10.1)	0.10	45 (44.6)	29 (28.7)	16 (15.8)	11 (10.9)	0.25
Snack bars, svg/d	164 (39.3)	172 (41.2)	69 (16.5)	12 (2.90)	0.34	56 (35.2)	59 (37.1)	39 (24.5)	5 (3.10)	0.23	45 (44.6)	38 (37.6)	18 (17.8)		0.41
Miscellaneous															
Baked goods, svg/d	153 (36.7)	167 (40.0)	90 (21.6)	7 (1.70)	0.29	54 (34.0)	69 (43.4)	25 (15.7)	11 (6.90)	0.23	37 (36.6)	37 (36.6)	18 (17.8)	9 (8.90)	0.20
Snack Chips, svg/d	168 (40.3)	160 (38.4)	67 (16.1)	22 (5.30)	0.31	53 (33.3)	80 (50.3)	22 (13.8)	4 (2.50)	0.31	40 (39.6)	40 (39.6)	17 (16.8)	4 (4.00)	0.32
Chocolate candy, svg/d	146 (35.0)	176 (42.2)	83 (19.9)	12 (2.90)	0.27	38 (23.9)	66 (41.5)	43 (27.0)	12 (7.50)	0.05	31 (30.7)	40 (39.6)	24 (23.8)	6 (5.90)	0.16
Beverages															
Sugar sweetened beverages, svg/d	151 (36.2)	162 (38.8)	82 (19.7)	22 (5.30)	0.25	58 (36.5)	72 (45.3)	17 (10.7)	12 (7.50)	0.28	34 (33.7)	44 (43.6)	19 (18.8)	4 (4.00)	0.25
Coffee, total, svg/d	248 (59.5)	154 (36.9)	15 (3.60)		0.65	88 (55.3)	67 (42.1)	3 (1.90)	1 (0.60)	0.62	59 (58.4)	31 (30.7)	10 (9.90)	1 (1.00)	0.57
Decaffeinated coffee, svg/d	180 (43.2)	143 (34.3)	73 (17.5)	21 (5.00)	0.32	55 (34.6)	55 (34.6)	36 (22.6)	13 (8.20)	0.16	37 (36.6)	38 (37.6)	20 (19.8)	6 (5.90)	0.24

Food Group	White (n=417)					African American (n=159)					Hispanic (n=101)				
	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]	Exact	± 1 Quartile	± 2 Quartiles	± 3 Quartiles	κ[d]
Caffeinated coffee, svg/d	247 (59.2)	154 (36.9)	16 (3.80)		0.64	92 (57.9)	56 (35.2)	9 (5.70)	2 (1.30)	0.60	51 (50.5)	42 (41.6)	6 (5.90)	2 (2.00)	0.52
Tea, total, svg/d	212 (50.8)	173 (41.5)	29 (7.00)	3 (0.70)	0.54	79 (49.7)	59 (37.1)	18 (11.3)	3 (1.90)	0.48	46 (45.5)	41 (40.6)	13 (12.9)	1 (1.00)	0.44
Decaffeinated tea, svg/d	154 (36.9)	162 (38.8)	75 (18.0)	26 (6.20)	0.25	54 (34.0)	56 (35.2)	43 (27.0)	6 (3.80)	0.19	38 (37.6)	35 (34.7)	21 (20.8)	7 (6.90)	0.22
Caffeinated tea, svg/d	193 (46.3)	168 (40.3)	46 (11.0)	10 (2.40)	0.44	69 (43.4)	67 (42.1)	18 (11.3)	5 (3.10)	0.40	46 (45.5)	38 (37.6)	13 (12.9)	4 (4.00)	0.40
Alcohol, total, svg/d	247 (59.2)	151 (36.2)	16 (3.80)	3 (0.70)	0.63	65 (40.9)	65 (40.9)	26 (16.4)	3 (1.90)	0.36	55 (54.5)	36 (35.6)	8 (7.90)	2 (2.00)	0.54
Beer, svg/d	164 (39.3)	188 (45.1)	51 (12.2)	14 (3.40)	0.36	58 (36.5)	57 (35.8)	33 (20.8)	11 (6.90)	0.21	52 (51.5)	35 (34.7)	13 (12.9)	1 (1.00)	0.49
Wine, total, svg/d	220 (52.8)	156 (37.4)	37 (8.90)	4 (1.00)	0.54	59 (37.1)	53 (33.3)	44 (27.7)	3 (1.90)	0.24	51 (50.5)	38 (37.6)	10 (9.90)	2 (2.00)	0.49
Wine, white, svg/d	164 (39.3)	170 (40.8)	65 (15.6)	18 (4.30)	0.32	50 (31.4)	61 (38.4)	37 (23.3)	11 (6.90)	0.15	38 (37.6)	37 (36.6)	21 (20.8)	5 (5.00)	0.25
Wine, red, svg/d	167 (40.0)	180 (43.2)	60 (14.4)	10 (2.40)	0.37	47 (29.6)	65 (40.9)	37 (23.3)	10 (6.30)	0.15	45 (44.6)	37 (36.6)	16 (15.8)	3 (3.00)	0.38

[a] Food groups were energy-adjusted according to the residual method.

[b] FFQ2

[c] Values are frequencies and row percentages except for the weighted Kappa coefficient.

[d] Weighted Kappa coefficient (κ).

[e] Includes soy milk; almond milk or rice milk.

[f] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.

Table 2.2.10. Energy[a] and age-adjusted beta coefficients from regression analyses of ln(dietary recall intake) on ln(food frequency questionnaire intake, same food group), among participants in the CPS-3 Diet Assessment Substudy (*n*=677) [b].

Food Group	Men	Women	White	African American	Hispanic
Fruits & Juices, total, svg/d	0.84 (0.09)	0.82 (0.07)	1.12 (0.08)	0.56 (0.10)	0.55 (0.09)
Whole Fruits, total (excluding juices), svg/d	0.87 (0.07)	0.88 (0.07)	0.96 (0.07)	0.66 (0.10)	0.91 (0.11)
Citrus Fruits (excluding juices), svg/d	0.54 (0.07)	0.61 (0.06)	0.67 (0.05)	0.41 (0.08)	0.43 (0.15)
Non-Citrus Fruits (excluding juices) , svg/d	0.85 (0.08)	0.86 (0.07)	0.94 (0.06)	0.67 (0.10)	0.85 (0.14)
Berries, svg/d	0.53 (0.06)	0.50 (0.05)	0.59 (0.05)	0.36 (0.07)	0.54 (0.09)
Fruit Juice, svg/d	0.45 (0.06)	0.39 (0.04)	0.44 (0.04)	0.40 (0.07)	0.32 (0.08)
Vegetables					
Starchy vegetables, svg/d	0.39 (0.09)	0.60 (0.08)	0.63 (0.08)	0.45 (0.11)	0.25 (0.14)
White/fried potatoes, svg/d	0.38 (0.09)	0.50 (0.06)	0.52 (0.06)	0.48 (0.09)	0.37 (0.12)
Non-starchy vegetables, svg/d	0.40 (0.05)	0.58 (0.04)	0.58 (0.04)	0.44 (0.07)	0.31 (0.08)
Tomato products, svg/d	0.28 (0.06)	0.45 (0.05)	0.37 (0.05)	0.41 (0.07)	0.26 (0.11)
Cruciferous vegetables, svg/d	0.64 (0.08)	0.61 (0.06)	0.58 (0.06)	0.77 (0.12)	0.54 (0.13)
Dark green vegetables, svg/d	0.72 (0.09)	0.77 (0.07)	0.85 (0.07)	0.51 (0.12)	0.66 (0.14)
Deep-yellow vegetables, svg/d	0.18 (0.07)	0.23 (0.05)	0.18 (0.05)	0.35 (0.09)	0.18 (0.09)
Legumes, svg/d	0.49 (0.09)	0.34 (0.06)	0.41 (0.06)	0.26 (0.11)	0.38 (0.16)
Garlic, fresh, svg/d	0.16 (0.05)	0.22 (0.03)	0.18 (0.04)	0.27 (0.05)	0.02 (0.08)
Vegetable juice, svg/d	0.51 (0.05)	0.22 (0.04)	0.46 (0.04)	0.25 (0.08)	0.13 (0.08)
Meats, Dairy, & Alternatives					
Dairy, total, svg/d	0.47 (0.04)	0.41 (0.03)	0.37 (0.03)	0.50 (0.05)	0.35 (0.05)
Dairy, low-fat, svg/d	0.36 (0.04)	0.32 (0.03)	0.33 (0.03)	0.28 (0.06)	0.33 (0.05)
Dairy, regular, svg/d	0.37 (0.05)	0.26 (0.03)	0.26 (0.04)	0.33 (0.06)	0.31 (0.08)
Yogurt, total, svg/d	0.62 (0.05)	0.62 (0.04)	0.64 (0.04)	0.55 (0.06)	0.54 (0.09)
Yogurt, low-fat, svg/d	0.47 (0.05)	0.43 (0.04)	0.46 (0.04)	0.44 (0.06)	0.32 (0.09)
Yogurt, regular, svg/d	0.20 (0.04)	0.11 (0.03)	0.19 (0.03)	0.05 (0.04)	0.16 (0.06)
Cheese, low-fat, svg/d	0.17 (0.10)	0.17 (0.06)	0.19 (0.06)	-.11 (0.12)	0.24 (0.13)
Cheese, regular, svg/d	0.42 (0.05)	0.35 (0.03)	0.34 (0.04)	0.41 (0.06)	0.33 (0.08)
Milk, low-fat, svg/d	0.64 (0.04)	0.51 (0.03)	0.59 (0.03)	0.43 (0.05)	0.53 (0.05)
Frozen Dairy Dessert, svg/d	0.32 (0.07)	0.39 (0.05)	0.44 (0.05)	0.19 (0.08)	0.31 (0.11)
Milk alternative[c], svg/d	0.66 (0.04)	0.57 (0.03)	0.64 (0.03)	0.59 (0.05)	0.53 (0.06)
Soy products[d], svg/d	0.46 (0.05)	0.39 (0.03)	0.43 (0.04)	0.41 (0.05)	0.35 (0.08)
Eggs, svg/d	0.70 (0.08)	0.68 (0.05)	0.71 (0.06)	0.61 (0.09)	0.69 (0.11)
Poultry, svg/d	0.68 (0.06)	0.69 (0.05)	0.78 (0.05)	0.49 (0.07)	0.60 (0.11)
Red meat, svg/d	0.59 (0.06)	0.58 (0.04)	0.62 (0.05)	0.52 (0.07)	0.67 (0.09)
Processed Meat, Total, svg/d	0.71 (0.05)	0.55 (0.04)	0.61 (0.04)	0.62 (0.06)	0.61 (0.10)

Food Group	Men	Women	White	African American	Hispanic
Red processed meat, svg/d	0.58 (0.05)	0.51 (0.04)	0.51 (0.04)	0.58 (0.06)	0.56 (0.07)
White processed meat, svg/d	0.31 (0.06)	0.38 (0.05)	0.33 (0.05)	0.39 (0.08)	0.35 (0.10)
Total seafood, svg/d	0.39 (0.08)	0.53 (0.06)	0.48 (0.06)	0.50 (0.10)	0.41 (0.11)
Light meat seafood, svg/d	0.09 (0.05)	0.17 (0.03)	0.11 (0.04)	0.18 (0.07)	0.17 (0.06)
Dark meat seafood, svg/d	0.28 (0.05)	0.38 (0.04)	0.36 (0.04)	0.28 (0.07)	0.35 (0.08)
Nuts and seeds, svg/d	0.77 (0.08)	0.65 (0.06)	0.70 (0.06)	0.72 (0.10)	0.67 (0.14)
Nut and seed butters, svg/d	0.57 (0.07)	0.42 (0.05)	0.50 (0.06)	0.38 (0.08)	0.42 (0.12)
Grains, total, svg/d	0.31 (0.05)	0.46 (0.03)	0.56 (0.03)	0.41 (0.08)	0.25 (0.05)
Whole grains, svg/d	0.74 (0.08)	0.71 (0.07)	0.72 (0.06)	0.93 (0.15)	0.64 (0.16)
Refined grains, svg/d	0.33 (0.05)	0.33 (0.03)	0.36 (0.03)	0.38 (0.07)	0.34 (0.05)
Cold Cereal, svg/d	0.69 (0.06)	0.64 (0.04)	0.72 (0.04)	0.63 (0.07)	0.52 (0.09)
Hot Cereal, svg/d	0.47 (0.05)	0.53 (0.04)	0.50 (0.04)	0.58 (0.07)	0.43 (0.08)
Bread, svg/d	0.14 (0.05)	0.48 (0.04)	0.49 (0.04)	0.38 (0.07)	0.29 (0.08)
Pasta, svg/d	0.37 (0.09)	0.44 (0.06)	0.42 (0.07)	0.43 (0.09)	0.39 (0.13)
Crackers, svg/d	0.34 (0.07)	0.36 (0.06)	0.37 (0.06)	0.21 (0.10)	0.43 (0.11)
Snack bars, svg/d	0.61 (0.05)	0.53 (0.04)	0.54 (0.04)	0.51 (0.06)	0.67 (0.08)
Miscellaneous					
Baked goods, svg/d	0.32 (0.07)	0.46 (0.05)	0.44 (0.05)	0.41 (0.09)	0.26 (0.10)
Snack Chips, svg/d	0.61 (0.08)	0.58 (0.06)	0.55 (0.06)	0.62 (0.09)	0.59 (0.13)
Chocolate candy, svg/d	0.39 (0.06)	0.40 (0.05)	0.46 (0.05)	0.14 (0.08)	0.39 (0.10)
Beverages					
Sugar sweetened beverages, svg/d	0.36 (0.06)	0.33 (0.05)	0.34 (0.05)	0.31 (0.08)	0.39 (0.10)
Coffee, total, svg/d	0.92 (0.03)	0.93 (0.02)	0.95 (0.02)	0.88 (0.04)	0.91 (0.07)
Decaffeinated coffee, svg/d	0.84 (0.04)	0.74 (0.04)	0.85 (0.03)	0.58 (0.06)	0.74 (0.06)
Caffeinated coffee, svg/d	0.92 (0.03)	0.88 (0.02)	0.94 (0.02)	0.84 (0.05)	0.79 (0.07)
Tea, total, svg/d	0.76 (0.05)	0.73 (0.04)	0.78 (0.04)	0.70 (0.08)	0.67 (0.09)
Decaffeinated tea, svg/d	0.41 (0.05)	0.44 (0.04)	0.47 (0.04)	0.40 (0.06)	0.41 (0.08)
Caffeinated tea, svg/d	0.75 (0.05)	0.63 (0.04)	0.72 (0.04)	0.60 (0.08)	0.57 (0.09)
Alcohol, total, svg/d	0.84 (0.05)	0.82 (0.03)	0.86 (0.03)	0.69 (0.06)	0.76 (0.08)
Beer, svg/d	0.73 (0.05)	0.61 (0.04)	0.67 (0.04)	0.60 (0.05)	0.72 (0.07)
Wine, total, svg/d	0.79 (0.05)	0.77 (0.04)	0.82 (0.03)	0.59 (0.06)	0.73 (0.08)
Wine, white, svg/d	0.66 (0.06)	0.69 (0.04)	0.72 (0.04)	0.53 (0.06)	0.59 (0.10)
Wine, red, svg/d	0.77 (0.05)	0.72 (0.04)	0.80 (0.04)	0.44 (0.06)	0.74 (0.08)
Median	0.51	0.51	0.54	0.44	0.43
ACS Diet Quality Score[e]	0.75 (0.05)	0.65 (0.04)	0.66 (0.04)	0.79 (0.06)	0.68 (0.08)

[a] Food groups were energy-adjusted according to the residual method.

[b] Values are beta coefficients and standard errors unless otherwise specified.
[c] Includes soy milk; almond milk or rice milk.
[d] Includes soy beans/edamame or soy nuts; tofu or tofu burgers; fermented soy, tempeh, miso; soy milk.
[e] Refer to **Table 2.2.2** and methods for additional details on score calculation.

Table 2.2.11. Cross-classification of a diet quality score[a] in concordance with the *American Cancer Society's Dietary Guidelines for Cancer Prevention* estimated by the Cancer Prevention Study-3 (CPS-3) food frequency questionnaire and the mean of the 24-hour dietary recalls among participants in the CPS-3 Diet Validation Study (*n*=677) [b].

Diet Quality Score from Dietary Recalls	White (*n*=411)			African American (*n*=158)			Hispanic (*n*=101)		
	Diet Quality Score from CPS-3 FFQ			Diet Quality Score from CPS-3 FFQ			Diet Quality Score from CPS-3 FFQ		
	0-2	3-5	6-9	0-2	3-5	6-9	0-2	3-5	6-9
0-2	26 (6.2)	38 (9.1)	4 (1.0)	12 (7.6)	29 (18.2)	3 (1.9)	6 (5.9)	8 (7.9)	1 (1.0)
3-5	30 (7.2)	117 (28.1)	46 (11.0)	7 (4.4)	34 (21.4)	23 (14.5)	6 (5.9)	26 (25.7)	13 (12.9)
6-9	5 (1.2)	49 (11.8)	102 (24.5)	0 (0.0)	12 (7.6)	39 (24.5)	1 (1.0)	13 (12.9)	27 (26.7)
Weighted Kappa	0.40			0.39			0.40		

[a] Refer to Supplemental Table S2 and methods for additional details.
[b] Values are frequencies (percentages) except for the weighted Kappa coefficient.

Chapter 3 − Post-diagnosis body mass index, weight change, and mortality due to prostate cancer, cardiovascular disease, and all causes among non-metastatic prostate cancer survivors in a large US cohort

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Abstract

PURPOSE: To investigate the association of post-diagnosis body mass index (BMI) and weight change with prostate cancer-specific mortality (PCSM), cardiovascular disease-related mortality (CVDM), and all-cause mortality among non-metastatic prostate cancer survivors.

METHODS: Men in the Cancer Prevention Study-II Nutrition Cohort diagnosed with non-metastatic prostate cancer between 1992 and 2013 were followed for mortality through December 2016. Current weight was self-reported on follow-up questionnaires approximately every two years. Post-diagnosis BMI was obtained from the first survey completed 1-<6 years post-diagnosis. Weight change was the difference in weight between the first and second post-diagnosis surveys. Deaths occurring within 4-years of the follow-up were excluded to reduce bias from reverse causation. Analyses of BMI and weight change included 8,330 and 6,942 participants, respectively.

RESULTS: Post-diagnosis BMI analyses included 3,855 deaths from all causes (500 PCSM, 1,155 CVDM). Using Cox proportional hazards models, hazard ratios (HR) associated with post-diagnosis obesity (BMI $\geq$30 kg/m^2) compared to healthy weight (BMI 18.5-<25.0 kg/m^2) were 1.28 for PCSM (95% confidence interval (95%CI): 0.97, 1.69), 1.24 for CVDM (95%CI: 1.03, 1.49), and 1.23 for all-cause mortality (95%CI: 1.11, 1.36). Weight gain analyses included 2,973 deaths (375 PCSM, 881 CVDM). Post-diagnosis weight gain (>5% of body weight), compared with stable weight (± <3%), was associated with a higher risk of PCSM (HR=1.64, 95%CI: 1.20, 2.24) and all-cause mortality (HR=1.27, 95%CI: 1.11, 1.44), but not CVDM.

CONCLUSION: Results suggest that among non-metastatic prostate cancer survivors with largely localized disease, post-diagnosis obesity is associated with higher CVDM and all-cause mortality, and possibly higher PCSM, and that post-diagnosis weight gain may be associated with a higher mortality due to all causes and prostate cancer.

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Introduction

In the United States (US), prostate cancer is the most commonly diagnosed cancer among men(1), and prostate cancer survivors may continue to experience excess mortality for up to 15-years post-diagnosis(5). Current evidence supports the link between obesity and risk of advanced prostate cancer(59), potentially through alterations in hormones, adipocytes, and inflammatory factors(60,61). As these factors are also implicated in tumor progression pathways, it is important to understand the potential consequences of obesity and weight gain on long-term survival after a prostate cancer diagnosis.

Some previous studies(62–67), though not all(68), suggest that obesity measured before or during the first year after a prostate cancer diagnosis may be associated with higher prostate cancer-specific mortality (PCSM). However, survivors cannot change pre-diagnosis behaviors and the initial hardships of a cancer diagnosis and primary treatment may influence body weight(10) and make efforts towards modifying weight around the time of diagnosis difficult. *Post-diagnosis* (defined here as >12-months after cancer diagnosis) obesity and weight change, may be more easily modified and relevant to inform recommendations for cancer survivors.

Only two previous studies investigated post-diagnosis body mass index (BMI) or weight gain on mortality among prostate cancer survivors, findings from which are conflicting(62,69). Therefore, the goals of this study were to investigate associations of post-diagnosis BMI and weight change with cause-specific and all-cause mortality among men diagnosed with non-metastatic prostate cancer.

Methods

Study Population

Among 86,402 male participants in the Cancer Prevention Study (CPS)-II Nutrition Cohort, we identified 11,788 incident prostate cancer cases diagnosed between 1992/1993 and 2013. The CPS-II Nutrition Cohort is a prospective study of cancer incidence and mortality, initiated in 1992/1993, that enrolled participants from 21 US states and is a subgroup of the larger CPS-II mortality cohort initiated in 1982 by the American Cancer Society(70). At baseline, a 10-page survey was mailed to all CPS-II Nutrition Cohort participants to collect information on demographics, medical conditions, lifestyle, and other factors. Follow-up surveys were sent to participants in 1997 and every two years thereafter to ascertain newly diagnosed cancers. All aspects of the CPS-II Nutrition Cohort are reviewed and approved by the Emory University Institutional Review Board.

Most prostate cancer cases were self-reported and subsequently verified through medical records (93.8%) or linkage with state cancer registries (6.1%). Additional cases were identified during the process of verifying another cancer (n=5). Two analytic cohorts, post-diagnosis BMI (n=8,330) and weight change (n=6,942) cohorts, were constructed to maximize sample size, as fewer men completed two post-diagnosis surveys. Men were excluded based on the criteria shown in **Figure 3.1**. To minimize reverse causation bias (i.e., preexisting disease leading to both weight loss and mortality), person-time and deaths occurring within 4-years of completing the post-diagnosis surveys were excluded from all analyses, similar to previous studies(71–73). A comparison of eligible participants included and excluded in analyses is described in the **Supplemental Text** and results presented in **Table 3.2.1**.

Assessment of BMI and Weight Change

Post-diagnosis BMI (kg/m^2) was based on height from the 1982 baseline survey in the original CPS-II cohort and weight from the first questionnaire completed 1-<6 years after diagnosis, and categorized as healthy weight (18.5-<25, referent group), overweight (25-<30), and obese (≥30). Weight change was the difference between post-diagnosis weight, and the weight reported on the next biennial survey. For participants who did not return the next biennial survey or did not report their weight (5%), we calculated weight change based on weight reported on the earliest subsequent biennial survey (up to four surveys after). Relative weight change was calculated as, $\left(\frac{weight_{2nd\ post-diagnosis\ survey} - weight_{1st\ post-diagnosis\ survey}}{weight_{1st\ post-diagnosis\ survey}}\right) \times 100\%$, and categorized as moderate gain (≥5%), small gain (3-<5%), maintenance (±<3%), small loss (3-<5%), and moderate loss (≥5%), according to expert recommendation(74). We also calculated absolute weight change (lbs.) and categorized as follows: gain ≥10, gain 5-<10, maintenance ±<5, loss 5-<10, loss ≥10.

Assessment of Outcomes

The primary outcome of interest was PCSM, defined as deaths for which the underlying cause was listed as prostate cancer, according to International Classification of Diseases (ICD) codes (ICD-9: 185; ICD-10: C61). Secondary outcomes of interest included CVDM (ICD-9: 390-459; ICD-10: I00-I99) and deaths due to all causes. Vital status, cause, and date of death were ascertained through linkage with the National Death Index, updated through December 31, 2016.

Statistical Analyses

Cumulative incidence functions(75) for PCSM, CVDM, and all-cause mortality were produced within strata of post-diagnosis BMI and relative weight change. Cox proportional hazards regression models were used to produce cause-specific hazard ratios (HR) and 95% confidence intervals (95%CI) to estimate associations of post-diagnosis BMI and weight change on mortality outcomes.

To mitigate the potential for bias due to reverse causation, follow-up started 4-years after completing the first post-diagnosis survey in BMI analyses and 4-years after completing the 2nd post-diagnosis survey in weight change analyses using delayed-entry models. For all analyses, follow-up ended on the death date or December 31, 2016, whichever came first.

Post-diagnosis BMI multivariable models controlled for age, education, smoking status, physical activity, American Joint Committee on Cancer primary tumor (T) category, Gleason score, initial treatment, and year of diagnosis. Post-diagnosis weight change models additionally adjusted for the first post-diagnosis BMI. All models adjusted for age by stratifying on single year of age at diagnosis. We used multiple imputation procedures to address missing covariate data (see **Supplemental Text**).

For post-diagnosis BMI analyses, we considered an interaction with risk of disease progression category based on the National Comprehensive Cancer Network (NCCN) guidelines, with T1-T2 tumors that have Gleason scores $\leq$7 classified as lower-risk tumors (NCCN low and intermediate risk groups), and T3-T4 tumors or tumors with Gleason scores $\geq$8 classified as high-risk tumors(76). We were unable to consider interactions with weight change due to the limited prostate cancer deaths within strata.

We conducted supplemental analyses to address concerns regarding: 1) competing causes of death (e.g., non-prostate cancer deaths in PCSM models); 2) the effects of hormone therapy on weight; 3) overcompensation for reverse causation through our exclusion of follow-up within four years of survey completion; and 4) the influence of pre-diagnosis BMI on outcomes. Please see **Supplemental Text** for additional details on all supplemental analyses, covariates, and imputation procedures.

Statistical analyses were performed using SAS (version 9.4, Cary, NC) and R (version 3.5.3, Vienna, Austria) software.

Results

Participant characteristics are presented by post-diagnosis BMI (**Table 3.1.1)** and weight change category (**Table 3.2.2**). In our post-diagnosis BMI cohort, ~36% of men were healthy weight, 49% overweight, and 16% obese. Obese men were less likely to have graduated from college or engage in physical activity than healthy weight men.

We observed 3,855 deaths in post-diagnosis BMI analyses and 2,973 deaths in weight change analyses (500 and 375 PCSM, respectively). In the post-diagnosis BMI cohort, the median time from diagnosis to survey completion was 2.2 years (IQR=1.2). In the weight change cohort, the median time from diagnosis to completion of the 1st post-diagnosis survey was 2.2 years (IQR=1.2) and the 2nd post-diagnosis survey was completed a median of 2.0 years (IQR=0.2) after the 1st post-diagnosis survey. The median follow-up time was 7.3 years (IQR=7.7) and 5.7 years (IQR=6.1) in post-diagnosis BMI and weight change cohorts, respectively.

Graphs depicting the cumulative incidence of PCSM, CVDM, and all-cause mortality over time within strata of post-diagnosis BMI and weight change are shown in **Figures 3.2-3.4**; corresponding estimates in **Table 3.2.3** and **3.2.4**.

Post-diagnosis BMI

Results from multivariable cause-specific models examining associations of post-diagnosis BMI with all mortality outcomes are presented overall and by risk of disease progression category in **Table 3.1.2**. Overall, compared to healthy weight men, obese men had a higher but non-significant hazard of PCSM (HR=1.28, 95%CI: 0.97, 1.69) and a higher hazard of CVDM (HR=1.24, 95%CI: 1.03, 1.49) and all-cause mortality (HR=1.23, 95%CI: 1.11, 1.36). Overweight men had a higher hazard of PCSM (HR=1.23. 95%CI: 1.00, 1.51), but not CVDM or all-cause mortality. The association of BMI with mortality outcomes appeared somewhat stronger among those diagnosed with lower-risk tumors, particularly for PCSM, although the interaction between risk category and continuous BMI was not statistically significant (p=0.63). For example, post-diagnosis obesity was associated with a higher hazard of PCSM among men diagnosed with lower-risk tumors (HR=1.59, 95%CI: 1.13, 2.23) but not high-risk tumors (HR=1.02, 95%CI: 0.65, 1.60).

Weight Change

Results from multivariable cause-specific models of the association of weight change with mortality outcomes are presented in **Table 3.1.3**. Compared to men who maintained their post-diagnosis weight, men who gained >5% had a higher hazard of PCSM (HR=1.64, 95%CI: 1.20, 2.24), whereas all other weight change categories had similar hazards. The hazard of all-cause mortality was higher among men who gained >5% (HR=1.27, 95%CI: 1.11, 1.44), lost 3-5% (HR=1.15, 95%CI: 1.02, 1.31), and lost >5% (HR=1.30, 95%CI: 1.16, 1.46), but not among men who gained 3-5%. No associations between weight change and CVDM were observed. Models examining absolute weight change yielded similar results.

Supplemental Analyses

Supplemental analyses accounting for the influence of other causes of death on PCSM and CVDM yielded similar results to primary analyses (**Table 3.2.5).** Results were similar after excluding men initially treated with hormone therapy, except that associations of obesity and weight gain with PCSM were somewhat stronger, though less precise due to smaller sample size (**Table 3.2.6).** After excluding follow-up occurring within two years of survey completion, results were similar except that associations of weight loss with CVDM and all-cause mortality were stronger, suggesting presence of reverse causation bias (**Table 3.2.7)**. Compared to men who maintained a healthy weight both pre- and post-diagnosis, men who were obese at both time points had a higher hazard of CVDM and all-cause mortality but not PCSM (**Table 3.2.8)**. A higher hazard of PCSM was observed among men with a combined pre-/post-diagnosis BMI category of overweight/obese (HR=1.69, 95%CI: 1.12, 2.57). See **Supplemental Text** for additional details and further discussion of results.

Discussion

In this large cohort study of US men diagnosed with non-metastatic prostate cancer, which was localized in the vast majority, we found that post-diagnosis obesity was associated with a higher hazard of mortality due to all causes and CVDM, and possibly an elevated hazard of PCSM, though the latter was statistically non-significant. In addition, we found higher overall mortality and PCSM among men who gained a modest-to-high amount of weight during the interval between their first post-diagnosis questionnaire, typically two years after diagnosis, and their second post-diagnosis questionnaire, typically four years after diagnosis.

Our observation of a higher overall mortality and marginally higher hazard of PCSM, though it included the null, among post-diagnosis obese men, is in contrast to the only previous study that examined BMI ≥1-year after prostate cancer diagnosis and survival(69). Farris and colleagues found that among 829 Canadian prostate cancer survivors, obesity, assessed ~2-3 years post-diagnosis, was not associated with PCSM or all-cause mortality(69). The observed higher hazard of PCSM among post-diagnosis obese prostate cancer survivors in our study was not statistically significant and inconsistent across analyses, and could be due to chance. However, obesity is an accepted risk factor for all-cause mortality in the general population(77), though there is some debate on whether this association attenuates with age(78), and there are several possible explanations for the null findings by Farris et al. including: 1) limited statistical power; 2) inclusion of men diagnosed with higher-risk tumors (all were diagnosed ≥ T2 cancers), a subgroup in which we observed no association with PCSM, potentially due to selection bias (see **Supplemental Text** for further discussion); and 3) bias due to reverse causation through inclusion of metastatic cases.

Several other studies examined the association of BMI, measured <1-year of prostate cancer diagnosis, with survival and largely suggest obesity is associated with higher PCSM and all-cause mortality (62–65,68,79,80). The largest of these studies, conducted by Chalfin et al. among 11,152 men (245 PCSM) who underwent radical prostatectomies at a single tertiary referral center, had similar findings to our study(63). The remaining studies were mostly conducted in clinical populations, with sample sizes ranging from 945 to 7,274 (61-220 prostate cancer deaths), and most(62,64,65,79), though not all(68,80), suggested a positive relationship between obesity and PCSM. The link between obesity and PCSM is further supported by evidence suggesting obesity may be associated with an increased risk of biochemical recurrence(81), which often precedes PCSM, though there is some debate on whether residual confounding by disease severity could account for positive results(82).

In our study, men who experienced modest-to-high weight gain (>5% of their body weight or >10 lbs.) after a prostate cancer diagnosis were more likely to die from prostate cancer and all-causes than men who maintained their weight. Similarly, Bonn and colleagues found prostate cancer survivors who gained >5% of their weight (from diagnosis to a median of 7.3 years later) were almost twice as likely to die from prostate cancer and somewhat more likely, to die from all causes, thought the latter was not statistically significant(62). However, estimates were imprecise due to few deaths (n=96 PCSM) and were based on retrospective report of weight change. In contrast, Farris and colleagues(69) observed no association between weight gain ≥2.6 lbs. (from diagnosis to 2-3 years post-diagnosis) with PCSM, but did not report the potential effects of greater amounts of weight gain, as was done in the present study. Two previous studies reported no relationship between pre-diagnosis adult weight gain and lethal prostate cancer(69,83), although one reported positive findings among never smokers(83). This is in contrast to our findings, and differences may be due to the extent of collider bias(12), the timing in which weight gain occurred, or residual confounding by smoking, disease severity, or treatment. In our study, we attempted to mitigate the potential for collider bias to influence weight change results by examining post-diagnosis weight change and controlling for the 1st post-diagnosis BMI measure (see **Figure 3.5, B**). Evidence suggesting that weight gain from pre-diagnosis to ~1-year post-diagnosis may be associated with an increased risk of prostate cancer recurrence(84) supports our current findings. Our findings regarding higher risk of all-cause mortality, but not PCSM, among men who lost weight are supported by similar previous studies(62,69). While weight loss could serve as a useful predictor, a causal interpretation should not be drawn as reverse causation due to underlying diseases likely biased the results.

Our findings should be considered in the context of our study limitations. First, despite efforts to reduce bias due to reverse causation through exclusion of follow-up ending within 4-years of completing the post-diagnosis surveys, this bias cannot be ruled out, though it is expected to bias results downwards and is unlikely to account for any positive findings. Also, while restricting the study population to those who survived at least 4-years after the post-diagnosis survey reduces the potential for reverse causation to bias results, it could induce selection bias in the presence of uncontrolled risk factors for the outcome(12). However, if our causal diagram is correct (**Figure 3.4, B**), this bias is unlikely to affect our weight change results, after controlling for the 1st post-diagnosis BMI measure. Third, BMI based on self-reported data may have been misclassified. Bias due to misclassification of BMI in this study is likely non-differential due to its prospective design and results are expected to be biased towards the null. Although BMI can be a poor proxy for excess body fatness, weight gain largely reflects an increase in body fat, given that height likely remains constant in our population. Most prostate cancer survivors included in our study were elderly and white; therefore, results may not be generalizable to a non-white or younger population. Also, we only had data on initial treatment and lacked details on completion dates and whether the patient received additional treatment, limiting our ability to better control for confounding. For example, if a patient received hormone therapy after initial treatment due to disease recurrence, they would have a higher risk of both dying and gaining weight, potentially biasing results. Further research will be needed to determine if there is an association between post-diagnosis weight gain and PCSM, independent of secondary treatments. Lastly, due to the deterministic relationship between BMI and weight change, it is difficult, if not impossible, to separate out their direct effects.

The current study has several noteworthy strengths. To our knowledge, our study was based on the largest number of prostate cancer deaths (n=500) to date and the first to examine post-diagnosis BMI and weight change with CVDM among prostate cancer survivors. Our study sample was selected from a longitudinal cohort that enabled us to examine weight change prospectively. Multiple imputation procedures were used to address missing data and we were able to consider lifestyle factors such as physical activity and smoking status. Finally, we conducted several sensitivity analyses indicating the associations of post-diagnosis obesity with CVDM and all-cause mortality as well as associations of weight gain with PCSM and all-cause mortality were robust to several assumptions.

Our results suggest that among non-metastatic prostate cancer survivors, post-diagnosis obesity may be associated with higher CVDM and all-cause mortality and that post-diagnosis weight gain may be associated with a higher mortality due to all causes and prostate cancer. Prostate cancer survivors are advised to maintain a healthy weight and avoid weight gain(4,85), and our findings provide additional evidence to follow these recommendations. This may be especially important given evidence that prostate cancer survivors may be more prone to weight gain compared to men in the general population(86). Our results do not support promotion of weight loss among prostate cancer survivors, although the observed positive association between weight loss and all-cause mortality is likely a result of underlying disease rather than a true causal relationship. Future studies are needed to determine whether intentional weight loss provides health benefits among overweight and obese prostate cancer survivors. Clinicians should be vigilant about identifying moderate weight loss or gain in prostate cancer survivors, as both have poor prognostic implications.

Supplemental Text

Comparison of eligible prostate cancer survivors included and excluded from analyses.

Of the 10,706 eligible cases identified, 2,376 (22%) were excluded from BMI analyses. We compared demographic and medical characteristics between eligible men who were excluded and included in analyses. Excluded men tended to be older, diagnosed with more aggressive tumors, and had higher BMIs compared to included men (**Table 3.2.1)**, this is not surprising as the majority (~62%) of men were excluded in efforts to reduce reverse causation bias. The exclusion of men with higher BMIs and those at higher risk of mortality is expected to bias results downwards.

Participants in the post-diagnosis BMI and weight change cohorts were mostly similar, except that participants in the weight change cohort tended to be diagnosed at younger ages and were more likely to be diagnosed in earlier years **(Table 3.1.1 and Table 3.2.2)**. This is expected, as younger men diagnosed in earlier years would be more likely to be able to complete at least two surveys > 12 months from diagnosis.

Covariates

Potential confounders were identified based on previous literature and a causal diagram and included: age at diagnosis (in years), race/ethnicity (white, other), education (<high school, high school graduate, some college, college graduate), tumor local extent (T1/T2, T3/T4), Gleason score (2-6, 7, 8-10, 5-7, 7-10), nodal involvement (yes, no), year of diagnosis (1992-1997, 1998-2002, 2003-2007, 2008-2012), initial treatment (surgery, radiation therapy, hormone therapy only, active surveillance), family history of prostate cancer (yes, no), smoking status (never, former, current), alcohol intake (none, <1 drink/day, 1+ drinks/day), physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17.5+ metabolic equivalent of task (MET-hour/week)), diet quality score (0-2, 3-5, 6-9), pre-diagnosis BMI (kg/m^2, weight change models only). Family history of prostate cancer, smoking status, alcohol, and physical activity were obtained from the post-diagnosis survey

Age at diagnosis (in years) was calculated based on self-reported birth date and the date of diagnosis obtained from medical records or state registries. Race/ethnicity and education level were self-reported by the participant at baseline.

Tumor local extent, nodal involvement, and Gleason score were obtained from abstracted medical records or state registries. A supplemental questionnaire on initial treatment was sent to participants who reported a cancer diagnosis on follow-up questionnaires and completed by 83.3% of cases in this cohort.

Data on recreational physical activity, alcohol use, smoking status, and family history of prostate cancer were self-reported at baseline and biennially beginning in 1999 (except for physical activity on the 2003 questionnaire). For recreational physical activity, a metabolic equivalent of task (MET) was assigned to each of the seven moderate-to-vigorous activities (cite compendium), multiplied by the number of hours per week spent for each activity, and summed across all activities to get the total MET hours per week (MET-h/wk). Based on the recommendation to engage in at least 150 minutes of moderate or 75 minutes of vigorous activity each week, which is equivalent to 8.75 MET-h/wk, we categorized physical activity into four groups.

Diet was assessed using a modified 68-item Block food frequency questionnaire (FFQ) in 1992 and using a modified 152-item Harvard FFQ in 1999 and 2003. Similar to previous publications(32), we calculated diet quality in accordance with ACS dietary guidelines for cancer prevention, with higher scores indicating greater concordance with dietary guidelines. Dietary data was not available post-diagnosis for approximately 49% of participants. Therefore, we compared estimates from models with and without diet among complete cases only to determine if diet was a substantial confounder.

Race, alcohol intake, involvement of local nodes, family history of prostate cancer, and diet were removed from models because they did not substantially change effect estimates (>10%).

Proportional hazard assumptions

Proportional hazard assumptions were assessed by comparing models with and without interactions with time via the likelihood ratio test. No violations were observed.

Multiple Imputations

Approximately 17% of participants did not return the supplemental questionnaire on initial cancer treatment, prompting the use of multiple imputation procedures (SAS PROC MI)(87). The supplemental questionnaire on initial cancer treatment was mailed separate from the routine biennial surveys, which may explain the high percentage of missing treatment data. All variables considered in all models, including statistical interactions between post-diagnosis BMI and tumor-risk category, were included in the imputation procedure to impute 10 datasets for each analytic cohort. We also included pre-diagnosis values for the following variables: family history of prostate cancer, smoking status, alcohol intake, and physical activity levels. Missing variables were imputed using the fully conditional specification algorithm for non-ordered categorical variables (88). Similar results were found when an indicator variable for missing treatment data was included in models, without the use of multiple imputation methods (results not shown).

Supplemental Analyses

Competing causes of death

Cox proportional hazard regression models censor competing causes of death at the time of death (e.g., non-prostate cancer deaths are censored at the time of death in prostate cancer-specific mortality (PCSM) models). Fine-Gray models are an alternative method that accounts for the presence of competing causes of deaths by including those who died due to competing causes in the risk set(89). Additional details regarding the two methods were published elsewhere, and current suggestions are to report both measures to aid interpretation(90,91). Therefore, we also used Fine-Gray models to produce subdistribution HRs (sdHR).

Supplemental analyses accounting for the influence of other causes of death on PCSM and cardiovascular disease-related mortality (CVDM) yielded similar results to primary analyses, albeit somewhat attenuated (**Table 3.2.5**).

Excluding men treated with hormone therapy

Due to the effects of hormone therapy on weight gain (10), we conducted a sensitivity analysis excluding men treated with hormone therapy (n=1,737) and men in which receipt of hormone therapy was unknown (n=1,298). Fewer than 10% of observations had missing covariates, therefore, we did not impute missing data and conducted analysis among cases with complete data only (n=4,853 in the BMI cohort and n=4,278 in the weight change cohort).

Results were largely comparable with our primary analyses, with some exceptions (**Table 3.2.6)**. First, all estimates were less precise due to smaller sample size and fewer deaths. Second, the associations of BMI and weight gain >5% with PCSM were stronger after excluding men on hormone therapy. Since hormone therapy is positively associated with weight gain and negatively associated with PCSM, residual confounding due to hormone therapy is expected to bias results from our primary analyses downwards, consistent with the results from this analysis.

Mitigating reverse causation using a 2-year lag

In primary analyses, person-time and deaths occurring within 4-years of completing the post-diagnosis surveys were excluded to minimize reverse causation bias (i.e., preexisting disease leading to both weight loss and mortality), similar to previous studies(71–73). However, it is possible that we overcompensated for this bias. Therefore, we conducted a sensitivity analysis excluding men with follow-up ending within 2-years of the first post-diagnosis survey, instead of 4-years, as in our primary analyses. Among the 10,706 eligible prostate cancer survivors, men were excluded for the following reasons: 1) no survey completed 1-<6 years of diagnosis (n=869); 2) follow-up ended within 2-years of the first post-diagnosis survey (n=506); 3) implausible BMI (n=49); and 4) BMI < 18.5 kg/m2 (n=7). Men were additionally excluded from the weight change cohort for the following reasons: 1) no second post-diagnosis survey completed (n=743); 2) follow-up ended within 2 years of the second post-diagnosis survey (n=528); 3) implausible second post-diagnosis BMI (n=14); 4) underweight second post-diagnosis BMI (n=31). The updated post-diagnosis BMI and weight change cohorts yielded 9,275 and 7,959 participants, respectively.

Results were largely comparable with our 4-year lag models, though associations between weight loss and mortality were stronger in the 2-year lag model, suggesting presence of reverse causation and supporting our use of a 4-year lag period (**Table 3.2.7**).

Accounting for the influence of pre-diagnosis body mass index

In these supplemental analyses, we examined the combined associations of pre- and post-diagnosis body mass index (BMI) on PCSM, CVDM, and all-cause mortality. We did this for several reasons. First, body weight changes over time and the effects of obesity are likely cumulative. Second, pre-diagnosis BMI may confound the relationship between post-diagnosis BMI and mortality. Third, by accounting for pre-diagnosis BMI, we could potentially reduce selection or "collider" bias (12). As seen in the diagram in **Figure 3.5, A**, by restricting our study population to prostate cancer survivors who survived at least 4 years after completing the post-diagnosis survey (conditioning on a "collider"), we potentially open a biasing pathway if there is an uncontrolled risk factor for mortality (U in the Figure S4). If the causal graph in **Figure 3.5, B** is correct, our weight change analyses that control for the 1st post-diagnosis BMI measure may be subject to little of this potential bias. According to the theory of directed acyclic graphs (92–94), conditioning on 1st post-diagnosis BMI would block the previously opened biasing path induced through conditioning on survival 4-years after the post-diagnosis survey.

To account for pre-diagnosis BMI, first pre-diagnosis BMI was calculated using weight from the first questionnaire completed $\geq$1 year before prostate cancer diagnosis (median = 2.4 years, interquartile range: 1.8 years). Secondly, pre-diagnosis BMI was combined with post-diagnosis BMI to create a 7-level categorical variable: healthy weight/healthy weight, healthy weight/overweight, overweight/healthy weight, overweight/overweight, overweight/obese, obese/overweight, and obese/obese (representing the various combinations of pre- and post-diagnosis BMI, respectively). We excluded individuals who did not complete a questionnaire $\geq$ 1-year before diagnosis (n=518) and those with extreme combinations (i.e., healthy weight/obese (n=7), obese/healthy weight (n=8)) because there were few people in these categories and no events.

Multivariable models for the association of combined pre- and post-diagnosis BMI with PCSM, CVDM, and all-cause mortality are presented in **Table 3.2.8.** Compared to healthy weight men both before and after being diagnosed with prostate cancer, men who were obese at both time points had higher hazards of CVDM (HR=1.38, 95%CI: 1.10, 1.73) and all-cause mortality (HR=1.25, 95% CI: 1.10, 1.41), but not PCSM (HR=1.14, 95%CI: 0.79, 1.63). However, the hazard of PCSM appeared higher among men who went from being overweight pre-diagnosis to obese post-diagnosis (HR=1.69, 95%CI: 1.12, 2.57). This may suggest that weight gain plays a larger role in PCSM than obesity in general. However, the deterministic relation between BMI and weight change makes it difficult to separate out their effects.

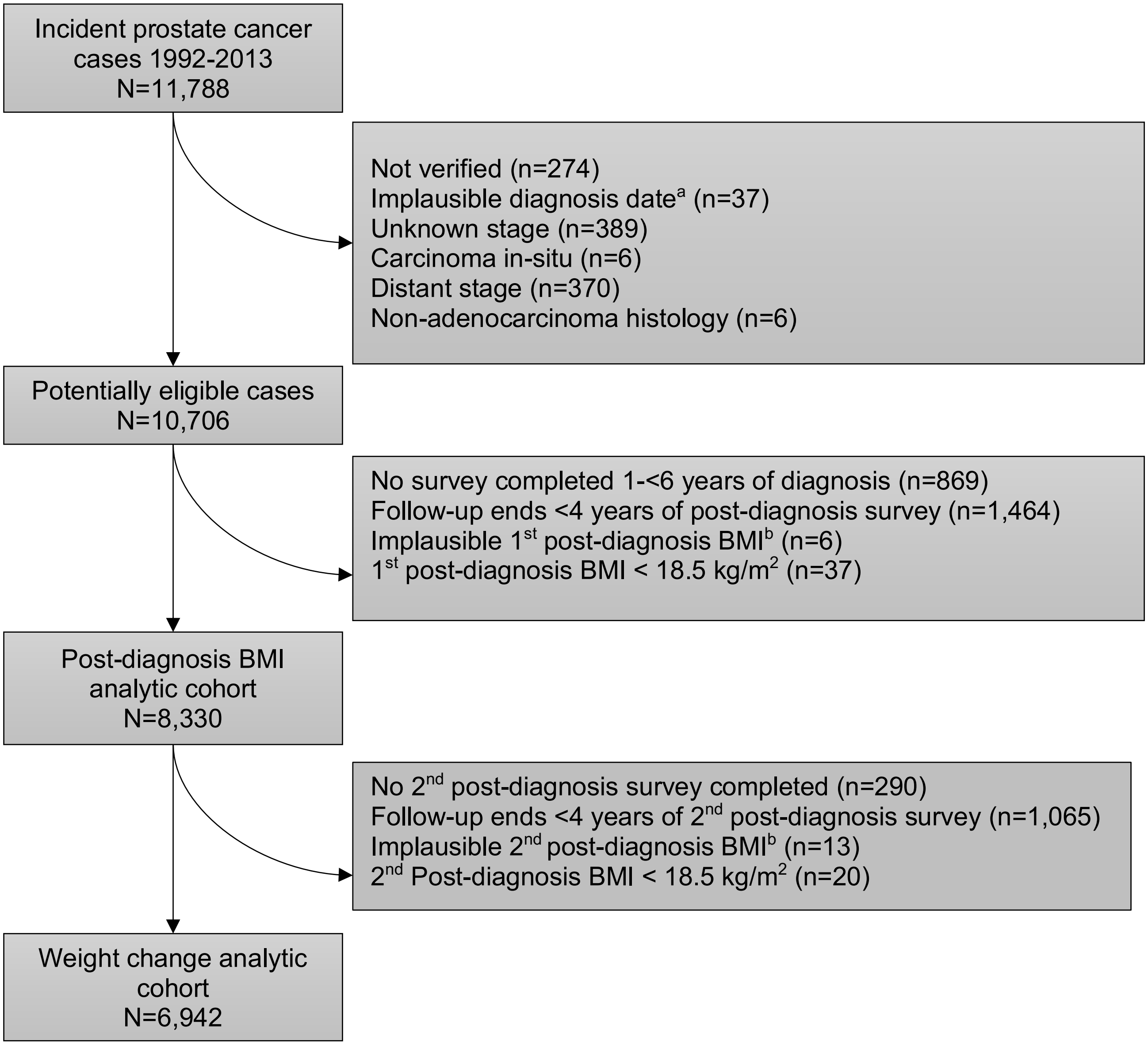
We also examined the effect of pre-diagnosis BMI on mortality outcomes, separate from post-diagnosis BMI. Among the 10,706 potentially eligible cases, we excluded individuals for whom pre-diagnosis BMI was missing or <18.5 kg/m^2, yielding an analytic sample of 9,863 men. Follow-up started on the date of prostate cancer diagnosis and ended at death or December 31, 2016, whichever came first. Models adjusted for age, tumor local extent, Gleason score, diagnosis year, education, pre-diagnosis smoking status, pre-diagnosis alcohol intake, and pre-diagnosis physical activity. All pre-diagnosis variables were obtained from the same questionnaire used to obtain pre-diagnosis BMI.

Multivariable models suggest that compared to pre-diagnosis healthy weight men, pre-diagnosis obese men had a higher hazard of CVDM (HR=1.41, 95%CI: 1.20, 1.66) and all-cause mortality (HR=1.30, 95%CI: 1.20, 1.42), but not PCSM (**Table 3.2.9**). It is important to note that this analysis is clearly subject to collider bias (12), as there is an open, biasing path from pre-diagnosis BMI→$\text{Survival}_{\text{Post-Diagnosis}}$←U→Survival (**Table 3.2.4**). The extent to which this bias would affect results is difficult to quantify.

Discussion of interactions with tumor risk type

Post-diagnosis obesity was associated with a higher risk of PCSM among men diagnosed with lower-risk tumors, but not high-risk tumors. This difference could be due to chance given that the HRs for BMI were not statistically significantly different. Alternatively, men had to survive at least 4-years after completing the post-diagnosis survey to be included in this study, resulting in potential selection bias(12). Because mortality was higher in the high-risk subgroup during this 4-year lag period, selection bias could have attenuated the association with BMI more in the high-risk group than in the lower-risk group.

Figure 3.1. Exclusion flow chart among male participants diagnosed with prostate cancer from 1992 to 2013 in the Cancer Prevention Study (CPS)-II Nutrition Cohort



[a] Exclusion due to implausible diagnosis dates included individuals with self-reported diagnosis dates that were >6 months before the diagnosis date obtained from medical records or cancer registries and those diagnosed at death.
[b] BMI <15 or > 60 kg/m^2.

Table 3.1.1. Participant Characteristics by Post-Diagnosis[a] Body Mass Index (BMI) Among N=8,330 Men Diagnosed with Non-Metastatic Prostate Cancer in the CPS-II Nutrition Cohort.

Variable	Categories	Total	Healthy Weight	Overweight	Obese
		N=8330	N=2977	N=4041	N=1312
		N (%)	N (%)	N (%)	N (%)
Age at Diagnosis (years)					
	<65	1111 (13.3)	300 (10.1)	593 (14.7)	218 (16.6)
	65-<70	2341 (28.1)	771 (25.9)	1166 (28.9)	404 (30.8)
	70-<75	2657 (31.9)	952 (32)	1278 (31.6)	427 (32.5)
	75-<80	1688 (20.3)	680 (22.8)	790 (19.5)	218 (16.6)
	80+	533 (6.4)	274 (9.2)	214 (5.3)	45 (3.4)
Race					
	White	8114 (97.4)	2917 (98)	3935 (97.4)	1262 (96.2)
	Other/Unknown	216 (2.6)	60 (2.0)	106 (2.6)	50 (3.8)
Education					
	<High School	489 (5.9)	133 (4.5)	240 (5.9)	116 (8.8)
	High School Grad	1355 (16.3)	427 (14.3)	659 (16.3)	269 (20.5)
	Some College	1976 (23.7)	637 (21.4)	994 (24.6)	345 (26.3)
	College Grad	4474 (53.7)	1768 (59.4)	2134 (52.8)	572 (43.6)
	Missing	36 (0.4)	12 (0.4)	14 (0.3)	10 (0.8)
Tumor Local Extent					
	T1 or T2	7717 (92.6)	2781 (93.4)	3723 (92.1)	1213 (92.5)
	T3 or T4	613 (7.4)	196 (6.6)	318 (7.9)	99 (7.5)
Gleason Score					
	2-6	4415 (53)	1633 (54.9)	2125 (52.6)	657 (50.1)
	7	2064 (24.8)	707 (23.7)	1038 (25.7)	319 (24.3)
	8-10	877 (10.5)	290 (9.7)	415 (10.3)	172 (13.1)
	5-7[b]	711 (8.5)	259 (8.7)	332 (8.2)	120 (9.1)
	7-10[b]	76 (0.9)	23 (0.8)	38 (0.9)	15 (1.1)
	Missing	187 (2.2)	65 (2.2)	93 (2.3)	29 (2.2)

Variable	Categories	Total	Healthy Weight	Overweight	Obese
Nodal Involvement					
	None	8247 (99.0)	2958 (99.4)	3993 (98.8)	1296 (98.8)
	Any	83 (1.0)	19 (0.6)	48 (1.2)	16 (1.2)
Calendar year of Diagnosis					
	1992-1997	2732 (32.8)	983 (33)	1351 (33.4)	398 (30.3)
	1998-2002	3060 (36.7)	1065 (35.8)	1502 (37.2)	493 (37.6)
	2003-2007	1978 (23.7)	730 (24.5)	929 (23.0)	319 (24.3)
	2008-2012	560 (6.7)	199 (6.7)	259 (6.4)	102 (7.8)
First Course of Treatment[c]					
	Surgery[d]	3027 (36.3)	1061 (35.6)	1503 (37.2)	463 (35.3)
	Radiation[e]	3039 (36.5)	1092 (36.7)	1459 (36.1)	488 (37.2)
	Hormone Only	332 (4.0)	121 (4.1)	167 (4.1)	44 (3.4)
	Watchful Waiting	542 (6.5)	238 (8.0)	247 (6.1)	57 (4.3)
	Missing	1390 (16.7)	465 (15.6)	665 (16.5)	260 (19.8)
Family History of Prostate Cancer[f]					
	No	6224 (74.7)	2235 (75.1)	3013 (74.6)	976 (74.4)
	Yes	2106 (25.3)	742 (24.9)	1028 (25.4)	336 (25.6)
Smoking Status[f]					
	Never	2405 (28.9)	952 (32.0)	1145 (28.3)	308 (23.5)
	Former	5691 (68.3)	1917 (64.4)	2799 (69.3)	975 (74.3)
	Current	231 (2.8)	107 (3.6)	95 (2.4)	29 (2.2)
	Missing	3 (0.0)	1 (0.0)	2 (0.0)	0 (0.0)

Variable	Categories	Total	Healthy Weight	Overweight	Obese
Alcohol Intake[f] (drinks/day)					
	None	2953 (35.5)	1016 (34.1)	1409 (34.9)	528 (40.2)
	<1	3251 (39.0)	1167 (39.2)	1584 (39.2)	500 (38.1)
	1+	2095 (25.2)	784 (26.3)	1037 (25.7)	274 (20.9)
	Missing	31 (0.4)	10 (0.3)	11 (0.3)	10 (0.8)
Physical Activity[f] (MET-hours/week)[g]					
	<3.5	3600 (43.2)	1182 (39.7)	1768 (43.8)	650 (49.5)
	3.5-<8.75	1322 (15.9)	459 (15.4)	646 (16.0)	217 (16.5)
	8.75-<17.5	1126 (13.5)	425 (14.3)	547 (13.5)	154 (11.7)
	17.5+	1588 (19.1)	661 (22.2)	763 (18.9)	164 (12.5)
	Missing	694 (8.3)	250 (8.4)	317 (7.8)	127 (9.7)
ACS Diet Quality Score[f, h]					
	0-2	948 (11.4)	292 (9.8)	493 (12.2)	163 (12.4)
	3-6	2297 (27.6)	761 (25.6)	1167 (28.9)	369 (28.1)
	7-9	1280 (15.4)	564 (18.9)	586 (14.5)	130 (9.9)
	Missing	3805 (45.7)	1360 (45.7)	1795 (44.4)	650 (49.5)
Energy Intake (kcal/day)		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
		1806.5 (611.3)	1766.1 (587.3)	1811.1 (604.5)	1886.4 (675.9)

Proportion of missing data are reported above. If missing data were not reported, then there were no missing values.
[a] Post-diagnosis BMI defined according to self-reported weight on the first survey completed 1-<6 years after prostate cancer diagnosis.
[b] Gleason score available as only a categorical score of "intermediate Gleason score" corresponding to scores 5–7 or "high Gleason score" corresponding to scores 7–10.
[c] Self-reported on questionnaire mailed to participant after initial report of prostate cancer.
[d] Among 3,027 participants who had surgery, 342 (11.3%) also had hormone therapy.
[e] Among 3,309 participants who had radiation therapy, 1046 (34.4%) also had hormone therapy.
[f] Obtained from the post-diagnosis survey.

[g] Metabolic equivalent of task (MET-hours/week).
[h] Diet quality was calculated in accordance with ACS dietary guidelines for cancer prevention, with higher scores indicating greater concordance with dietary guidelines.

Table 3.1.2. Cox Proportional Hazard Ratios (HR) and 95% Confidence Intervals (95% CI) for the Association of Post-Diagnosis[a] Body Mass Index (BMI) with Mortality due to Prostate Cancer, Cardiovascular Disease, and All-Causes, for the Total Cohort (n=8,330) and Stratified[b] by Risk of Disease Progression Category.

	Total (n=8,330)			Lower-Risk Tumors[c] (n=6,749)			High-Risk Tumors[d] (n=1,339)		
	# Deaths/ person-years	HR (95% CI)	p-value	# Deaths	HR (95% CI)	p-value	# Deaths	HR (95% CI)	p-value
Prostate Cancer-Specific Mortality									
Post-diagnosis BMI									
Healthy Weight (*18.5-<25.0 kg/m²*)	156/ 21,542	1.00 (-)		90	1.00(-)		56	1.00(-)	
Overweight (*25.0-<30.0 kg/m²*)	260/ 30,495	1.23 (1.00, 1.50)		166	1.35 (1.05, 1.73)		84	1.09 (0.79, 1.51)	
Obese (*30.0+ kg/m²*)	84 /9,345	1.28 (0.96, 1.67)		55	1.58 (1.13, 2.22)		29	1.00 (0.63, 1.58)	
Per 5-unit increase		1.09 (0.96, 1.24)	0.17		1.13 (0.99, 1.29)	0.07		1.10 (0.95, 1.26)	0.21
Cardiovascular Disease-Related Mortality									
Post-diagnosis BMI									
Healthy Weight (*18.5-<25.0 kg/m²*)	420/ 21,542	1.00 (-)		351	1.00(-)		57	1.00(-)	
Overweight (*25.0-<30.0 kg/m²*)	561/ 30,495	1.08 (0.95, 1.23)		466	1.09 (0.95, 1.26)		77	0.96 (0.69, 1.33)	
Obese (*30.0+ kg/m²*)	174 /9,345	1.24 (1.03, 1.49)		139	1.28 (1.04, 1.57)		30	1.15 (0.74, 1.78)	
Per 5-unit increase		1.10 (1.01, 1.19)	0.03		1.12 (1.03, 1.22)	0.01		1.07 (0.94, 1.21)	0.31
All-Cause Mortality									
Post-diagnosis BMI									
Healthy Weight (*18.5-<25.0 kg/m²*)	1,400 / 21,542	1.00 (-)		1121	1.00(-)		234	1.00(-)	
Overweight (*25.0-<30.0 kg/m²*)	1,825/ 30,495	1.01 (0.94, 1.09)		1422	1.01 (0.93, 1.09)		345	1.01 (0.87, 1.19)	
Obese (*30.0+ kg/m²*)	630 /9,345	1.23 (1.11, 1.35)		483	1.27 (1.14, 1.42)		127	1.12 (0.90, 1.38)	
Per 5-unit increase		1.07 (1.02, 1.12)	0.01		1.08 (1.03, 1.13)	<0.01		1.05 (0.98, 1.11)	0.15

Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

[a] Post-diagnosis BMI defined according to self-reported weight on the first survey completed 1-<6 years after prostate cancer diagnosis.

[b] Results from stratified analysis obtained from a single model that included an interaction term between post-diagnosis BMI (healthy weight, overweight, obese) and risk of disease progression category (lower-risk, high-risk). 242 observations were excluded from the interaction analysis due to missing values for tumor-risk type.

[c] Defined as T1/T2 and Gleason score ≤7.

[d] Defined as T3/T4 or Gleason score > 8 or Nodal involvement.

Table 3.1.3. Cox Proportional Hazard Ratios (HR) and 95% Confidence Intervals (95% CI) for the Associations of Post-Diagnosis[a] Body Weight Change from with Mortality due to Prostate Cancer, Cardiovascular Disease, and All-Causes (N=6,942).

	# Deaths	Person-Years	HR (95% CI)
Prostate Cancer-Specific Mortality			
Relative Body Weight Change			
Gain >5%	52	3,584	1.65 (1.21, 2.25)
Gain 3-5%	27	3,698	0.93 (0.62, 1.40)
Stable +/- <3%	234	28,733	1.00 (-)
Loss 3-5%	27	3,852	0.78 (0.52, 1.17)
Loss >5%	35	4,093	0.95 (0.66, 1.37)
Absolute Body Weight Change			
Gain 10+ lbs.	55	3,945	1.62 (1.18, 2.22)
Gain 5-<10 lbs.	46	5,985	1.00 (0.71, 1.39)
Stable +/- <5 lbs.	178	22,965	1.00 (-)
Lost 5-<10 lbs.	55	6,540	0.99 (0.73, 1.35)
Lost 10+ lbs.	41	4,524	1.07 (0.75, 1.54)
Cardiovascular Disease-Related Mortality			
Relative Body Weight Change			
Gain >5%	76	3,584	1.19 (0.93, 1.52)
Gain 3-5%	61	3,698	0.90 (0.69, 1.18)
Stable +/- <3%	556	28,733	1.00 (-)
Loss 3-5%	91	3,852	1.15 (0.92, 1.44)
Loss >5%	97	4,093	1.11 (0.89, 1.38)
Absolute Body Weight Change			
Gain 10+ lbs.	79	3,945	1.18 (0.92, 1.51)
Gain 5-<10 lbs.	110	5,985	1.02 (0.83, 1.26)
Stable +/- <5 lbs.	445	22,965	1.00 (-)
Lost 5-<10 lbs.	137	6,540	1.02 (0.84, 1.24)
Lost 10+ lbs.	110	4,524	1.20 (0.96, 1.49)
All-Cause Mortality			
Relative Body Weight Change			
Gain >5%	276	3,584	1.27 (1.12, 1.45)
Gain 3-5%	232	3,698	1.06 (0.92, 1.21)
Stable +/- <3%	1,806	28,733	1.00 (-)
Loss 3-5%	292	3,852	1.15 (1.02, 1.31)
Loss >5%	367	4,093	1.30 (1.16, 1.46)
Absolute Body Weight Change			
Gain 10+ lbs.	297	3,945	1.31 (1.15, 1.49)
Gain 5-<10 lbs.	385	5,985	1.11 (0.99, 1.25)
Stable +/- <5 lbs.	1,417	22,965	1.00 (-)
Lost 5-<10 lbs.	471	6,540	1.12 (1.01, 1.25)
Lost 10+ lbs.	403	4,524	1.37 (1.22, 1.54)

Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012), and first post-diagnosis BMI (kg/m^2 - continuous).

[a] Weight change was the difference between post-diagnosis weight, and the weight reported on the next biennial survey

Table 3.2.1. Comparison of participant characteristics between eligible[a] prostate cancer survivors in the Cancer Prevention Study-II Nutrition Cohort included (n=8,330) and excluded (n=2,376) from analyses.

Variable	Categories	Total N=10,706	Included N=8,330	Excluded N=2,376
		Mean (SD)	**Mean (SD)**	**Mean (SD)**
Age at Diagnosis (years)		71.8 (6.11)	70.9 (5.72)	75 (6.31)
		N (%)	**N (%)**	**N (%)**
Race				
	White	10417 (97.3)	8114 (97.4)	2303 (96.9)
	Other	289 (2.7)	216 (2.6)	73 (3.1)
Education				
	<High School	707 (6.6)	489 (5.9)	218 (9.3)
	High School Grad	1781 (16.7)	1355 (16.3)	426 (18.1)
	Some College	2628 (24.7)	1976 (23.8)	652 (27.7)
	College Grad	5531 (51.9)	4474 (53.9)	1057 (44.9)
Tumor local extent				
	T1 or T2	9900 (92.5)	7717 (92.6)	2183 (91.9)
	T3 or T4	806 (7.5)	613 (7.4)	193 (8.1)
Gleason Score				
	2-6	5297 (50.8)	4415 (54.2)	882 (38.7)
	7	2602 (25.0)	2064 (25.3)	538 (23.6)
	8-10	1385 (13.3)	877 (10.8)	508 (22.3)
	5-7[b]	958 (9.2)	711 (8.7)	247 (10.8)
	7-10[b]	178 (1.7)	76 (0.9)	102 (4.5)
Nodal Involvement				
	Not Present	10567 (98.7)	8247 (99.0)	2320 (97.6)
	Present (N1)	139 (1.3)	83 (1.0)	56 (2.4)
Year of Diagnosis				
	1992-1997	3277 (30.6)	2732 (32.8)	545 (22.9)
	1998-2002	3675 (34.3)	3060 (36.7)	615 (25.9)
	2003-2007	2505 (23.4)	1978 (23.7)	527 (22.2)
	2008-2012	1249 (11.7)	560 (6.7)	689 (29.0)
Initial Treatment				
	Surgery, Ref	3419 (40.6)	3027 (43.6)	392 (26.3)
	Radiation	3714 (44.1)	3039 (43.8)	675 (45.3)

Variable	Categories	Total N=10,706	Included N=8,330	Excluded N=2,376
	Hormone Only	526 (6.2)	332 (4.8)	194 (13.0)
	Watchful Waiting	771 (9.1)	542 (7.8)	229 (15.4)
Baseline[c] Body Mass Index (kg/m^2)				
	<18.5	33 (0.3)	11 (0.1)	22 (1.0)
	18.5-<25	3848 (36.4)	3082 (37.1)	766 (33.6)
	25-<30	5366 (50.7)	4213 (50.8)	1153 (50.5)
	30-<35	1134 (10.7)	852 (10.3)	282 (12.4)
	35+	199 (1.9)	141 (1.7)	58 (2.5)

[a] Eligible participants included all male participants in the Cancer Preventions Study-II Nutrition Cohort diagnosed with incident prostate cancer between 1992 and 2012 who did not meet any of the following criteria: unverified prostate cancer case; implausible diagnosis date; unknown stage; distant stage; non-adenocarcinoma histology; carcinoma in-situ (see **Figure 1** for more details).
[b] Gleason score available as only a categorical score of "intermediate Gleason score" corresponding to scores 5–7 or "high Gleason score" corresponding to scores 7–10.
[c] Body mass index (BMI) was calculated using weight obtained from the baseline survey completed in 1992

Table 3.2.2. Participant characteristics by post-diagnosis relative body weight change category among men diagnosed with non-metastatic prostate cancer in the CPS-II Nutrition Cohort (N=6,942).

Variable	Categories	Total	Gain >5%	Gain 3-5%	Stable ± 3%	Loss 3-5%	Loss >5%
		N=6942	N=571	N=554	N=4419	N=651	N=747
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Age at Diagnosis (years)							
	<65	1042 (15.0)	112 (19.6)	109 (19.7)	645 (14.6)	79 (12.1)	97 (13.0)
	65-<70	2129 (30.7)	198 (34.7)	170 (30.7)	1374 (31.1)	180 (27.6)	207 (27.7)
	70-<75	2198 (31.7)	166 (29.1)	166 (30)	1394 (31.5)	220 (33.8)	252 (33.7)
	75-<80	1254 (18.1)	71 (12.4)	88 (15.9)	815 (18.4)	137 (21.0)	143 (19.1)
	80+	319 (4.6)	24 (4.2)	21 (3.8)	191 (4.3)	35 (5.4)	48 (6.4)
Race							
	White	6766 (97.5)	557 (97.5)	535 (96.6)	4308 (97.5)	638 (98.0)	728 (97.5)
	Other	176 (2.5)	14 (2.5)	19 (3.4)	111 (2.5)	13 (2.0)	19 (2.5)
Education							
	<High School	392 (5.6)	43 (7.5)	37 (6.7)	224 (5.1)	31 (4.8)	57 (7.6)
	High School Grad	1129 (16.3)	102 (17.9)	91 (16.4)	704 (15.9)	97 (14.9)	135 (18.1)
	Some College	1633 (23.5)	136 (23.8)	144 (26.0)	997 (22.6)	175 (26.9)	181 (24.2)
	College Grad	3759 (54.2)	288 (50.4)	281 (50.7)	2474 (56.0)	345 (53.0)	371 (49.7)
	Missing	29 (0.4)	2 (0.4)	1 (0.2)	20 (0.5)	3 (0.5)	3 (0.4)
Tumor Local Extent							
	T1 or T2	6415 (92.4)	510 (89.3)	517 (93.3)	4073 (92.2)	617 (94.8)	698 (93.4)
	T3 or T4	527 (7.6)	61 (10.7)	37 (6.7)	346 (7.8)	34 (5.2)	49 (6.6)

Variable	Categories	Total	Gain >5%	Gain 3-5%	Stable ± 3%	Loss 3-5%	Loss >5%
Gleason Score							
	2-6	3827 (55.1)	314 (55)	334 (60.3)	2419 (54.7)	352 (54.1)	408 (54.6)
	7	1675 (24.1)	129 (22.6)	111 (20.0)	1101 (24.9)	164 (25.2)	170 (22.8)
	8-10	666 (9.6)	56 (9.8)	39 (7.0)	423 (9.6)	68 (10.4)	80 (10.7)
	5-7[b]	584 (8.4)	53 (9.3)	53 (9.6)	358 (8.1)	51 (7.8)	69 (9.2)
	7-10[b]	38 (0.5)	3 (0.5)	1 (0.2)	26 (0.6)	2 (0.3)	6 (0.8)
	Missing	152 (2.2)	16 (2.8)	16 (2.9)	92 (2.1)	14 (2.2)	14 (1.9)
Nodal Involvement							
	None	6874 (99.0)	562 (98.4)	547 (98.7)	4381 (99.1)	645 (99.1)	739 (98.9)
	Any	68 (1.0)	9 (1.6)	7 (1.3)	38 (0.9)	6 (0.9)	8 (1.1)
Year of Diagnosis							
	1992-1997	2422 (34.9)	236 (41.3)	221 (39.9)	1541 (34.9)	205 (31.5)	219 (29.3)
	1998-2002	2737 (39.4)	198 (34.7)	203 (36.6)	1744 (39.5)	269 (41.3)	323 (43.2)
	2003-2007	1638 (23.6)	132 (23.1)	117 (21.1)	1046 (23.7)	158 (24.3)	185 (24.8)
	2008-2012	145 (2.1)	5 (0.9)	13 (2.3)	88 (2.0)	19 (2.9)	20 (2.7)
First Course of Treatment[c]							
	Surgery	2772 (39.9)	237 (41.5)	240 (43.3)	1810 (41.0)	239 (36.7)	246 (32.9)
	Radiation	2518 (36.3)	182 (31.9)	180 (32.5)	1628 (36.8)	255 (39.2)	273 (36.5)

Variable	Categories	Total	Gain >5%	Gain 3-5%	Stable ± 3%	Loss 3-5%	Loss >5%
	Hormone Only	239 (3.4)	21 (3.7)	18 (3.2)	136 (3.1)	29 (4.5)	35 (4.7)
	Watchful Waiting	410 (5.9)	34 (6.0)	40 (7.2)	256 (5.8)	40 (6.1)	40 (5.4)
	Missing	1003 (14.4)	97 (17.0)	76 (13.7)	589 (13.3)	88 (13.5)	153 (20.5)
Family History of Prostate Cancer[d]							
	No	5190 (74.8)	424 (74.3)	417 (75.3)	3312 (74.9)	483 (74.2)	554 (74.2)
	Yes	1752 (25.2)	147 (25.7)	137 (24.7)	1107 (25.1)	168 (25.8)	193 (25.8)
Smoking Status[d]							
	Never	2048 (29.5)	153 (26.8)	159 (28.7)	1343 (30.4)	188 (28.9)	205 (27.4)
	Former	4704 (67.8)	397 (69.5)	372 (67.1)	2975 (67.3)	443 (68)	517 (69.2)
	Current	188 (2.7)	21 (3.7)	22 (4.0)	101 (2.3)	19 (2.9)	25 (3.3)
	Missing	2 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	1 (0.2)	0 (0.0)
Alcohol Intake[d] (drinks/day)							
	None	2416 (34.8)	219 (38.4)	198 (35.7)	1480 (33.5)	228 (35.0)	291 (39.0)
	<1	2680 (38.6)	213 (37.3)	213 (38.4)	1751 (39.6)	245 (37.6)	258 (34.5)
	1+	1818 (26.2)	137 (24.0)	140 (25.3)	1174 (26.6)	174 (26.7)	193 (25.8)
	Missing	28 (0.4)	2 (0.4)	3 (0.5)	14 (0.3)	4 (0.6)	5 (0.7)
Physical Activity[d] (MET-hours/week)[e]							

Variable	Categories	Total	Gain >5%	Gain 3-5%	Stable ± 3%	Loss 3-5%	Loss >5%
	<3.5	3115 (44.9)	243 (42.6)	225 (40.6)	1951 (44.2)	310 (47.6)	386 (51.7)
	3.5-<8.75	1056 (15.2)	104 (18.2)	101 (18.2)	635 (14.4)	105 (16.1)	111 (14.9)
	8.75-<17.5	957 (13.8)	81 (14.2)	71 (12.8)	625 (14.1)	90 (13.8)	90 (12.0)
	17.5+	1360 (19.6)	102 (17.9)	108 (19.5)	947 (21.4)	106 (16.3)	97 (13.0)
	Missing	454 (6.5)	41 (7.2)	49 (8.8)	261 (5.9)	40 (6.1)	63 (8.4)
ACS Diet Quality Score[d, f]							
	0-2	856 (12.3)	70 (12.3)	80 (14.4)	533 (12.1)	83 (12.7)	90 (12.0)
	3-6	2098 (30.2)	178 (31.2)	184 (33.2)	1332 (30.1)	206 (31.6)	198 (26.5)
	7-9	1191 (17.2)	94 (16.5)	86 (15.5)	804 (18.2)	90 (13.8)	117 (15.7)
	Missing	2797 (40.3)	229 (40.1)	204 (36.8)	1750 (39.6)	272 (41.8)	342 (45.8)
Energy Intake (kcal/day)		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
		1802.9 (607.2)	1799.3 (603.9)	1787.6 (600.54)	1800.1 (605.5)	1788.7 (599.6)	1846.6 (631.1)

[a] Post-diagnosis weight change based on weights obtained from the first questionnaire completed 1-<6 years after diagnosis and the following questionnaire.
[b] Gleason score available as only a categorical score of "intermediate Gleason score" corresponding to scores 5–7 or "high Gleason score" corresponding to scores 7–10.
[c] Self-reported on questionnaire mailed to participant after initial report of prostate cancer.
[d] Obtained from the post-diagnosis survey.
[e] Metabolic equivalent of task (MET-hours/week).
[f] Diet quality was calculated in accordance with ACS dietary guidelines for cancer prevention, with higher scores indicating greater concordance with dietary guidelines.

Table 3.2.3. Cumulative incidence estimates and 95% confidence intervals of prostate cancer-specific mortality, cardiovascular disease-related mortality, and all-cause mortality within strata of post-diagnosis body mass index (BMI) among men diagnosed with non-metastatic prostate cancer (n=8,330).

	Time Since Diagnosis			
BMI Category	**6 years**	**10 years**	**15 years**	**20 years**
	Prostate Cancer-Specific Mortality			
Healthy Weight	0.08 (0.01, 0.57)	2.66 (2.10, 3.38)	4.80 (4.02, 5.73)	6.53 (5.56, 7.67)
Overweight	0.36 (0.09, 1.36)	2.78 (2.16, 3.57)	6.04 (5.19, 7.01)	8.91 (7.83, 10.14)
Obese	0.31 (0.04, 2.15)	3.16 (2.2, 4.53)	6.22 (4.86, 7.93)	8.58 (6.84, 10.72)
	Cardiovascular Disease-Related Mortality			
Healthy Weight	1.13 (0.62, 2.07)	6.16 (5.16, 7.35)	13.50 (12.09, 15.05)	18.90 (17.13, 20.82)
Overweight	0.40 (0.15, 1.09)	5.53 (4.75, 6.42)	12.83 (11.70, 14.07)	18.48 (17.02, 20.05)
Obese	0.43 (0.11, 1.70)	5.39 (4.15, 6.99)	12.59 (10.70, 14.78)	17.80 (15.42, 20.49)
	All-Cause Mortality			
Healthy Weight	5.20 (3.09, 8.68)	23.62 (21.11, 26.37)	46.50 (44.10, 48.97)	64.31 (61.87, 66.74)
Overweight	2.13 (1.34, 3.38)	18.63 (17.19, 20.18)	42.15 (40.41, 43.93)	62.24 (60.21, 64.27)
Obese	2.15 (1.11, 4.12)	21.05 (18.63, 23.75)	46.08 (43.07, 49.19)	63.9 (60.46, 67.33)

Table 3.2.4. Cumulative incidence estimates and 95% confidence intervals of prostate cancer-specific mortality, cardiovascular disease-related mortality, and all-cause mortality within strata of post-diagnosis relative weight change category among men diagnosed with non-metastatic prostate cancer (n=6,942).

Weight Change Category	Time Since Diagnosis			
	8 years	10 years	15 years	20 years
	Prostate Cancer-Specific Mortality			
Weight Gain 5%+	0 (0, 0)	2.53 (1.35, 4.71)	7.93 (5.78, 10.83)	10.82 (8.18, 14.25)
Weight Gain 3-<5%	0.99 (0.25, 3.92)	1.85 (0.74, 4.57)	3.99 (2.35, 6.74)	6.97 (4.69, 10.3)
Stable	1.06 (0.53, 2.12)	2.47 (1.76, 3.46)	5.34 (4.45, 6.4)	7.71 (6.65, 8.94)
Loss 3-<5%	0.53 (0.07, 3.68)	1.59 (0.65, 3.82)	3.18 (1.84, 5.45)	6.48 (4.4, 9.51)
Loss 5%+	0 (0, 0)	0.93 (0.39, 2.26)	3.62 (2.4, 5.44)	6.05 (4.3, 8.49)
	Cardiovascular Disease-Related Mortality			
Weight Gain 5%+	0.77 (0.11, 5.37)	3.24 (1.64, 6.35)	11.62 (8.82, 15.24)	18.86 (15.18, 23.29)
Weight Gain 3-<5%	0 (0, 0)	2.74 (1.52, 4.92)	9.79 (7.37, 12.96)	13.29 (10.34, 17)
Stable	1.1 (0.5, 2.43)	3.5 (2.63, 4.65)	10.74 (9.55, 12.08)	16.85 (15.34, 18.49)
Loss 3-<5%	0.74 (0.1, 5.15)	4.43 (2.65, 7.35)	14.05 (11.17, 17.61)	18.85 (15.42, 22.93)
Loss 5%+	1.11 (0.36, 3.41)	3.73 (2.28, 6.07)	11.9 (9.41, 14.97)	17.73 (14.39, 21.74)
	All-Cause Mortality			
Weight Gain 5%+	7.13 (4.80, 10.52)	15.51 (13.00, 18.45)	38.65 (36.34, 41.06)	58.86 (56.66, 61.09)
Weight Gain 3-<5%	9.12 (4.70, 17.30)	20.09 (14.92, 26.75)	50.91 (46.11, 55.90)	71.32 (66.50, 75.98)
Stable	3.93 (1.64, 9.26)	15.88 (12.17, 20.59)	42.56 (38.13, 47.28)	63.71 (58.67, 68.74)
Loss 3-<5%	0.99 (0.25, 3.92)	11.29 (8.40, 15.09)	36.08 (31.75, 40.80)	54.87 (49.78, 60.12)
Loss 5%+	2.18 (0.69, 6.84)	15.10 (11.54, 19.62)	43.20 (38.66, 48.03)	63.96 (58.99, 68.91)

Table 3.2.5. Subdistribution hazard ratios (sdHR) and 95% confidence intervals (95% CI) for the association of post-diagnosis BMI (n=8,330) and weight change (n=6,942) with mortality due to prostate cancer and cardiovascular disease.

	Prostate Cancer-Specific Mortality			Cardiovascular Disease-Related Mortality		
Category	Total #Deaths	Person-Yrs	sdHR(95% CI)	Total #Deaths	Person-Yrs	sdHR(95% CI)
Post-Diagnosis BMI[a]						
Healthy Weight	156	21,542	1.00 (-)	420	21,542	1.00 (-)
Overweight	260	30,495	1.25 (1.02, 1.53)	561	30,495	1.08 (0.95, 1.23)
Obese	84	9,345	1.24 (0.94, 1.63)	174	9,345	1.16 (0.97, 1.39)
Relative Weight Change[b]						
Gain >5%	52	3,584	1.56 (1.13, 2.16)	76	3,584	1.11 (0.87, 1.41)
Gain 3-5%	27	3,698	0.93 (0.63, 1.39)	61	3,698	0.88 (0.68, 1.15)
Stable ± <3%	234	28,733	1.00 (-)	556	28,733	1.00 (-)
Loss 3-5%	27	3,852	0.76 (0.51, 1.13)	91	3,852	1.09 (0.87, 1.36)
Loss >5%	35	4,093	0.87 (0.60, 1.26)	97	4,093	0.99 (0.80, 1.23)
Absolute Weight Change[b]						
Gain 10+ lbs	55	3,945	1.52 (1.09, 2.11)	79	3,945	1.07 (0.84, 1.36)
Gain 5-<10 lbs	46	5,985	0.96 (0.69, 1.34)	110	5,985	0.98 (0.79, 1.21)
Stable ± <5 lbs.	178	22,965	1.00 (-)	445	22,965	1.00 (-)
Lost 5-<10 lbs	55	6,540	0.97 (0.72, 1.32)	137	6,540	0.97 (0.80, 1.18)
Lost 10+ lbs	41	4,524	0.97 (0.68, 1.38)	110	4,524	1.04 (0.83, 1.29)

[a] Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-

diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

[b]Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012), and first post-diagnosis BMI (kg/m^2 - continuous).

Table 3.2.6. Cox proportional hazard ratios (HR) and 95% confidence intervals (95% CI) for the association of post-diagnosis BMI and weight change with mortality due to prostate cancer, cardiovascular disease, and all causes – excluding men reporting hormone therapy as first course of treatment.

Category	Prostate Cancer-Specific Mortality		Cardiovascular Disease-Related Mortality		All-Cause Mortality	
	Total #Deaths	HR(95% CI)	Total #Deaths	HR(95% CI)	Total #Deaths	HR(95% CI)
Post-Diagnosis BMI[a] (n=4853)						
Healthy Weight	75	1.00 (-)	236	1.00 (-)	790	1.00 (-)
Overweight	129	1.27 (0.95, 1.70)	318	1.08 (0.91, 1.29)	1011	0.99 (0.90, 1.09)
Obese	37	1.35 (0.89, 2.04)	90	1.30 (1.01, 1.67)	316	1.22 (1.07, 1.40)
Relative Weight Change[b] (n=4278)						
Gain >5%	29	1.96 (1.29, 2.98)	38	1.10 (0.78, 1.55)	157	1.35 (1.13, 1.60)
Gain 3-5%	14	0.89 (0.51, 1.57)	35	0.78 (0.55, 1.12)	142	1.01 (0.85, 1.21)
Stable ± <3%	129	1.00 (-)	354	1.00 (-)	1121	1.00 (-)
Loss 3-5%	13	0.66 (0.37, 1.18)	61	1.14 (0.87, 1.51)	169	1.04 (0.88, 1.23)
Loss >5%	18	1.00 (0.60, 1.66)	46	0.94 (0.69, 1.30)	189	1.27 (1.08, 1.49)
Absolute Weight Change[b] (n=4278)						
Gain 10+ lbs	29	1.71 (1.11, 2.64)	40	1.07 (0.76, 1.50)	172	1.37(1.16, 1.62)
Gain 5-<10 lbs	22	0.94 (0.58, 1.51)	68	1.03 (0.79, 1.36)	225	1.09 (0.94, 1.26)
Stable ± <5 lbs.	99	1.00 (-)	284	1.00 (-)	883	1.00 (-)
Loss 5-<10 lbs	31	1.00 (0.66, 1.52)	89	1.10 (0.86, 1.43)	292	1.18 (1.03, 1.35)
Loss 10+ lbs	22	1.19 (0.73, 1.94)	53	1.05 (0.77, 1.43)	206	1.34 (1.14, 1.57)

[a] Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

[b]Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012), and first post-diagnosis BMI (kg/m^2 - continuous).

Table 3.2.7. Cox proportional hazard ratios (HR) and 95% confidence intervals (95% CI) for the association of post-diagnosis body mass index (BMI) (n=9,275) and weight change (n=7,959) with mortality due to prostate cancer, cardiovascular disease, and all causes – using a 2-year lag instead of a 4-year lag.

	Prostate Cancer-Specific Mortality		Cardiovascular Disease-Related Mortality		All-Cause Mortality	
Category	**Total #Deaths**	**HR(95% CI)**	**Total #Deaths**	**HR(95% CI)**	**Total #Deaths**	**HR(95% CI)**
Post-diagnosis BMI[a]						
Healthy Weight	200	1.00 (-)	491	1.00 (-)	1,658	1.00 (-)
Overweight	305	1.14 (0.95, 1.37)	647	1.07 (0.94, 1.20)	2,088	0.98 (0.92, 1.05)
Obese	98	1.15 (0.90, 1.49)	200	1.20 (1.01, 1.42)	745	1.21 (1.10, 1.32)
Relative Body Weight Change[b]						
Gain >5%	63	1.61 (1.21, 2.13)	99	1.26 (1.02, 1.58)	352	1.34 (1.19, 1.50)
Gain 3-5%	34	0.97 (0.68, 1.40)	76	0.94 (0.74, 1.19)	281	1.07 (0.95, 1.22)
Stable ± <3%	288	1.00 (-)	660	1.00 (-)	2,133	1.00 (-)
Loss 3-5%	34	0.78 (0.55, 1.13)	112	1.15 (0.94, 1.41)	352	1.14 (1.02, 1.28)
Loss >5%	54	1.12 (0.83, 1.51)	147	1.34 (1.12, 1.61)	516	1.48 (1.34, 1.63)
Absolute Body Weight Change[b]						
Gain 10+ lbs	66	1.59 (1.19, 2.12)	104	1.27 (1.02, 1.58)	378	1.38 (1.23, 1.55)
Gain 5-<10 lbs	61	1.09 (0.81, 1.45)	135	1.05 (0.87, 1.27)	463	1.12 (1.01, 1.25)
Stable ± <5 lbs.	217	1.00 (-)	525	1.00 (-)	1,667	1.00 (-)
Loss 5-<10 lbs	69	1.00 (0.76, 1.31)	173	1.07 (0.90, 1.28)	576	1.14 (1.03, 1.25)
Loss 10+ lbs	60	1.22 (0.90, 1.64)	157	1.37 (1.14, 1.66)	550	1.52 (1.38, 1.69)

[a] Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-

diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

[b] Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012), and first post-diagnosis BMI (kg/m^2 - continuous).

Table 3.2.8. Cox proportional hazard ratios (HR) and 95% confidence intervals (95% CI) for the associations of pre-/post-diagnosis body mass index (BMI) with prostate cancer-specific mortality, cardiovascular disease-related mortality, and all-cause mortality (n=7,797).

Pre-/Post-Diagnosis BMI	Prostate Cancer Mortality		Cardiovascular Disease-Related Mortality		All-Cause Mortality	
	# Deaths	HR (95% CI)	# Deaths	HR (95% CI)	# Deaths	HR (95% CI)
Healthy Weight/ Healthy Weight	121	1.00 (-)	313	1.00 (-)	1076	1.00 (-)
Healthy Weight/ Overweight	35	1.33 (0.90, 1.99)	59	0.95 (0.71, 1.27)	222	1.03 (0.89, 1.20)
Overweight/Healthy Weight	18	0.93 (0.55, 1.56)	65	1.22 (0.93, 1.61)	198	1.06 (0.91, 1.24)
Overweight/Overweight	182	1.15 (0.90, 1.46)	413	1.08 (0.93, 1.26)	1349	0.99 (0.91, 1.08)
Overweight/Obese	30	1.69 (1.12, 2.57)	46	1.13 (0.82, 1.56)	178	1.19 (1.01, 1.40)
Obese/Overweight	13	1.68 (0.92, 3.04)	28	1.90 (1.28, 2.82)	88	1.54 (1.23, 1.93)
Obese/Obese	44	1.14 (0.79, 1.63)	114	1.38 (1.10, 1.73)	393	1.25 (1.10, 1.41)

The following pre-/post-diagnosis BMI combinations were excluded due to low cell count: healthy weight/obese (n=7); obese/healthy weight (n=8).

Models adjust for age (stratified on single years), initial treatment (surgery, radiation, hormone therapy only, watchful waiting), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), post-diagnosis smoking status (never, current, former), post-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

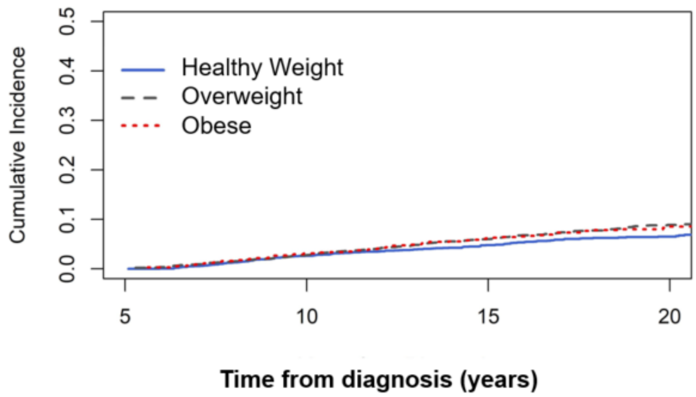
Table 3.2.9. Cox proportional hazard ratios (HR) and 95% confidence intervals (95% CI) for the associations of pre-diagnosis body mass index (BMI) with prostate cancer-specific mortality, cardiovascular disease-related mortality, and all-cause mortality (n=9,963).

Pre-Diagnosis BMI	Prostate Cancer Mortality		Cardiovascular Disease-Related Mortality		All-Cause Mortality	
	# Deaths	HR (95% CI)	# Deaths	HR (95% CI)	# Deaths	HR (95% CI)
Healthy Weight	266	1.00 (-)	534	1.00 (-)	1,919	1.00 (-)
Overweight	386	1.12 (0.95, 1.31)	727	1.08 (0.96, 1.21)	2,531	1.02 (0.96, 1.09)
Obese	101	1.14 (0.90, 1.45)	218	1.41 (1.20, 1.66)	777	1.30 (1.20, 1.42)

Models adjust for age (stratified on single years), tumor local extent (T1/T2, T3/T4), Gleason score (2, 7, 8-10, 5-7, 7-10), pre-diagnosis smoking status (never, current, former), pre-diagnosis physical activity (<3.5, 3.5-<8.75, 8.75-<17.5, 17+ MET hours/week), education (<high school, high school graduate, some college, college graduate), and diagnosis year (1992-1997, 1998-2002, 2003-2007, 2008-2012).

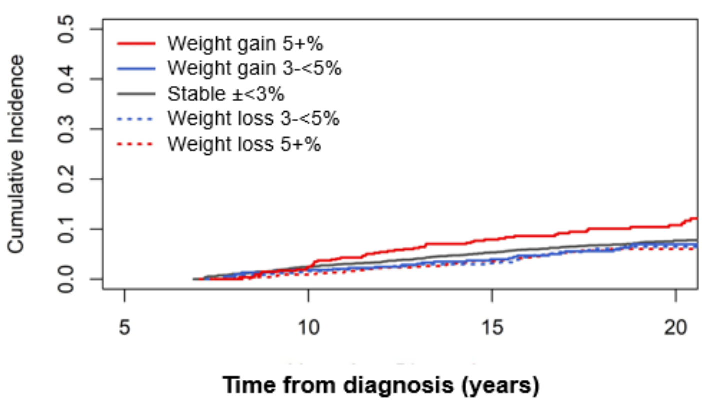
Figure 3.2. Cumulative incidence of prostate cancer-specific mortality stratified by post-diagnosis body mass index (BMI) and weight change, among N=8,330 and N=6,942 men diagnosed with non-metastatic prostate cancer in post-diagnosis BMI and weight change cohorts, respectively*.

A) Post-diagnosis Body Mass Index and Prostate Cancer-Specific Mortality (n=8,330)



# at Risk	6	10	15	20
Healthy Weight	1184	2183	1095	330
Overweight	1675	3080	1611	455
Obese	502	954	484	131

B) Relative Body Weight Change and Prostate Cancer-Specific Mortality (n=6,942)

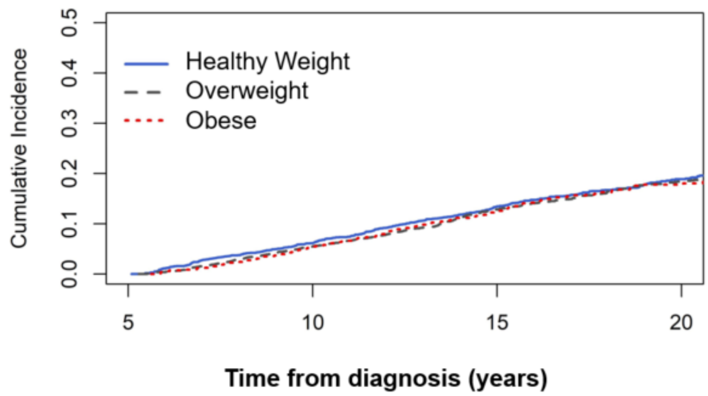


# at Risk	8	10	15	20
Weight gain 5+%	203	416	249	93
Weight gain 3-<5%	225	412	265	101
Stable ±<3%	1825	3429	2043	577
Weight loss 3-<5%	260	495	261	62
Weight loss 5+%	274	543	281	62

*The y-axis has been modified to range from 0 to 0.50.

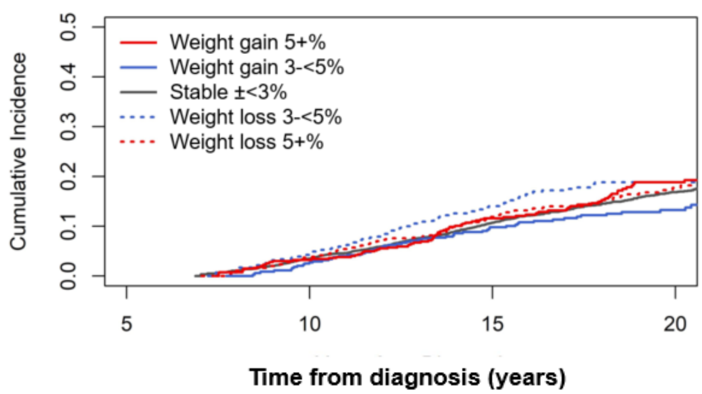
Figure 3.3. Cumulative incidence of cardiovascular disease-related mortality stratified by post-diagnosis body mass index (BMI) and weight change, among N=8,330 and N=6,942 men diagnosed with non-metastatic prostate cancer in post-diagnosis BMI and weight change cohorts, respectively*.

A) Post-diagnosis Body Mass Index and Cardiovascular Disease-Related Mortality (n=8,330)



# at Risk	6	10	15	20
Healthy Weight	1184	2183	1095	330
Overweight	1675	3080	1611	455
Obese	502	954	484	131

B) Relative Body Weight Change and Cardiovascular Disease-Related Mortality (n=6,942)

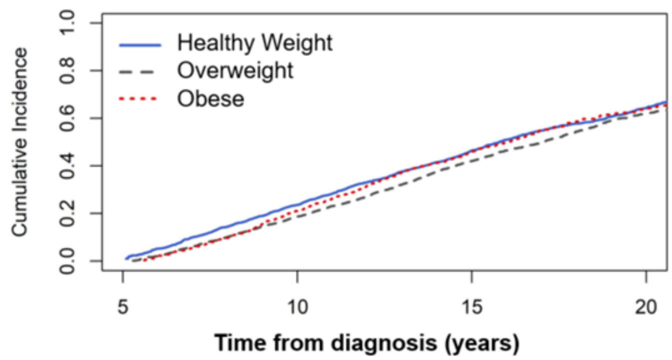


# at Risk	8	10	15	20
Weight gain 5+%	203	416	249	93
Weight gain 3-<5%	225	412	265	101
Stable ±<3%	1825	3429	2043	577
Weight loss 3-<5%	260	495	261	62
Weight loss 5+%	274	543	281	62

*The y-axis has been modified to range from 0 to 0.50.

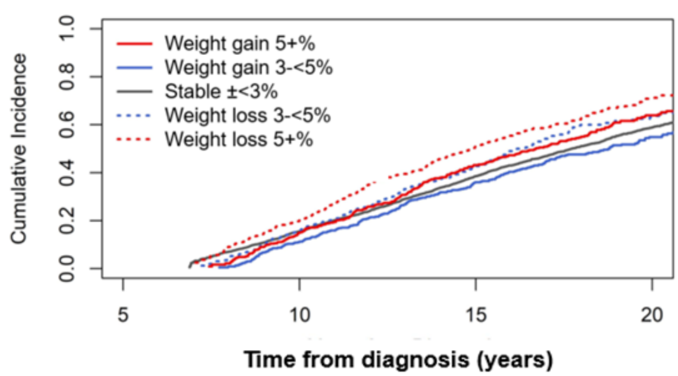
Figure 3.4. Cumulative incidence of all-cause mortality stratified by post-diagnosis body mass index (BMI) and weight change, among N=8,330 and N=6,942 men diagnosed with non-metastatic prostate cancer in post-diagnosis BMI and weight change cohorts, respectively.

A) Post-diagnosis Body Mass Index and All-Cause Mortality (n=8,330)



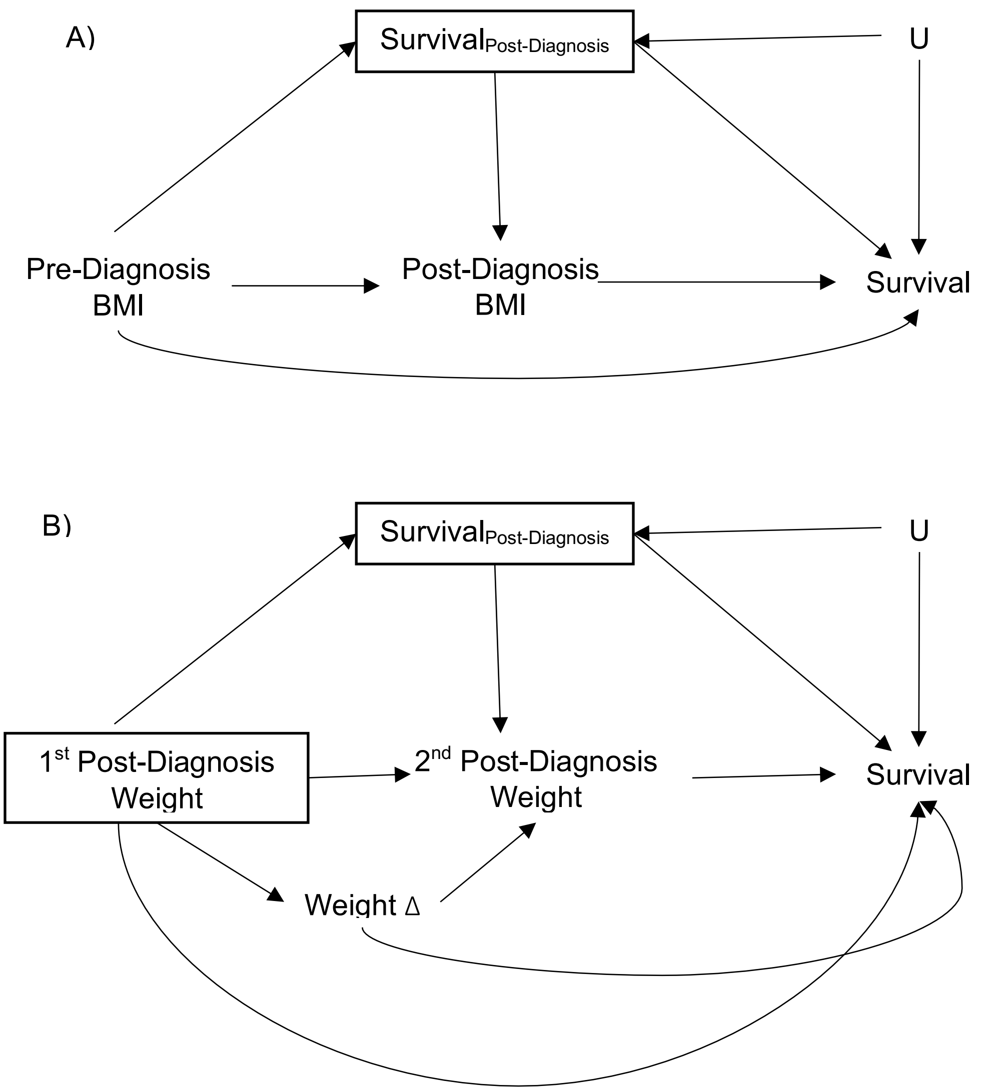
# at Risk	6	10	15	20
Healthy Weight	1184	2183	1095	330
Overweight	1675	3080	1611	455
Obese	502	954	484	131

B) Relative Body Weight Change and All-Cause Mortality (n=6,942)



# at Risk	8	10	15	20
Weight gain 5+%	203	416	249	93
Weight gain 3-<5%	225	412	265	101
Stable ±<3%	1825	3429	2043	577
Weight loss 3-<5%	260	495	261	62
Weight loss 5+%	274	543	281	62

Figure 3.5. Directed acyclic diagram depicting potential selection or "collider" bias in studying the association of post-diagnosis body mass index (BMI) on survival.



Survival$_{post\text{-}diagnosis}$ represents survival 4-years after the post-diagnosis survey.
U represents the uncontrolled risk factor for mortality.
By restricting the study population to men who survived 4-years after the post-diagnosis survey, a biasing pathway is opened in the presence of an uncontrolled risk factor, U (Post-Diagnosis BMI ← Pre-Diagnosis BMI → Survival$_{post\text{-}diagnosis}$ ← U → Survival).
If the causal diagram is correct, we can control for bias induced by conditioning on Survival$_{post\text{-}diagnosis}$ by estimating the effect of weight change on survival, conditional on both the 1st post-diagnosis weight and Survival$_{post\text{-}diagnosis}$.

Chapter 4 – **Associations of post-diagnosis lifestyle with prognosis among women with invasive breast cancer**

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Abstract

PURPOSE: To investigate the separate and combined associations of post-diagnosis diet, physical activity, and body fatness with breast cancer recurrence, breast cancer-specific mortality, and all-cause mortality among a cohort of women diagnosed with invasive breast cancer. In addition, examine whether post-diagnosis changes in lifestyle are associated with prognosis.

METHODS: We analyzed data from 1,964 women diagnosed with invasive breast cancer who participated in the Kaiser Permanente Northern California Pathways Study. We calculated a total lifestyle score (range: 0–18) based on concordance with 9 recommendations related to diet, physical activity, and body weight from the *American Cancer Society/American Society of Clinical Oncology Breast Cancer Survivorship Guidelines,* using data that was self-reported around the time of diagnosis and approximately 2-years post-diagnosis.

RESULTS: We observed 290 deaths (80 due to breast cancer) over a median follow-up of 9.7 years (IQR=3.8) in the mortality cohort, and 176 recurrences over a median follow-up of 9.5 years (IQR=3.9) years in the recurrence cohort. Using multivariable Cox proportional hazards models, the overall lifestyle score was inversely associated with all-cause mortality (HR per 2-point increase=0.89, 95%CI: 0.82, 0.98), and breast cancer-specific mortality (HR=0.78, 95%CI: 0.65, 0.94), but not breast cancer recurrence. Relative to those who maintained low concordance levels with lifestyle recommendations both before and after diagnosis, while those who maintained high concordance levels had the lowest risk of mortality, there was some suggestion that improving concordance levels was associated with a lower hazard of all-cause mortality, particularly for aerobic physical activity (HR=0.47, 95%CI: 0.26, 0.84).

CONCLUSION: Results suggest that among invasive breast cancer survivors, a healthier post-diagnosis lifestyle may be associated with a lower risk of all-cause mortality and breast cancer-specific mortality. In addition, our findings suggest that adopting certain healthier behaviors, such as aerobic physical activity, after a diagnosis of breast cancer may be associated with improved prognosis.

Introduction

Breast cancer is the most commonly diagnosed cancer among US women, accounting for approximately 15% of all new cancer cases (95). There are more than 3.5 million breast cancer survivors living in the US; an estimate projected to increase to over 4.5 million in the next decade(3). Due to advances in treatment and early detection, women diagnosed with breast cancer are living longer, and 5-year survival rates now approach 90%(1). However, long-term health remains especially important for breast cancer survivors, who are at risk for breast cancer recurrence and increased risk for chronic disease and mortality(4). Among cancer survivors, there is considerable interest in what they can do to improve prognosis. The role of lifestyle on the risk of developing breast cancer is fairly well-established(96), and there is growing evidence suggesting that modifiable lifestyle behaviors in various domains, including diet and physical activity, may play a significant role in symptom management, physical function, and the long-term prognosis in this growing population(4,97).

Post-diagnosis (defined here as >1 year after cancer diagnosis) physical activity, obesity, and certain aspects of diet, such as saturated fat intake, have each been linked separately (with varying levels of evidence) to breast cancer-related outcomes(98–100), with perhaps the most consistent and convincing evidence for physical activity. However, lifestyle behaviors are often correlated (e.g., those who are more physically active often eat a healthier diet and are leaner) and may interact to impact health, which makes studying lifestyle factors independently a challenge. To our knowledge, only two previous studies investigated the combined effects of post-diagnosis behaviors on prognosis among breast cancer survivors(101,102). In the first study, breast cancer survivors with high levels of physical activity combined with a diet high in fruits and vegetables after diagnosis had a lower risk of all-cause mortality than women with low physical activity levels and/or low fruit/vegetable consumption(102). In the second study, breast cancer survivors with high relative to low concordance with World Cancer Research Fund guidelines for cancer prevention (high levels of physical activity; diets rich in vegetables, fruits, whole grains, and legumes, and low in red/processed meats, alcohol, and salt; and healthy body weight) after diagnosis had a lower risk of all-cause mortality and possibly breast cancer mortality(101). While both previous studies provide some support for the possible benefits of engaging in multiple healthy behaviors on overall mortality, neither were able to investigate the impact of post-diagnosis lifestyle on breast cancer recurrence. Moreover, as many cancer survivors may have had previously “unhealthy” lifestyles, investigating whether improvements in lifestyle after diagnosis impact health is of considerable interest.

In this study, among a large cohort of US women diagnosed with invasive breast cancer, we aimed to investigate the separate and combined effects of post-diagnosis body weight, physical activity, and diet on all-cause mortality, breast cancer-specific mortality, and breast cancer recurrence. In addition, we evaluated whether changes in lifestyle factors from pre- to post-diagnosis are associated with breast cancer prognosis.

Methods

Study Population

Using data from the previously described prospective Kaiser Permanente Northern California (KPNC) Pathways Study(103), we identified 4,505 women newly diagnosed with breast cancer from January 2006 to April 2013. Briefly, women were eligible for the Pathways Study if they were: 1) at least 21 years of age; 2) a current KP member; 3) recently diagnosed with invasive breast cancer; 4) not previously diagnosed with a malignant cancer; 5) able to speak English, Spanish, Cantonese, or Mandarin; and 6) living within a 65-mile radius of a field interviewer. Participants completed interviewer- and self-administered questionnaires at baseline (approximately 2 months after diagnosis) and self-administered questionnaires at 6-months, 2-

years, and 4-years after baseline. All aspects of the Pathways Study cohort are reviewed and approved by the institutional review boards of all collaborating institutions.

Breast cancer cases were identified using methods for rapid case ascertainment. After excluding 102 participants who died within 2 years of diagnosis, approximately 38% of women (*n* = 1,715) did not respond to the 2-year post-diagnosis follow-up questionnaire, the primary time point of interest in this study. An additional 14%, 1%, and 1% of women did not provide 2-year post-diagnosis follow-up data on body weight (n=621), physical activity (n=45), and diet (n=58). For our primary analysis, we created two analytic cohorts, the mortality cohort and the recurrence cohort. After excluding women with missing data on body weight, physical activity, and diet at the 2-year post-diagnosis follow-up, our mortality cohort yielded an analytic sample of 1,964. For the recurrence cohort, we additionally excluded living women who experienced a breast cancer recurrence before the 2-year follow-up (n=40), yielding an analytic sample of 1,924.

Exposure Assessment

In order to investigate the combined effects of lifestyle factors on breast cancer prognosis, we created a total lifestyle score based on concordance with 9 recommendations from the *American Cancer Society/American Society of Clinical Oncology (ACS/ASCO) Breast Cancer Survivorship Guidelines*(97) regarding body weight, physical activity, and diet, (all assessed at approximately 2 months, 6 months, and 2 years after diagnosis), calculated using the scoring criteria outlined in **Table 4.1.1**. The main time point of interest was approximately 2 years after diagnosis, so that most participants would have completed active primary treatment. For each of the 9 recommendations, we assigned participants 0 points if they did not meet the recommendation, 1 point if they partially met the recommendation, and 2 points if they fully met the recommendation. Scores for the 9 recommendations (1 recommendaiton for body weight, 3 for physical activity, and 5 for diet) were summed so that the total score ranged from 0–18, with higher scores indicating greater concordance with the guidelines. We also considered each of the 9 recommendations separately.

Body weight was assessed via body mass index (BMI), computed as weight (kg) divided by height squared (m^2), and classified as follows: <18.5 (underweight), 18.5 to <25 (healthy weight), 25 to <30 (overweight), 30+ kg/m^2 (obese). Body weight and height were measured by the field interviewer at baseline, and weight was self-reported by the participant at each follow-up. Missing BMI at baseline (*n* = 15) was backfilled using KPNC electronic health record data.

Physical activity over the previous 6-months was self-reported at baseline, ~6 months post-diagnosis, and ~2 years post-diagnosis using the 47-item Arizona Activity Frequency Questionnaire(104), and used to estimate concordance with three physical activity recommendations (sedentary behavior, aerobic recreational activity, and strength training). Leisure sedentary behavior (hours/week) was calculated based on 6 items from the “other recreational activities” section of the questionnaire (see **Table 4.2.1**) and categorized based on tertiles of distribution. For aerobic recreational activity, we calculated the total metabolic equivalent of task-hours/week (MET-hr/wk) for each moderate-to-vigorous activity (19-items from “sports, exercise, and hobbies” section, see **Table 4.2.1**) as the product of its MET value (105), frequency, and duration. Scores were subsequently summed across all activities, where 8.75 MET-hr/wk is approximately equivalent to 150 minutes of moderate or 75 minutes of vigorous activity. We also calculated the frequency in which the participant engaged in strength training activities (2-items from “sports, exercise, and hobbies” section, see **Table 4.2.1**).

Dietary intake over the previous year was self-reported using a 139-item modified version of the Block 2005 FFQ(106), administered at baseline, ~6 months post-diagnosis, and ~2 years post-diagnosis, and used to estimate concordance with 5 dietary recommendations (consumption of fruit/vegetables, legumes, whole grains, saturated fats, and alcohol). Fruit and vegetable consumption (servings/day) was the sum of 28 line-items and legume intake (servings/day) was the sum of 7 line-items (see **Table 4.2.1**). We used values estimated by NutritionQuest(106) to calculate the percent of total grain intake that was whole (based on 1-ounce equivalents of total grain and whole grain intake), the percent of total energy intake (kcal/day) from saturated fats, total ethanol intake (grams/day), and total energy intake (kcal/day). All dietary components — fruit and vegetable intake (servings/day), legume intake (servings/day), percent of grains that were whole, and percent of total energy intake from saturated fats — were then categorized according to tertiles of their distributions and scored (percent of total energy intake from saturated fats was reverse scored, see **Table 4.1.1**). We divided grams of ethanol intake by 14 to estimate the number of alcoholic beverages per day and categorized as follows: 0 drinks/day, ≤1 drink/day, and >1 drink/day.

Outcome Assessment

Outcomes of interest included all-cause mortality, breast cancer-specific mortality, and breast cancer recurrence. Participants or their relatives were contacted annually through follow-up interviews to ascertain recurrences and cause of deaths. Additional recurrences were identified through the KPNC cancer registry and an algorithm that searched through KPNC electronic databases on an annual basis to identify recurrence-related diagnoses (see **Table 4.2.2** for a list of relevant ICD-9 or ICD-10 codes used to flag potential recurrences or second primary tumors) and care (e.g., the participant reinitiated chemotherapy). All potential events were subsequently verified by medical record review. Recurrences were typically of the same tumor cell type and included local recurrences (original breast cancer in the same breast without lymph node involvement), regional recurrences (original breast cancer with lymph node involvement), and distant recurrences (original breast cancer that spread to a distant site).

Covariates

Information on age, race/ethnicity, education, household income, marital status, menopausal status, and family history of breast cancer were self-reported by the participant at baseline. Tumor characteristics (e.g., stage at diagnosis, ER status), cancer treatments, and clinical characteristics (e.g., comorbidities) were obtained through electronic medical records. Comorbidities were assessed using the Charlson Comorbidity Index(107) (range 0–5).

Statistical Analyses

Cumulative incidence functions for breast cancer recurrence, BCSM, and ACM were produced according to tertiles of the lifestyle score. We used multivariable Cox proportional hazards regression models to produce cause-specific hazard ratios (HR) and their corresponding 95% confidence intervals (CI) to estimate associations of the total lifestyle score with all-cause mortality, breast cancer-specific mortality, and breast cancer recurrence. We examined potential interactions of the lifestyle score with selected characteristics of interest (ER status, tumor stage, menopausal status, age at diagnosis, and smoking status).

In order to examine the relative importance of each of the nine recommendations on associations of the guideline score with the outcomes of interest, we conducted two sets of analyses. First, we included all nine recommendations together in a multivariable Cox proportional hazards regression model to examine their separate associations with the outcomes of interest while adjusting for the other components, as well as other confounding factors. Second, we excluded each of the nine components from the guideline score one-by-one to assess the relative importance of that particular component on the overall lifestyle score-mortality association.

All multivariable models controlled for age (continuous), stage (I, II, III/IV), ER status (positive, negative), chemotherapy (yes, no), Herceptin (yes, no), radiation (yes, no), comorbidities (continuous), smoking status (never, former, current), education level (high school graduate or less, some college, college graduate, post-graduate), and income (<$25,000, ≥$25,000). The following variables did not have a substantial impact on our overall score-mortality/recurrence associations (<5%) and were therefore excluded from models: race/ethnicity, marital status, menopausal status, family history of breast cancer, and total energy intake. Follow-up began on the completion date of the 2-year post-diagnosis survey. For all models, follow-up ended on the death date or December 31, 2018. For recurrence models, follow-up ended on the date of the recurrence, death, or December 31, 2018, whichever came first.

We also wanted to account for the influence of pre-diagnosis lifestyle on the associations of interest, for several reasons: 1) lifestyle changes over time and the effects are likely cumulative; 2) pre-diagnosis lifestyle may confound the relationship between post-diagnosis lifestyle and prognosis; and 3) by accounting for pre-diagnosis lifestyle, we could potentially reduce selection or "collider" bias (12). Therefore, we calculated the lifestyle score as well as concordance with 8 of the 9 recommendations (BMI was excluded from this analysis since it already incorporated both time points) at both baseline (a survey in which much of the recall period occurred prior to diagnosis) and 2-years post-diagnosis. Lifestyle scores were then categorized based on the distribution of scores into low (0–7), partial (8–10), and high concordance (11+). The 8 component scores were categorized and scored as described in **Table 4.1.1**. We then created a composite variable representing the change in lifestyle score calculated from the baseline and the 2-year follow-up surveys with the following levels: 1) maintained high concordance at both time points; 2) maintained partial concordance at both time points; 3) maintained low concordance at both time points; 4) improved concordance from baseline to follow-up; and 5) worsened concordance from baseline to follow-up.

Supplemental analyses – Addressing potential non-response bias

Of primary concern was the potential for nonresponse bias due to the substantial proportion of missing follow-up data to calculate our lifestyle score (55%, see **Table 4.2.3**). It seemed likely that participants with “less healthy” behaviors (and therefore, lower lifestyle scores) would be less likely to respond to the follow-up questionnaire. It also seemed plausible that those at higher risk for mortality may also be less likely to respond to the follow-up questionnaire. As a result, we believed that there was a high likelihood that the data were not missing at random (i.e., the missing data was dependent on its unobserved value). Therefore, we followed a similar approach to Bradshaw and colleagues(108), and conducted a supplemental analysis using a selection model for a Bayesian proportional hazards regression with non-ignorable missing time-varying covariates(109). Briefly, the selection model is used to derive the likelihood and describes the joint distribution of three models: 1) event times; 2) missing covariates; and 3) the probability that covariate data are missing (the latter two of which describe ancillary models containing parameters not of inferential interest). For our selection model, we excluded women who died prior to the 2-year follow-up (n=102) and those with minor amounts of missing data (<5%) for the covariates of interest (n=102), resulting in an analytic sample of 4,301 for the mortality cohort. We additionally excluded those with recurrences occurring before the 2-year follow-up (n=124) in the recurrence cohort, yielding an analytic sample of 4,184.

For the distribution of event times, we used a proportional hazards regression with time-varying covariates in order to estimate the effect of the post-diagnosis lifestyle score on survival time. This model additionally adjusted for age, stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, education level, and income. For the distribution of missing covariates, we used four models, one for the lifestyle score at each of the 3 time points and one for income, which was the only other covariate containing more than 5% missing data. For the lifestyle scores at each time, we used a linear regression model and included variables we thought would be associated with the lifestyle score as predictors in the models, including lifestyle scores at previous time points, age, chemotherapy, menopausal status, race, BMI at baseline, and comorbidities. For missing income, we used a logistic regression model, including age, education, race/ethnicity, and comorbidities as predictors. For our models on the probability that the covariate data were missing, we modeled the probability that the lifestyle score data were missing at each time point using logistic regression models and included age, guideline score at that particular time point, and missing indicators for previous guideline scores as predictors. Since income also had the potential to be missing not at random, we included a logistic model to account for the fact that income may not be missing at random and included age, race, education, and income as predictors.

Analyses to address the potential for non-response bias were conducted using a fully Bayesian approach to parameter estimation using the ‘rjags’ package in R software. We used vague prior distributions, the same as those used in a similar analysis by Bradshaw et al(108). Posterior HRs and 95% posterior credible intervals were estimated from a sampler run for 10,000 iterations, discarding the first 4,000 as the burn-in sample.

Cumulative incidence functions and the Bayesian selection model were conducted using R (version 4.0.3; R Foundation, Vienna, Austria) software. All other analyses were conducted using SAS statistical software (version 9.4; SAS Statistical Institute).

Results

The total lifestyle score ranged 0–18 (median=9, interquartile range=4). Participant characteristics are presented by tertiles of the guideline score (**Table 4.1.2**). Participants with greater guideline concordance were more likely to be Asian, be more educated, and have a higher income.

We observed 290 deaths (80 due to breast cancer) over a median follow-up of 9.7 years (IQR=3.8) in the mortality cohort, and 176 recurrences over a median follow-up of 9.5 years (IQR=3.9) years in the recurrence cohort. Surveys administered at baseline and the first and second follow-ups were completed a median of 0.2 years (IQR=0.1), 0.6 years (IQR=0.1), and 2.1 years (IQR=0.1) after diagnosis, respectively.

The 10-year cumulative incidence of all-cause mortality was almost twice as high among participants in the lowest tertile of the lifestyle score (21%) compared to those in the highest (11%) (**Figure 4.2**). The 10-year cumulative incidence of breast cancer-specific mortality was also higher among participants in the lowest tertile of the lifestyle score (7%) compared to those in the highest (2%). No meaningful differences in the cumulative incidence of recurrence by lifestyle score tertile were observed.

Post-Diagnosis Lifestyle

In multivariable Cox models examining the overall lifestyle score with the outcomes of interest, the lifestyle score was inversely associated with all-cause mortality (HR per 2-point increase=0.89, 95%CI: 0.82, 0.98), and breast cancer-specific mortality (HR=0.78, 95%CI: 0.65, 0.94), though results were less precise for the latter due to limited events (**Table 4.1.3**). We observed no meaningful associations of the lifestyle score with breast cancer recurrence.

In our component model that included each of the 9 recommendations together in a multivariable model, higher intake of legumes and alcohol as well as higher levels of aerobic physical activity and strength training exercises appeared inversely related with all-cause mortality (**Table 4.1.4**). Trends for recommendations regarding fruit/vegetable intake, whole grain consumption, saturated fat intake, and sedentary behavior with all-cause mortality were less clear. We had too few breast cancer events to enable any meaningful interpretation of breast cancer-specific mortality models. Higher intake of legumes and higher levels of aerobic physical activity appeared inversely associated with breast cancer recurrence, while fruit/vegetable consumption appeared positively associated with breast cancer recurrence. We did not observe any trends for any of the other recommendations with breast cancer recurrence that appeared meaningful. Removal of the aerobic physical activity and legume intake recommendations from the overall lifestyle score resulted in the greatest changes in the associations of the reduced scores with all-cause mortality (**Table 4.2.4**). Removal of recommendations regarding body weight, legumes, and strength training resulted in the greatest changes in the associations of the reduced scores with breast cancer-specific mortality. None of the variants of the guideline score were associated with breast cancer recurrence.

Associations of the total lifestyle score with all-cause mortality appeared stronger among women who were postmenopausal (relative to premenopausal) (**Table 4.2.5**). Also, the lifestyle score was inversely associated with all-cause mortality among former and never smokers but was positively associated with mortality among current smokers.

Behavior Change Models

In multivariable models that accounted for the influence of pre-diagnosis lifestyle, women with the highest levels of concordance with the lifestyle guidelines at both baseline (representing pre-diagnosis lifestyle) and approximately 2-years post-diagnosis had approximately half the risk of all-cause mortality relative to women who with lowest levels of concordance at both time points (HR=0.50, 95%CI: 0.32, 0.79; **Table 4.2.6**). Relative to women with the lowest levels of concordance at both time points, the risk of all-cause mortality was lower among women with partial concordance at both time points (HR=0.80, 95%CI: 0.57, 1.12), and women who were less concordant post-diagnosis than they were at baseline (e.g., went from high to low concordance; HR=0.61, 95%CI: 0.41, 0.91).

In our models examining changes in concordance for each of the recommendations, the hazard of all-cause mortality among women who maintained medium or high levels of aerobic physical activity at both baseline and post-diagnosis and women who changed their physical activity levels was less than half that of women who reported no recreational physical activity at both time points (e.g., increasing physical activity levels HR=0.43, 95%CI: 0.24, 0.78) (**Table 4.2.7**). Similar trends were found for legumes, saturated fats, and strength training, though associations were weaker and less precise than those with aerobic physical activity (e.g., changing % of energy from saturated fats from >11.8% at diagnosis to ≤11.8% post-diagnosis vs >11.8% at both time points: HR=0.74, 95%CI: 0.43, 1.25). Relative to those who consumed more than 1 drink/day at both time points, women who reported consuming less alcohol at both time points, and especially those who decreased their alcohol consumption, appeared to have a higher hazard of all-cause mortality (e.g., decreased alcohol consumption, HR=2.22, 95%CI: 1.15, 4.29). Spending less time doing sedentary leisure-time activities at both time points was associated with a somewhat higher hazard of all-cause mortality relative to those who spent >21–54 hours/week (e.g., <14.5 hours/week: HR=1.40, 95%CI: 0.90, 2.17). We did not observe any meaningful trends in our change models for fruits/vegetables or grains. We were unable to examine the component change models with breast cancer-specific mortality due to too few events. In recurrence models, we observed somewhat similar trends to our all-cause mortality results for legumes and saturated fats. The hazard of recurrence appeared somewhat lower among those who maintained physical activity relative to those who were inactive at both time points, though results were substantially weaker with wider confidence intervals than those with all-cause mortality, (e.g., high-high HR=0.70, 95%CI: 0.40, 1.23). Higher relative to lower consumption of fruits and vegetables at both time points appeared associated with a higher hazard of recurrence.

Supplemental Analyses

Results from models accounting for the potential that the data to calculate the lifestyle score were not missing at random were mostly comparable to those from our complete case analysis (the main results), albeit somewhat stronger (**Table 4.2.8**). Findings were similar after excluding deaths occurring within the first two years of the post-diagnosis survey in efforts to mitigate the potential for bias due to reverse causation (**Table 4.2.9**).

Discussion

In this cohort of US breast cancer survivors, we found that overall, a healthier lifestyle, assessed in concordance with the ACS/ASCO breast cancer survivorship guidelines approximately 2 years after breast cancer diagnosis, was associated with a lower risk of mortality due to all causes, especially due to breast cancer, but not with breast cancer recurrence. Many of the individual lifestyle behaviors we considered appeared to contribute to the inverse association of the lifestyle score with all-cause mortality, including aerobic physical activity, legume/nut intake, strength training, and possibly body weight. While the overall lifestyle score was not associated with breast cancer recurrence, some components appeared associated with a lower risk of recurrence, such as legume/nut intake and aerobic physical activity. Importantly, while women who reported healthier lifestyle behaviors both around and after the time of diagnosis had the lowest risk of mortality, there appeared to be some survival advantage when certain behaviors, such as aerobic physical activity levels, were improved after diagnosis.

Combined Lifestyle

To our knowledge, only two previous studies examined the combined effects of post-diagnosis (>1 year after diagnosis) lifestyle on breast cancer prognosis, both of which largely support our findings that a healthier post-diagnosis lifestyle may be associated with lower all-cause and breast cancer-specific mortality(101,102), though methods for lifestyle assessment substantially varied by study. In the first, conducted among early stage breast cancer survivors participating in the Women's Healthy Eating and Living Study, women with both high fruit and vegetable consumption and high levels of physical activity had a lower hazard of all-cause mortality compared to those with low consumption and low physical activity, regardless of obesity(102).

In the other study, conducted among a cohort of older cancer survivors, breast cancer survivors with higher relative to lower lifestyle guideline concordance scores (assessed in concordance with the WCRF/AICR cancer prevention guidelines a median of 8.6 years after diagnosis) had a lower risk of all-cause mortality and possibly breast cancer-specific mortality, though the latter was imprecise due to few events (n=75)(101).

Physical Activity

In our study, recreational aerobic physical activity appeared to have the strongest impact on the association of the lifestyle score with all-cause mortality. We observed lower risks of mortality among those who partially and fully met the recommended levels of physical activity, relative to those who reported being inactive, indicating that any level of physical activity may be beneficial. Importantly, we found that those who reported increasing levels of physical activity after diagnosis had less than half the risk of mortality among those who reported being inactive at both time points, similar to the risk found among those who maintained some level of aerobic physical activity both before and after diagnosis, supporting the idea that improving behaviors after diagnosis may impact survival after all. Most(110–113), but not all(114), previous studies largely support our current findings regarding the benefits of maintained activity on mortality among breast cancer survivors. Findings regarding the benefits of increasing physical activity levels after a breast cancer diagnosis are more mixed, with some studies(110,112,114), but not all(111,113), supporting our current findings. We also observed a lower mortality risk among those who decreased their physical activity levels, which may be largely due to individuals in this category maintaining a physically active lifestyle for a long enough time for prolonged beneficial effects on health.

We also found that engaging in some strength training activities (1–2 days per week) may be associated with a lower mortality risk, though we had too few events among those who engaged in strength training activities to draw any strong conclusions. We observed similar results in our models examining breast cancer-specific mortality and recurrence, though, again, these findings should be interpreted cautiously. Though strength training is less studied than aerobic activity, findings from a recent meta-analysis, conducted among the general population, suggest that strength training, separately and in combination with aerobic activity, may be associated with lower mortality(115). In a secondary analysis of a randomized controlled trial, breast cancer survivors assigned to one year of resistance exercise, compared to a placebo control condition, had lower levels of biomarkers associated with cancer progression(116), providing further support for our findings. Strength training exercises may be particularly important among women treated with chemotherapy, as low muscle mass may be associated with poorer tolerance to chemotherapy and reduced survival(117).

Diet

To our knowledge, we are the first to report that among a cohort of breast cancer survivors, post-diagnosis legume/nut intake appeared strongly and inversely associated with all-cause mortality, and possibly breast cancer-specific mortality and recurrence, though confidence intervals were wide due to few events. The benefits of legume/nut intake on all-cause mortality and possibly, recurrence, were even more apparent when habitual intake of legumes/nuts (pre- to post-diagnosis) was considered. Moreover, those who increased legume intake after diagnosis also appeared to have some survival benefit. The inverse association between legume/nut intake and mortality was previously observed in the general population(118). We observed similar trends with saturated fat intake, although the relationship between post-diagnosis intake of saturated fat and mortality was less clear. Previous studies that examined post-diagnosis saturated fat intake with mortality among breast cancer survivors largely support our findings and suggest a possible positive association with mortality due to all causes and breast cancer(119,120) .

Moderate post-diagnosis alcohol consumption, relative to no consumption, appeared somewhat beneficial with regards to all-cause mortality, though confidence intervals were wide and overlapping. Previous studies conducted among breast cancer survivors suggested a possible inverse or null association between post-diagnosis alcohol intake and mortality(119,121–123). The potential benefits of moderate alcohol consumption on total mortality may be due, in part, to the beneficial effects of alcohol on cardiovascular disease, which has been well-documented in the general population(124). Alternatively, women with more advanced disease may have been more likely to stop drinking and be categorized as "non-drinkers" according to the 2-year post-diagnosis follow-up survey (making this category appear more high risk than it truly is), which could also potentially explain our observed inverse association. Most participants in our study maintained their pre- to post-diagnosis consumption of alcohol (81%) and we had too few events among those who increased their consumption to draw any strong conclusions from our change analysis. The relationship of alcohol consumption with breast cancer-specific mortality and recurrence also remained unclear in our study. Similar to previous studies among cohorts of breast cancer survivors(32,102), post-diagnosis fruit and vegetable consumption as well as the percentage of total grain that is whole did not appear associated with the risk of all-cause mortality.

Body Weight

The risk of mortality in our study was somewhat higher among women who were obese relative to healthy weight at both time points. Although we had too few breast cancer deaths to enable meaningful interpretation of results regarding specific lifestyle behaviors, it appeared that post-diagnosis obesity may be associated with a higher risk of breast cancer-specific mortality, particularly among those who were obese prior to diagnosis as well. These results are somewhat consistent with a previous meta-analysis that found that both pre- and post-diagnosis obesity were associated with higher risk of all-cause mortality (pre-diagnosis BMI [21 studies]:

HR=1.41, 95%CI: 1.29, 1.53; post-diagnosis BMI [5 studies]: HR=1.21, 95%CI: 1.06, 1.38) and breast cancer mortality (pre-diagnosis BMI [22 studies]: HR=1.35, 95%CI: 1.24, 1.47; post-diagnosis BMI [2 studies]: HR=1.68, 95%CI: 0.90, 3.15)(98).

Strengths/Limitations

The results of our study should be considered in context with our study limitations. First, a substantial number of participants in this study were excluded from most analyses because they did not respond to all or parts of the 2-year post-diagnosis follow-up questionnaire, potentially biasing our results, especially if the data were not missing at random (i.e., lifestyle related to responding to the questionnaire). However, in our supplemental analysis that accounted for the fact that the data might not be missing at random, we observed similar associations between the overall lifestyle score with the outcomes of interest as was found in our complete case analysis, suggesting this bias may have minimal impact on our study results. Second, studies conducted among cancer survivor populations may be subject to special type of selection bias, sometimes referred to as “index-event” bias(12), in the presence of uncontrolled risk factors for the outcome when examining an exposure related to cancer incidence. However, if our causal diagram is correct, this bias is unlikely to affect our results regarding changes in lifestyle. Third, our lifestyle score relied on participant self-reported data and may have been subject to misclassification. However, due to the study’s prospective design, exposure misclassification is likely to be non-differential with respect to our outcomes, which we would expect to bias our results comparing high versus low tertiles of concordance towards the null, and is unlikely to account for our positive findings. Fourth, underlying severe disease leading to changes in body weight and death, sometimes referred to as reverse causation, could bias our study results for BMI, making obesity appear less harmful. In models that excluded deaths occurring within the first 2-years of post-diagnosis survey completions in an effort to mitigate potential bias due to reverse causation, our associations between maintained obesity (or overweight-obese) with mortality were mostly similar, albeit somewhat stronger, to our main results, suggesting this bias may have a limited impact on our study results. Lastly, we had too few breast cancer deaths and recurrence cases to enable meaningful interpretation of the individual lifestyle component models. Strengths of our study include the study's prospective design, diverse study population, rapid case ascertainment methods, use of electronic medical records to collect information on tumor and treatment characteristics, and repeated follow-up measures that enabled us to examine changes in lifestyle.

In summary, our results suggest that among women diagnosed with invasive breast cancer a healthier post-diagnosis lifestyle may be associated with a lower risk of all-cause mortality and possibly, breast cancer-specific mortality. Not surprisingly, we found the strongest evidence for the potential benefits of aerobic physical activity on all-cause mortality, though several other factors appeared to contribute to our observed lifestyle-mortality association, including legume/nut intake, strength training, and possibly body weight. Perhaps our most important findings are those supporting the potential benefits of changing certain behaviors (e.g., increasing aerobic activity, and possibly increasing legume/nut intake or decreasing saturated fat intake) after a breast cancer diagnosis. Future studies, particularly well-conducted randomized controlled trials, are needed to confirm the role of post-diagnosis lifestyle on breast cancer prognosis as well as investigate ways to motivate and maintain behavior change, a current challenge.

Figure 4.1. Exclusion of Participants in the Pathways Cohort for the Complete Case Analysis.

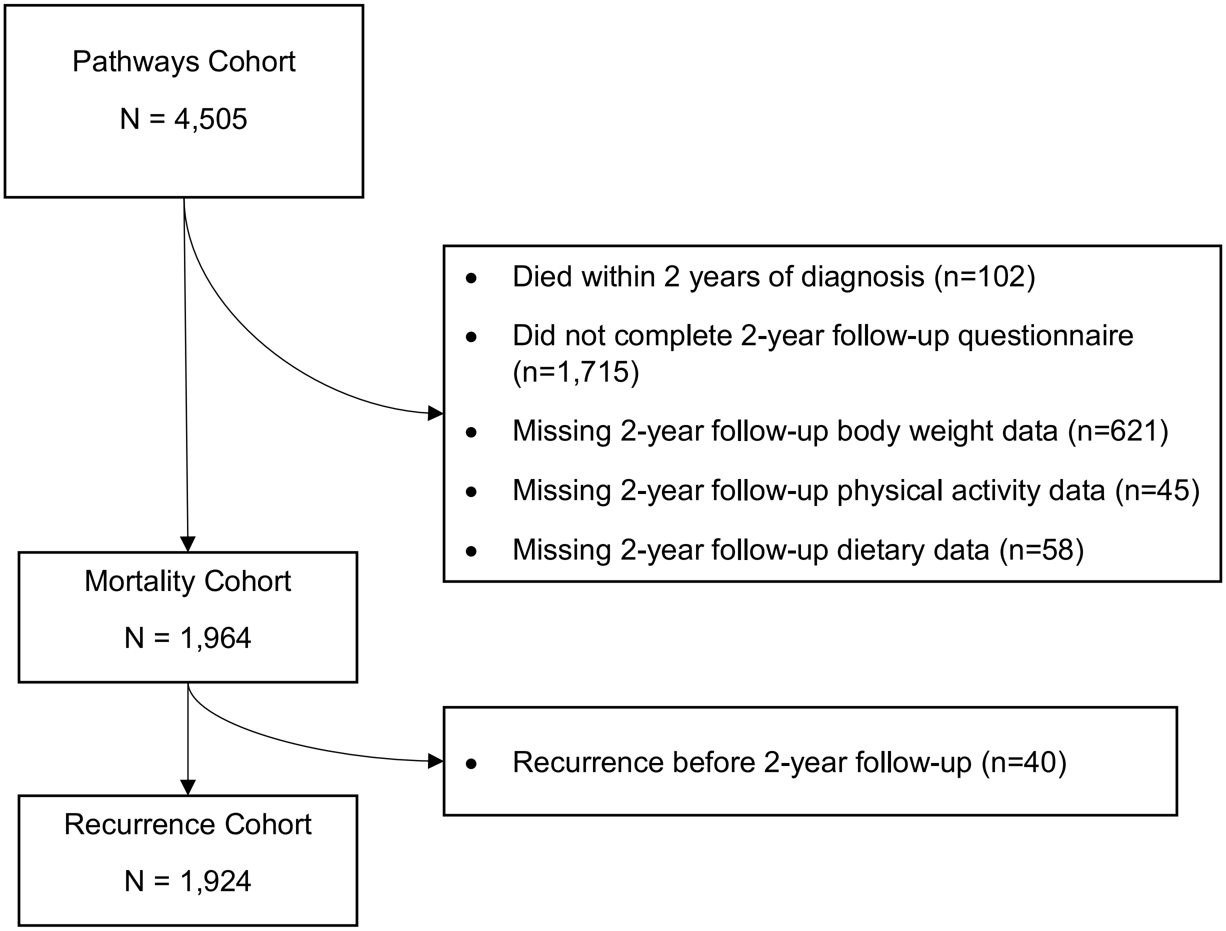

Table 4.1.1. Construction of the Constituents of the American Cancer Society/American Society of Clinical Oncology Recommendations for Breast Cancer Survivorship Score.

Domain	ACS/ASCO Recommendation	Data	Operationalization	Score	N (%)
Obesity	(1) Achieve and maintain a healthy weight;	(1) BMI at baseline and 2-years post-diagnosis	Healthy weight (18.5–<25.0 kg/m^2) at both time points	2	662 (33.7)
			Other combinations	1	696 (35.4)
			Obese (≥30 kg/m^2) at both time points or overweight (25–<30 kg/m^2)-obese	0	608 (30.9)
Physical Activity	1) avoid inactivity and return to normal daily activities as soon as possible following diagnosis;	(1) Sedentary behavior (6-items)	0–14.4 hr/wk	2	668 (34)
			14.5–20.9 hr/wk	1	640 (32.6)
			>21–54 hr/wk	0	658 (33.5)
	(2) aim for at least 150 min of moderate or 75 min of vigorous aerobic exercise per week;	(2) Aerobic recreational activity (19-items)	8.75+ MET hrs/wk	2	989 (50.3)
			0–8.74 MET hrs/week	1	486 (24.7)
			0 MET hrs/week	0	491 (25)
	(3) include strength training exercises at least 2 days per week	(3) Strength training (2-items)	>2 times/week	2	450 (22.9)
			1–2 times/week	1	378 (19.2)
			0 times/week	0	1138 (57.9)
Nutrition	Achieve a dietary pattern that is high in vegetables, fruits, whole grains, and legumes; low in saturated fats; limited in alcohol consumption	(1) Total fruit and vegetable intake frequency (28-items)	5.56+ servings/day	2	663 (33.7)
			3.33–5.56 servings/day	1	659 (33.5)
			0–3.33 servings/day	0	644 (32.8)
		(2) Total legume intake frequency (7-items)	0.32+ servings/day	2	665 (33.8)
			0.09–0.32 servings/day	1	661 (33.6)
			0–0.09 servings/day	0	640 (32.6)
		(3) % grains that are whole	>30.0%	2	658 (33.5)
			12.5–30.0%	1	659 (33.5)
			0–12.5%	0	649 (33.0)
		(4) % energy intake from saturated fats	<9.5%	2	656 (33.4)
			9.5–11.8%	1	669 (34.0)

	>11.8%	0	641 (32.6)
	no alcohol	2	191 (9.7)
(5) Total alcohol intake	≤1 drink/day	1	1424 (72.4)
	>1 drink/day	0	351 (17.9)

Abbreviations: BMI, body mass index

Table 4.1.2. Baseline Characteristics of Women Diagnosed with Invasive Breast Cancer in the Pathways Study According to Tertiles of the Lifestyle Score, 2006–2013.

			Lifestyle Score Tertile		
Variable	**Categories**	**Total**	**1 – Lowest concordance**	**2**	**3 – highest concordance**
		N=1964	**N=656**	**N=693**	**N=615**
		N (%)	**N (%)**	**N (%)**	**N (%)**
Race/ethnicity					
	White	1403 (71.4)	499 (76.1)	482 (69.6)	422 (68.6)
	Black	91 (4.6)	35 (5.3)	34 (4.9)	22 (3.6)
	Asian	236 (12)	43 (6.6)	92 (13.3)	101 (16.4)
	Hispanic	187 (9.5)	59 (9)	71 (10.2)	57 (9.3)
	Other	47 (2.4)	20 (3)	14 (2)	13 (2.1)
Education Status					
	HS grad or Less	264 (13.5)	119 (18.2)	80 (11.6)	65 (10.6)
	Some college	635 (32.4)	264 (40.3)	227 (32.9)	144 (23.4)
	College grad	564 (28.8)	168 (25.6)	208 (30.1)	188 (30.6)
	Post-graduate	498 (25.4)	104 (15.9)	176 (25.5)	218 (35.4)
Household Income					
	< $25K	160 (9.1)	75 (13.1)	44 (7.1)	41 (7.4)
	$25K-69K	671 (38.3)	257 (44.8)	237 (38)	177 (31.8)
	>= $70K	923 (52.6)	242 (42.2)	343 (55)	338 (60.8)
Marital Status					
	Married/Marriage-like	1262 (64.5)	374 (57.1)	460 (66.8)	428 (69.8)
	Single/separated/divorced	695 (35.5)	281 (42.9)	229 (33.2)	185 (30.2)
Menopausal Status					

Variable	Categories	Total	Lifestyle Score Tertile 1 – Lowest concordance	2	3 – highest concordance
	Premenopausal	469 (23.9)	99 (15.1)	160 (23.1)	210 (34.1)
	Postmenopausal	1495 (76.1)	557 (84.9)	533 (76.9)	405 (65.9)
Family hx of BC					
	No	1549 (79.2)	507 (77.6)	562 (81.3)	480 (78.3)
	Yes	408 (20.8)	146 (22.4)	129 (18.7)	133 (21.7)
Tumor Stage					
	Stage I	1131 (57.9)	367 (56)	399 (57.8)	365 (59.8)
	Stage II	640 (32.7)	218 (33.3)	222 (32.2)	200 (32.8)
	Stage III	172 (8.8)	65 (9.9)	63 (9.1)	44 (7.2)
	Stage IV	12 (0.6)	5 (0.8)	6 (0.9)	1 (0.2)
Tumor Subtype					
	Luminal A	979 (51.7)	350 (55.1)	321 (48.1)	308 (52)
	Luminal B	644 (34)	205 (32.3)	237 (35.5)	202 (34.1)
	Her2-Enriched	84 (4.4)	22 (3.5)	37 (5.5)	25 (4.2)
	Triple Negative	188 (9.9)	58 (9.1)	73 (10.9)	57 (9.6)
Chemotherapy					
	No	1099 (56.2)	389 (59.7)	371 (53.6)	339 (55.3)
	Yes	858 (43.8)	263 (40.3)	321 (46.4)	274 (44.7)
Radiation Therapy					
	No	1042 (53.1)	348 (53)	358 (51.7)	336 (54.6)
	Yes	922 (46.9)	308 (47)	335 (48.3)	279 (45.4)
Herceptin					

Variable	Categories	Total	Lifestyle Score Tertile 1 – Lowest concordance	2	3 – highest concordance
	No	1790 (91.5)	606 (92.9)	619 (89.5)	565 (92.2)
	Yes	167 (8.5)	46 (7.1)	73 (10.5)	48 (7.8)
Smoking Status	Never	1142 (58.2)	344 (52.4)	398 (57.4)	400 (65.0)
	Former	763 (2.8)	287 (43.8)	273 (39.4)	203 (33.0)
	Current	5 (0.3)	24 (3.7)	19 (2.7)	11 (1.8)
		Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age at diagnosis		61.2 (11.54)	64.1 (11.05)	61.3 (11.39)	57.9 (11.37)
Charlson comorbidity index		0.2 (0.64)	0.3 (0.85)	0.2 (0.6)	0.1 (0.31)

Figure 4.2. Cumulative Incidence of All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence Women Diagnosed with Invasive Breast Cancer in the Pathways Study, According to Tertiles of the Lifestyle Score, 2006–2018.

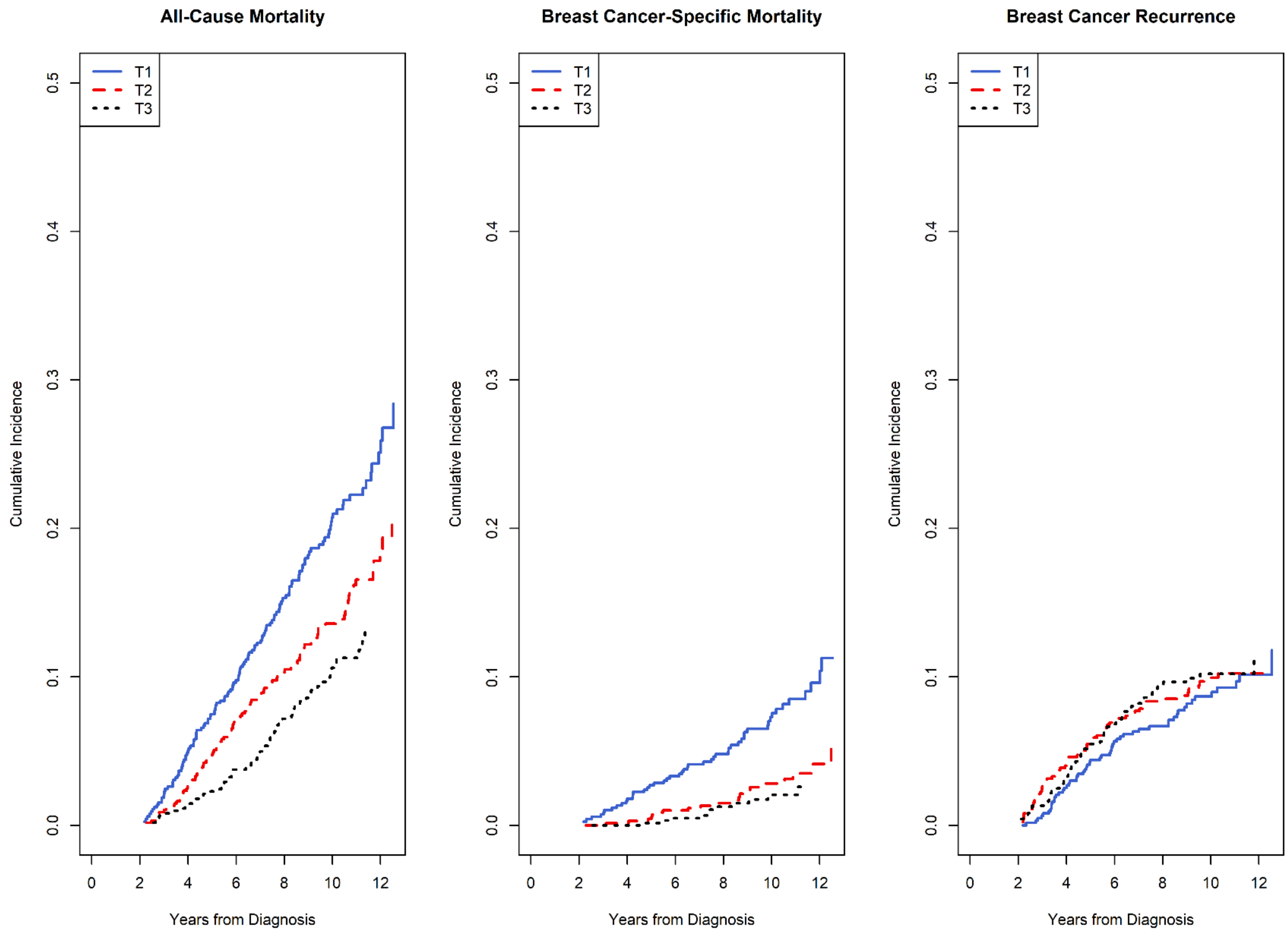

Table 4.1.3. Hazard Ratios and 95% Confidence Intervals for the Association of the Lifestyle Score with All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence

		Complete Case Analysis			
		Model 1		Model 2	
		# Events	HR (95% CI)	# Events	HR (95% CI)
		All-Cause Mortality			
Score tertile (range)	1 (0–7)	133	1.00 (-)	130	1.00 (-)
	2 (8–10)	98	0.78 (0.60, 1.02)	96	0.90 (0.68, 1.20)
	3 (11–18)	59	0.64 (0.47, 0.87)	57	0.73 (0.51, 1.05)
Continuous, per 2 point increase			0.87 (0.80, 0.94)		0.89 (0.82, 0.98)
		Breast Cancer-Specific Mortality			
Score tertile (range)	1 (0–7)	49	1.00 (-)	42	1.00 (-)
	2 (8–10)	20	0.47 (0.28, 0.79)	20	0.51 (0.29, 0.90)
	3 (11–18)	11	0.41 (0.21, 0.80)	11	0.67 (0.33, 1.34)
Continuous, per 2 point increase			0.74 (0.63, 0.86)		0.78 (0.65, 0.94)
		Breast Cancer Recurrence			
Score tertile (range)	1 (0–7)	63	1.00 (-)	62	1.00 (-)
	2 (8–10)	51	1.04 (0.72, 1.49)	49	1.07 (0.73, 1.58)
	3 (11–18)	62	1.06 (0.73, 1.55)	61	1.11 (0.74, 1.66)
Continuous, per 2 point increase			1.00 (0.90, 1.11)		0.98 (0.88, 1.10)

Abbreviations: HR, hazard ratio; CI, confidence interval
Model 1 adjusts for age only. Mortality cohort (n= 1,964); Recurrence cohort (n=1,924).
Model 2 adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level. Observations were additionally excluded due to missing covariates in the mortality cohort (n=311) and the recurrence cohort (n = 301). Mortality cohort (n= 1,653); Recurrence cohort (n=1,623).

Table 4.1.4. Hazard Ratios and 95% Confidence Intervals for Associations[a] of each of the 9 Components of the Lifestyle Score with All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence.

		All-Cause Mortality		Breast Cancer-Specific Mortality		Breast Cancer Recurrence	
Recommendation	**Category**	**# Events**	**HR (95% CI)**	**# Events**	**HR (95% CI)**	**# Events**	**HR (95% CI)**
Fruits/Vegetables	0–3.33 svg/d	80	1.00 (-)	30	1.00 (-)	44	1.00 (-)
	3.33–5.56 svg/d	83	1.24 (0.91, 1.69)	25	0.94 (0.54, 1.65)	51	1.23 (0.82, 1.86)
	5.56+ svg/d	68	1.20 (0.85, 1.70)	14	0.79 (0.39, 1.57)	53	1.49 (0.97, 2.29)
	per 2 svg/d increase		1.02 (0.92, 1.12)		0.94 (0.76, 1.16)		1.08 (0.98, 1.21)
Legumes	0–0.09 svg/d	99	1.00 (-)	38	1.00 (-)	53	1.00 (-)
	0.09–0.32 svg/d	74	0.92 (0.68, 1.25)	16	0.56 (0.31, 1.02)	54	0.97 (0.66, 1.43)
	0.32+ svg/d	58	0.66 (0.47, 0.94)	15	0.57 (0.29, 1.10)	41	0.67 (0.44, 1.03)
	per 2 svg/d increase		0.40 (0.18, 0.89)		0.52 (0.10, 2.70)		0.48 (0.20, 1.15)
% of grains that are whole	0–12.5%	80	1.00 (-)	26	1.00 (-)	47	1.00 (-)
	12.5–30.0%	74	1.15 (0.83, 1.58)	19	1.04 (0.55, 1.95)	53	1.09 (0.73, 1.62)
	> 30.0%	77	1.15 (0.83, 1.59)	24	1.24 (0.68, 2.28)	48	0.99 (0.65, 1.51)
	Per 2% increase		1.00 (0.99, 1.02)		1.00 (0.97, 1.03)		1.00 (0.98, 1.02)
% calories from saturated fats	<9.5%	74	1.00 (-)	32	1.00 (-)	46	1.00 (-)
	9.5–11.8%	73	0.87 (0.62, 1.21)	15	0.47 (0.23, 0.93)	50	1.06 (0.70, 1.59)
	>11.8%	84	1.05 (0.76, 1.47)	22	1.12 (0.62, 2.04)	52	1.13 (0.75, 1.72)
	Per 2% increase		1.02 (0.92, 1.14)		1.11 (0.92, 1.34)		1.03 (0.91, 1.17)
Alcohol	Nondrinker	32	1.00 (-)	12	1.00 (-)	17	1.00 (-)
	≤1 drink/d	163	0.81 (0.55, 1.21)	47	1.00 (0.51, 1.98)	100	0.75 (0.44, 1.27)
	>1 drink/d	36	0.70 (0.43, 1.15)	10	1.30 (0.52, 3.25)	31	0.90 (0.48, 1.67)
	Per 2 drinks/d increase		0.94 (0.69, 1.29)		1.02 (0.57, 1.82)		1.02 (0.70, 1.48)
Aerobic	0 MET hrs/wk	107	1.00 (-)	35	1.00 (-)	38	1.00 (-)
	0-<8.75 MET hrs/wk	47	0.58 (0.41, 0.83)	11	0.64 (0.32, 1.30)	38	0.86 (0.53, 1.37)
	8.75+ MET hrs/wk	77	0.55 (0.39, 0.76)	23	1.05 (0.57, 1.95)	72	0.84 (0.54, 1.31)
	Per 3.5 MET hr/wk increase		0.97 (0.94, 1.00)		1.03 (0.96, 1.09)		0.97 (0.94, 1.01)
Strength	None	165	1.00 (-)	56	1.00 (-)	87	1.00 (-)
	1–2x/wk	24	0.63 (0.41, 0.98)	3	0.26 (0.08, 0.87)	23	0.81 (0.51, 1.29)
	>2x/wk	42	0.99 (0.69, 1.42)	10	0.89 (0.43, 1.85)	38	1.26 (0.84, 1.89)

Sedentary	0–14.4 hr/wk	68	1.00 (-)	30	1.00 (-)	52	1.00 (-)
	14.5–20.9 hr/wk	73	0.91 (0.65, 1.27)	19	0.65 (0.33, 1.26)	45	0.89 (0.59, 1.34)
	> 21–54 hr/wk	90	0.93 (0.67, 1.30)	20	0.87 (0.48, 1.61)	51	0.97 (0.64, 1.46)
	Per 2hr/wk increase		0.97 (0.94, 1.00)		0.96 (0.91, 1.03)		1.00 (0.96, 1.04)
Body Weight[b]	Normal-Normal	50	1.00 (-)	32	1.00 (-)	37	1.00 (-)
	Other	100	1.20 (0.85, 1.68)	26	1.59 (0.75, 3.36)	68	1.30 (0.87, 1.94)
	Obese-obese or overweight-obese	81	1.23 (0.85, 1.78)	11	3.28 (1.55, 6.94)	43	1.15 (0.72, 1.83)

[a] Model includes all 9 recommendations together in a multivariable Cox model and additionally adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level. Mortality cohort (n= 1653); Recurrence cohort (n=1623). No collinearity issues were identified.

[b] Body weight at baseline and 2-years post-diagnosis.

Table 4.2.1. Individual line-items Involved in Calculating Concordance with the American Cancer Society/American Society of Clinical Oncology Breast Cancer Survivorship Guidelines.

Recommendation	Line Items Involved
≥ 150 minutes of moderate or 75 minutes of vigorous aerobic exercise per week	Running or jogging; swimming; bicycle riding; Stairmaster, elliptical; aerobic dance or exercise class; cross-country skiing, rowing; downhill skiing, ice skating, roller blading; hiking or backpacking; walking for pleasure at a brisk pace; walking the dog (if intense); volleyball; tennis, racquet ball, squash; soccer, basketball; baseball, softball; golf (not using cart); golf (using cart), bowling; horseback riding; fly fishing, hunting; social, folk dancing; jazz, ballet, modern tap, hip hop, ethnic dance
Limiting sedentary activity	Arts & crafts projects (such as knitting, quilting, model building, drawing, painting); reading, writing, being on a computer other than at work; socializing, visiting with friends, talking on the phone; attending religious, social or service club meetings, sporting events, concerts, movies, or shows; watching TV, videos (while not doing other activities); playing board or card games
2 days/week of strength training	Sit-up, push-ups, calisthenics, floor exercise, or core strengthening exercises; and weight lifting, free weights, circuit training
Fruits/vegetables	Bananas; apples or pears; oranges or tangerines; grapefruit; peaches or nectarines; cantaloupe; strawberries or other berries; watermelon; other fresh fruits like grapes, plums, honeydew, mango; canned fruit like applesauce, fruit cocktail, canned peaches, or canned pineapple.
Legumes	Edamame, boiled green soybeans; pinto beans, black beans, chili with beans, baked beans; split pea, bean, or lentil soup; peanuts; soynuts, roasted soy beans; refried beans or bean burritos.

Table 4.2.2. List of the International Classification of Diseases (ICD) codes based on the 9th and 10th revisions used to identify breast cancer recurrences in the Pathways Study.

ICD-9	ICD-9 Diagnosis Description	ICD-10	ICD-10 Diagnosis Description
155.2	Malignant neoplasm of liver, not specified as primary or secondary	C22.9	Malignant neoplasm of liver, not specified as primary or secondary
174.9	Malignant neoplasm of breast (female), unspecified	C50.911	Malignant neoplasm of unspecified site of right female breast
174.9	Malignant neoplasm of breast (female), unspecified	C50.912	Malignant neoplasm of unspecified site of left female breast
174.9	Malignant neoplasm of breast (female), unspecified	C50.919	Malignant neoplasm of unspecified site of unspecified female breast
196.0	Secondary and unspecified malignant neoplasm of lymph nodes of head, face, and neck	C77.0	Secondary and unspecified malignant neoplasm of lymph nodes of head, face and neck
196.1	Secondary and unspecified malignant neoplasm of intrathoracic lymph nodes	C77.1	Secondary and unspecified malignant neoplasm of intrathoracic lymph nodes
196.2	Secondary and unspecified malignant neoplasm of intra-abdominal lymph nodes	C77.2	Secondary and unspecified malignant neoplasm of intra-abdominal lymph nodes
196.3	Secondary and unspecified malignant neoplasm of lymph nodes of axilla and upper limb	C77.3	Secondary and unspecified malignant neoplasm of axilla and upper limb lymph nodes
196.5	Secondary and unspecified malignant neoplasm of lymph nodes of inguinal region and lower limb	C77.4	Secondary and unspecified malignant neoplasm of inguinal and lower limb lymph nodes
196.6	Secondary and unspecified malignant neoplasm of intrapelvic lymph nodes	C77.5	Secondary and unspecified malignant neoplasm of intrapelvic lymph nodes
196.8	Secondary and unspecified malignant neoplasm of lymph nodes of multiple sites	C77.8	Secondary and unspecified malignant neoplasm of lymph nodes of multiple regions
196.9	Secondary and unspecified malignant neoplasm of lymph nodes, site unspecified	C77.9	Secondary and unspecified malignant neoplasm of lymph node, unspecified
197.0	Secondary malignant neoplasm of lung	C78.00	Secondary malignant neoplasm of unspecified lung
197.0	Secondary malignant neoplasm of lung	C78.01	Secondary malignant neoplasm of right lung
197.0	Secondary malignant neoplasm of lung	C78.02	Secondary malignant neoplasm of left lung
197.1	Secondary malignant neoplasm of mediastinum	C78.1	Secondary malignant neoplasm of mediastinum
197.2	Secondary malignant neoplasm of pleura	C78.2	Secondary malignant neoplasm of pleura
197.3	Secondary malignant neoplasm of other respiratory organs	C78.30	Secondary malignant neoplasm of unspecified respiratory organ
197.3	Secondary malignant neoplasm of other respiratory organs	C78.39	Secondary malignant neoplasm of other respiratory organs
197.4	Secondary malignant neoplasm of small intestine including duodenum	C78.4	Secondary malignant neoplasm of small intestine
197.5	Secondary malignant neoplasm of large intestine and rectum	C78.5	Secondary malignant neoplasm of large intestine and rectum
197.6	Secondary malignant neoplasm of retroperitoneum and peritoneum	C78.6	Secondary malignant neoplasm of retroperitoneum and peritoneum
197.7	Malignant neoplasm of liver, secondary	C78.7	Secondary malignant neoplasm of liver and intrahepatic bile duct
197.8	Secondary malignant neoplasm of other digestive organs and spleen	C78.7	Secondary malignant neoplasm of liver and intrahepatic bile duct
197.8	Secondary malignant neoplasm of other digestive organs and spleen	C78.80	Secondary malignant neoplasm of unspecified digestive organ
197.8	Secondary malignant neoplasm of other digestive organs and spleen	C78.89	Secondary malignant neoplasm of other digestive organs
198.0	Secondary malignant neoplasm of kidney	C79.00	Secondary malignant neoplasm of unspecified kidney and renal pelvis

198.0	Secondary malignant neoplasm of kidney	C79.01	Secondary malignant neoplasm of right kidney and renal pelvis
198.0	Secondary malignant neoplasm of kidney	C79.02	Secondary malignant neoplasm of left kidney and renal pelvis
198.1	Secondary malignant neoplasm of other urinary organs	C79.10	Secondary malignant neoplasm of unspecified urinary organs
198.1	Secondary malignant neoplasm of other urinary organs	C79.11	Secondary malignant neoplasm of bladder
198.1	Secondary malignant neoplasm of other urinary organs	C79.19	Secondary malignant neoplasm of other urinary organs
198.2	Secondary malignant neoplasm of skin	C79.2	Secondary malignant neoplasm of skin
198.3	Secondary malignant neoplasm of brain and spinal cord	C79.31	Secondary malignant neoplasm of brain
198.4	Secondary malignant neoplasm of other parts of nervous system	C79.32	Secondary malignant neoplasm of cerebral meninges
198.4	Secondary malignant neoplasm of other parts of nervous system	C79.40	Secondary malignant neoplasm of unspecified part of nervous system
198.4	Secondary malignant neoplasm of other parts of nervous system	C79.49	Secondary malignant neoplasm of other parts of nervous system
198.5	Secondary malignant neoplasm of bone and bone marrow	C79.51	Secondary malignant neoplasm of bone
198.5	Secondary malignant neoplasm of bone and bone marrow	C79.52	Secondary malignant neoplasm of bone marrow
198.6	Secondary malignant neoplasm of ovary	C79.60	Secondary malignant neoplasm of unspecified ovary
198.6	Secondary malignant neoplasm of ovary	C79.61	Secondary malignant neoplasm of right ovary
198.6	Secondary malignant neoplasm of ovary	C79.62	Secondary malignant neoplasm of left ovary
198.7	Secondary malignant neoplasm of adrenal gland	C79.70	Secondary malignant neoplasm of unspecified adrenal gland
198.7	Secondary malignant neoplasm of adrenal gland	C79.71	Secondary malignant neoplasm of right adrenal gland
198.7	Secondary malignant neoplasm of adrenal gland	C79.72	Secondary malignant neoplasm of left adrenal gland
198.81	Secondary malignant neoplasm of breast	C79.81	Secondary malignant neoplasm of breast
198.82	Secondary malignant neoplasm of genital organs	C79.82	Secondary malignant neoplasm of genital organs
198.89	Secondary malignant neoplasm of other specified sites	C79.89	Secondary malignant neoplasm of other specified sites
198.89	Secondary malignant neoplasm of other specified sites	C79.9	Secondary malignant neoplasm of unspecified site

Abbreviations: ICD-9, International Classification of Diseases, 9th revision; ICD-10, International Classification of Diseases, 10th revision

Table 4.2.3. Descriptive characteristics among 4,403[a] women diagnosed with invasive breast cancer in the Pathways Cohort, 2006–2018

Variable	*n*	%[b]
Deaths through December 31, 2018		
All causes	703	16.0
Breast cancer	188	4.3
Recurrences through December 31, 2018	527	12.0
BMI, baseline		
Underweight (<18.5 kg/m^2)	42	1.0
Normal (18.5–<25 kg/m^2)	1419	32.2
Overweight (25–<30 kg/m^2)	1396	31.7
Obese (≥30 kg/m^2)	1546	35.1
BMI, 2-years post-diagnosis		
Underweight (<18.5 kg/m^2)	26	1.3
Normal (18.5–<25 kg/m2)	796	38.3
Overweight (25–<30 kg/m^2)	668	32.2
Obese (≥30 kg/m^2)	586	28.2
Missing	2327	
Recreational aerobic activity		
0 MET hrs/week	548	25.8
0–<8.75 MET hrs/week	523	24.6
≥8.75	1055	49.6
Missing	2277	
Strength training		
<1 time/month	1235	58.1
1–2 times/week	412	19.4
>2 times/week	479	22.5
Missing	2277	
Leisure-time sedentary behavior		

0–14.4 hr/wk	731	34.3
14.5–20.9 hr/wk	694	32.6
> 21–54 hr/wk	705	33.1
Missing	2273	
Diet Score		
0–4	868	41.3
5–7	388	18.5
8–12	846	40.3
Missing	2301	
Alcohol use		
Non-drinker	371	10.2
≤1 drink/day	1516	72.1
>1 drink/day	215	17.7
Missing	2301	
Race/ethnicity		
White	2831	64.3
Black	343	7.8
Asian	572	13.0
Hispanic/Other	657	14.9
Education		
High school graduate or less	687	15.6
Some college	1525	34.7
College graduate	1218	27.7
Post-graduate	965	22.0
Missing	8	
Household income		
< $25K	420	10.8
$25k–69K	1480	38.1
$70K+	1983	51.1

Missing	520	
Marital Status		
Married/Married like	2689	61.3
Single/separated/divorced	1698	38.7
Missing	16	
Menopausal Status		
Pre	1324	30.1
Post	3079	69.9
Family history of breast cancer		
No	3473	79.3
Yes	905	20.7
Missing	25	
Tumor stage		
Stage I	2410	55.0
Stage II	1518	34.7
Stage III	398	9.1
Stage IV	55	1.3
Missing	22	
Tumor subtype		
Luminal A	2196	51.8
Luminal B	1375	32.4
HER2-enriched	196	4.6
Triple-negative	474	11.2
Missing	162	
Chemotherapy		
Yes	2079	47.2
No	2311	52.5
Missing	13	
Radiation therapy		

Yes	1940	44.1
No	2463	55.9
Hormone therapy		
Yes	3293	74.8
No	1084	24.6
Missing	26	
Herceptin		
Yes	4010	91.1
No	380	8.6
Missing	13	
Age at diagnosis	59.1 ± 12.01	
Charlson comorbidity index	0.2 ± 0.67	

[a] Excludes those who died prior to the 2-year post-diagnosis survey or 2 years after completing the baseline questionnaire (if the 2nd follow-up survey was not completed).
[b] Percents are among participants with non-missing data.

Table 4.2.4. Hazard Ratios and 95% Confidence Intervals for Associations[a] of the Reduced Lifestyle Scores (Removing One Component at a Time) with All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence.

	All-cause mortality		Breast Cancer-Specific Mortality		Breast Cancer Recurrence	
Score variant	**HR (95%CI)**	**Proportional change in HR[b] (%)**	**HR (95%CI)**	**Proportional change in HR[b] (%)**	**HR (95%CI)**	**Proportional change in HR[b] (%)**
Score overall	0.89 (0.82, 0.98)	0.0	0.78 (0.65, 0.94)	0.0	0.98 (0.88, 1.10)	0.0
Minus fruits/vegetables	0.87 (0.79, 0.96)	2.2	0.77 (0.63, 0.94)	1.3	0.95 (0.84, 1.08)	3.1
Minus legumes	0.91 (0.82, 1.00)	-2.2	0.80 (0.66, 0.97)	-2.6	1.01 (0.89, 1.14)	-3.1
Minus grains	0.87 (0.79, 0.96)	2.2	0.73 (0.60, 0.90)	6.4	0.98 (0.86, 1.11)	0.0
Minus saturated fats	0.88 (0.80, 0.97)	1.1	0.77 (0.63, 0.94)	1.3	0.99 (0.87, 1.11)	-1.0
Minus alcohol	0.88 (0.80, 0.96)	1.1	0.77 (0.64, 0.92)	1.3	0.98 (0.87, 1.10)	0.0
Minus aerobic activity	0.93 (0.84, 1.03)	-4.5	0.76 (0.62, 0.93)	2.6	0.98 (0.87, 1.12)	0.0
Minus strength training	0.90 (0.81, 0.99)	-1.1	0.79 (0.65, 0.96)	-1.3	0.96 (0.85, 1.09)	2.0
Minus sedentary	0.88 (0.80, 0.97)	1.1	0.76 (0.63, 0.92)	2.6	0.98 (0.87, 1.10)	0.0
Minus body weight	0.90 (0.81, 0.99)	-1.1	0.83 (0.69, 1.01)	-6.4	0.99 (0.87, 1.12)	-1.0

Abbreviations: CI, confidence intervals; HR, hazard ratio

[a] Adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level

[b] HR is per 2 point increase in the guideline score variant

[c] Calculated according to the following formula, $\frac{HR-HR\prime}{HR} \times 100$, where HR is the hazard ratio from the full score and HR’ is the hazard ratio from the reduced score

Table 4.2.5. Interactions Between the Lifestyle score and Selected Characteristics with All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence in the Pathways Study.

Characteristic	All-Cause Mortality		Breast Cancer Mortality		Recurrence	
	# Events	HR[a] (95%CI)	# Events	HR[a] (95%CI)	# Events	HR[a] (95%CI)
ER Status						
ER -	41	0.81 (0.65, 1.01)	7	0.70 (0.41, 1.17)	28	0.82 (0.62, 1.09)
ER +	201	0.91 (0.83, 1.01)	63	0.80 (0.66, 0.96)	124	1.01 (0.90, 1.15)
Stage						
Stage I	104	0.94 (0.83, 1.07)	40	0.84 (0.67, 1.05)	51	1.14 (0.95, 1.37)
Stage II	90	0.88 (0.76, 1.02)	21	0.73 (0.53, 1.01)	66	0.89 (0.75, 1.06)
Stage III/IV	48	0.83 (0.68, 1.03)	9	0.57 (0.31, 1.07)	35	0.95 (0.75, 1.19)
Menopausal Status						
Pre	39	0.86 (0.69, 1.08)	3	0.41 (0.16, 1.01)	39	1.04 (0.83, 1.30)
Post	203	0.89 (0.81, 0.98)	67	0.81 (0.67, 0.97)	113	0.96 (0.84, 1.10)
Age						
< 55 years	40	0.84 (0.68, 1.04)	3	0.28 (0.09, 0.89)	43	1.11 (0.90, 1.36)
≥ 55 years	202	0.90 (0.82, 1.00)	67	0.82 (0.68, 0.98)	109	0.94 (0.82, 1.07)
Smoking Status						
Never	110	0.90 (0.79, 1.03)	26	0.64 (0.47, 0.87)	90	0.95 (0.82, 1.10)
Former	120	0.87 (0.77, 0.99)	35	0.79 (0.62, 1.01)	60	1.02 (0.86, 1.21)
Current	12	1.20 (0.76, 1.90)	9	1.49 (0.90, 2.46)	2	1.21 (0.41, 3.58)
2-years post-diagnosis Body Mass Index*						
Healthy Weight	68	0.95 (0.80, 1.13)	15	1.03 (0.72, 1.48)	46	0.93 (0.75, 1.15)
Overweight	77	0.85 (0.72, 1.01)	21	0.84 (0.60, 1.17)	54	1.04 (0.85, 1.29)
Obese	94	0.89 (0.75, 1.07)	33	0.65 (0.47, 0.91)	50	1.00 (0.79, 1.26)

[a] HR is per 2-unit increase of the lifestyle score. Model adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level.

[b] The HR is per 2-unit increase of the reduced lifestyle score that excludes BMI. Also excluded n=19 underweight participants in both the mortality and recurrence cohorts.

Table 4.2.6. Multivariate Cox Proportional Hazards Models for the Associations of Changes in Lifestyle on All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence in the Pathways Study.

	All-Cause Mortality		Breast Cancer-Specific Mortality		Breast Cancer Recurrence	
Concordance Level	**# events**	**HR[a] (95%CI)**	**# events**	**HR[a] (95%CI)**	**# events**	**HR[a] (95%CI)**
Maintained Low[b]	75	1.00 (-)	26	1.00 (-)	27	1.00 (-)
Maintained Partial[c]	35	0.73 (0.49, 1.10)	7	0.45 (0.19, 1.07)	19	0.83 (0.46, 1.50)
Maintained High[d]	26	0.50 (0.32, 0.79)	8	0.67 (0.30, 1.54)	36	1.48 (0.88, 2.47)
Improved[e]	44	0.90 (0.62, 1.31)	10	0.71 (0.33, 1.50)	33	1.51 (0.91, 2.51)
Worsened[f]	39	0.63 (0.43, 0.93)	12	0.57 (0.28, 1.17)	28	1.04 (0.61, 1.77)

Abbreviations: CI, confidence intervals; HR, hazard ratio

[a] Adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level.

[b] Participant in lowest category of guideline concordance (lifestyle score <7) at both baseline and 2-years post-diagnosis.

[c] Participant in the middle category of guideline concordance (lifestyle score 8–10) at both baseline and 2-years post-diagnosis.

[d] Participant in the highest category of guideline concordance (lifestyle score 11+) at both baseline and 2-years post-diagnosis.

[e] Participant improved category of guideline concordance from baseline to 2 years post-diagnosis (e.g., participant went from being in the lowest category of concordance at baseline to being in the middle category 2 years post-diagnosis).

[f] Participant worsened category of guideline concordance from baseline to 2 years post-diagnosis (e.g., participant went from being in the highest category of concordance at baseline to being in the middle category 2 years post-diagnosis).

Table 4.2.7. Multivariate Cox Proportional Hazards Models for the Associations of Changes in Components of the Lifestyle Score on All-Cause Mortality and Breast Cancer Recurrence in the Pathways Study.

		All-Cause Mortality		Breast Cancer Recurrence	
Component	**Concordance Level**	**Events**	**HR[a] (95%CI)**	**Events**	**HR[a] (95%CI)**
Fruits/vegetables	Maintained Low[b]	54	1.00 (-)	27	1.00 (-)
	Maintained Partial[c]	66	1.19 (0.82, 1.74)	38	1.26 (0.75, 2.09)
	Maintained High[d]	37	0.93 (0.59, 1.47)	37	1.56 (0.91, 2.67)
	Improved[e]	18	1.56 (0.89, 2.73)	14	1.80 (0.91, 3.55)
	Worsened[f]	48	0.83 (0.55, 1.25)	28	0.94 (0.55, 1.62)
Legumes	Maintained Low[b]	63	1.00 (-)	32	1.00 (-)
	Maintained Partial[c]	62	0.84 (0.58, 1.21)	42	0.80 (0.50, 1.29)
	Maintained High[d]	28	0.58 (0.36, 0.94)	26	0.60 (0.34, 1.06)
	Improved[e]	17	0.79 (0.45, 1.40)	11	0.64 (0.31, 1.32)
	Worsened[f]	55	1.08 (0.74, 1.59)	33	0.85 (0.51, 1.41)
Grains	Maintained Low[b]	46	1.00 (-)	25	1.00 (-)
	Maintained Partial[c]	69	1.13 (0.77, 1.67)	49	1.22 (0.74, 2.02)
	Maintained High[d]	46	1.03 (0.66, 1.59)	25	0.82 (0.46, 1.48)
	Improved[e]	20	1.06 (0.61, 1.83)	17	1.42 (0.75, 2.68)
	Worsened[f]	44	0.66 (0.43, 1.01)	28	0.72 (0.41, 1.25)
Saturated Fat[g]	Maintained Low[b]	60	1.00 (-)	36	1.00 (-)
	Maintained Partial[c]	63	0.74 (0.52, 1.07)	41	0.79 (0.50, 1.26)
	Maintained High[d]	43	0.72 (0.47, 1.09)	22	0.52 (0.30, 0.91)
	Improved[e]	20	0.75 (0.44, 1.28)	16	0.90 (0.49, 1.66)
	Worsened[f]	39	0.57 (0.37, 0.86)	29	0.67 (0.41, 1.11)
Alcohol[g]	Maintained Low[b]	20	1.00 (-)	18	1.00 (-)
	Maintained Partial[c]	155	1.59 (0.98, 2.57)	96	1.13 (0.67, 1.90)
	Maintained High[d]	10	1.50 (0.68, 3.31)	5	1.08 (0.39, 2.98)
	Improved[e]	18	2.45 (1.25, 4.81)	10	1.88 (0.84, 4.21)
	Worsened[f]	22	1.79 (0.96, 3.35)	15	1.51 (0.75, 3.06)
Aerobic PA	Maintained Low[b]	76	1.00 (-)	23	1.00 (-)
	Maintained Partial[c]	40	0.48 (0.32, 0.71)	26	0.70 (0.39, 1.25)
	Maintained High[d]	55	0.40 (0.26, 0.59)	52	0.73 (0.42, 1.27)
	Improved[e]	15	0.47 (0.26, 0.84)	19	1.17 (0.61, 2.24)
	Worsened[f]	50	0.47 (0.32, 0.69)	29	0.71 (0.40, 1.25)
Strength Training	Maintained Low[b]	146	1.00 (-)	73	1.00 (-)
	Maintained Partial[c]	29	0.72 (0.47, 1.09)	25	0.76 (0.47, 1.23)
	Maintained High[d]	20	0.79 (0.48, 1.30)	19	1.03 (0.60, 1.77)
	Improved[e]	10	1.38 (0.70, 2.70)	11	1.97 (1.01, 3.86)
	Worsened[f]	31	0.65 (0.44, 0.97)	21	0.70 (0.43, 1.16)
Sedentary[g]	Maintained Low[b]	53	1.00 (-)	34	1.00 (-)
	Maintained Partial[c]	67	1.12 (0.77, 1.63)	40	0.90 (0.56, 1.44)
	Maintained High[d]	39	1.38 (0.88, 2.14)	29	0.92 (0.54, 1.57)
	Improved[e]	19	0.88 (0.51, 1.52)	17	0.98 (0.54, 1.80)
	Worsened[f]	58	1.38 (0.94, 2.03)	29	0.86 (0.51, 1.43)

Abbreviations: CI, confidence intervals; HR, hazard ratio

[a] Adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level. Excluded participants who were underweight at baseline or follow-up.
[b] Participant in lowest category of guideline concordance (component score of 0) at both baseline and 2-years post-diagnosis.
[c] Participant in the middle category of guideline concordance (component score of 1) at both baseline and 2-years post-diagnosis.
[d] Participant in the highest category of guideline concordance (component score of 2) at both baseline and 2-years post-diagnosis.
[e] Participant improved category of guideline concordance from baseline to 2 years post-diagnosis (e.g., participant went from being in the lowest category of concordance at baseline to being in the middle category 2 years post-diagnosis).
[f] Participant worsened category of guideline concordance from baseline to 2 years post-diagnosis (e.g., participant went from being in the highest category of concordance at baseline to being in the middle category 2 years post-diagnosis).
[g] Levels are still in relation to concordance level with that specific recommendation. For example, low concordance at both time points for saturated fats indicates that the participant was in the highest tertile of saturated fats (modeled as a percent of total energy intake) consumption category at both time points. (highest risk category) .

Table 4.2.8. Posterior Hazard Ratios and 95% Credible Intervals from Piecewise Exponential Proportional Hazards Model for All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence in the Pathways Study.

		HR[a] (95% Credible Interval)
		All-Cause Mortality
Lifestyle Score Tertile	1	1.00 (-)
	2	0.92 (0.74, 1.14)
	3	0.81 (0.62, 1.05)
		Breast Cancer-Specific Mortality
Lifestyle Score Tertile	1	1.00 (-)
	2	0.57 (0.36, 0.91)
	3	0.47 (0.25, 0.89)
		Breast Cancer Recurrence
Lifestyle Score Tertile	1	1.00 (-)
	2	1.03 (0.77, 1.38)
	3	1.16 (0.86, 1.56)

Abbreviations: HR, hazard ratio
[a] Models adjust for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level. The selection model specifies a model for the distribution of missing covariates and missing data indicators for the lifestyle scores and income.

Table 4.2.9. Hazard Ratios and 95% Confidence Intervals for Associations of each of the 9 Components of the Lifestyle Score with All-Cause Mortality, Breast Cancer-Specific Mortality, and Breast Cancer Recurrence, Excluding Deaths and Recurrences Occurring within 4 Years of Diagnosis.

		All-Cause Mortality		Breast Cancer-Specific Mortality		Recurrence	
Recommendation	Category	# Events	HR[a] (95% CI)	# Events	HR[a] (95% CI)	# Events	HR[a] (95% CI)
F/V	0–3.33 svg/d	58	1.00 (-)	20	1.00 (-)	27	1.00 (-)
	3.33–5.56 svg/d	74	1.42 (1.00, 2.03)	23	1.12 (0.59, 2.13)	32	1.28 (0.76, 2.17)
	5.56+ svg/d	55	1.33 (0.90, 1.98)	14	1.12 (0.53, 2.39)	38	1.67 (0.99, 2.84)
	per 2 svg/d increase		1.03 (0.93, 1.15)		1.02 (0.82, 1.26)		1.15 (1.02, 1.30)
Legumes	0–0.09 svg/d	75	1.00 (-)	29	1.00 (-)	29	1.00 (-)
	0.09–0.32 svg/d	64	1.01 (0.71, 1.44)	13	0.50 (0.25, 1.00)	40	1.31 (0.80, 2.14)
	0.32+ svg/d	48	0.73 (0.49, 1.08)	15	0.71 (0.35, 1.45)	28	0.84 (0.48, 1.45)
	per 2 svg/d increase		0.42 (0.17, 1.03)		0.77 (0.17, 3.40)		0.43 (0.14, 1.39)
% of grains that are whole	0–12.5%	59	1.00 (-)	19	1.00 (-)	30	1.00 (-)
	12.5–30.0%	62	1.28 (0.89, 1.86)	16	1.13 (0.55, 2.34)	34	1.09 (0.66, 1.81)
	> 30.0%	66	1.28 (0.88, 1.86)	22	1.51 (0.76, 3.00)	33	1.07 (0.64, 1.82)
	Per 2% increase		1.00 (0.99, 1.02)		1.01 (0.97, 1.04)		1.00 (0.98, 1.03)
% calories from saturated fats	<9.5%	62	1.00 (-)	23	1.00 (-)	35	1.00 (-)
	9.5–11.8%	61	0.91 (0.63, 1.30)	14	0.50 (0.25, 1.01)	33	0.86 (0.53, 1.39)
	>11.8%	64	1.11 (0.76, 1.62)	20	1.13 (0.58, 2.18)	29	0.79 (0.47, 1.33)
	Per 2% increase		0.97 (0.85, 1.09)		0.99 (0.79, 1.22)		1.05 (0.90, 1.23)
Alcohol	Nondrinker	23	1.00 (-)	7	1.00 (-)	22	1.00 (-)
	≤1 drink/d	130	0.82 (0.51, 1.30)	39	0.84 (0.35, 2.02)	62	0.73 (0.44, 1.21)
	>1 drink/d	34	0.80 (0.46, 1.41)	11	0.98 (0.34, 2.79)	13	1.31 (0.63, 2.72)
	Per 2 drinks/d increase		1.05 (0.75, 1.46)		1.10 (0.58, 2.08)		1.08 (0.69, 1.69)
Aerobic	0 MET hrs/wk	79	1.00 (-)	25	1.00 (-)	22	1.00 (-)
	0-<8.75 MET hrs/wk	41	0.66 (0.45, 0.99)	11	0.85 (0.39, 1.83)	23	0.89 (0.48, 1.63)
	8.75+ MET hrs/wk	67	0.61 (0.42, 0.88)	21	1.35 (0.69, 2.64)	52	0.99 (0.56, 1.74)
	Per 3.5 MET hr/wk increase		0.98 (0.94, 1.02)		1.04 (0.98, 1.11)		0.98 (0.93, 1.02)
Strength	None	133	1.00 (-)	45	1.00 (-)	55	1.00 (-)

	1–2x/wk	19	0.62 (0.38, 1.02)	3	0.26 (0.08, 0.91)	16	0.84 (0.47, 1.51)
	>2x/wk	35	0.96 (0.64, 1.44)	9	0.95 (0.43, 2.10)	26	1.21 (0.73, 2.01)
Sedentary	0–14.4 hr/wk	55	1.00 (-)	15	1.00 (-)	37	1.00 (-)
	14.5–20.9 hr/wk	58	0.86 (0.59, 1.27)	16	0.70 (0.33, 1.49)	23	0.58 (0.34, 0.99)
	> 21–54 hr/wk	74	0.97 (0.67, 1.40)	26	1.05 (0.53, 2.09)	37	0.94 (0.58, 1.53)
			0.98 (0.94, 1.01)		0.99 (0.93, 1.06)		1.00 (0.95, 1.05)
Body Weight[b]	Normal-Normal	42	1.00 (-)	10	1.00 (-)	25	1.00 (-)
	Other	79	1.23 (0.83, 1.81)	21	1.47 (0.65, 3.32)	42	1.20 (0.73, 1.99)
	Obese-obese or overweight-obese	66	1.33 (0.88, 2.02)	26	3.42 (1.51, 7.74)	30	1.21 (0.69, 2.14)

[a] Model 2 adjusts for age, tumor stage, ER status, chemotherapy, Herceptin, radiation, comorbidities, smoking status, income, and education level.

[b] Body weight at baseline and 2-years post-diagnosis.

Chapter 5 – Summary of Results, Future Research

The overarching goal of this dissertation was to examine lifestyle factors, including diet, physical activity, and body fatness, and their relationship with cancer prognosis. Due to the heterogeneous nature of cancer and cancer survivorship, the analytic portion of this dissertation focused on the two most commonly diagnosed cancers among US men and women, and on the post-diagnosis period of cancer survivorship. To address the overarching goal of this dissertation, we proposed three study aims. Briefly, in Aim 1, we evaluated the performance of a modified food frequency questionnaire (FFQ) for use in the ethnically diverse Cancer Prevention Study-3 (CPS-3) cohort, which was designed to assess cancer incidence and survival outcomes. In Aim 2, we investigated associations of post-diagnosis body weight and weight change on prostate cancer-specific mortality, cardiovascular disease-related mortality, and all-cause mortality among a cohort of men diagnosed with non-metastatic prostate cancer. In Aim 3, we investigated the separate and combined associations of diet, physical activity, and body fatness on breast cancer recurrence, breast cancer-specific mortality, and all-cause mortality among a cohort of women diagnosed with invasive breast cancer.

Review of Major Findings

In Aim 1, we evaluated the performance of a modified FFQ in assessing major food groups and overall diet quality for use in the ethnically diverse CPS-3 cohort, as food groups and dietary patterns are often the subject of epidemiological studies of diet and cancer-related outcomes (e.g., cancer risk, cancer survival outcomes). We identified a subset of CPS-3 participants (433 women, 244 men) who participated in the cross-sectional diet assessment sub-study. Participants in the sub-study completed two FFQs, one upon study entry and one approximately 1-year later, as well as up to six interviewer-administered 24-hour dietary recalls (24HR) between the time of study entry and completing the second FFQ. We calculated diet quality in accordance with the American Cancer Society Cancer Prevention Guidelines and identified 63 *a* *priori* food groups commonly used in dietary indices (e.g., fruits, vegetables, whole grains), of increasing general interest (e.g., white processed meats, dark meat fish), and of cancer-specific interest (e.g., berries, soy). Reproducibility was assessed by comparing food group intakes and the diet quality score estimated by the two FFQs, completed approximately 1-year apart, using spearman correlation coefficients. Validity was assessed by comparing FFQ estimates with estimates from the 24HRs, using energy adjusted Spearman correlations, deattenuated for day-today variability. We also calculated attenuation factors to estimate the degree to which diet-disease relationships may be underestimated due to measurement error in the FFQ, with factors close to 1 indicating minimal attenuation and factors close to 0 indicating maximal attenuation. All analyses were conducted within strata of sex (men, women) and race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic).

In this aim, we found that reproducibility correlations for the repeated FFQs were $\geq$0.50 for 83-97% of food groups analyzed across strata of sex and race. Energy-adjusted, deattenuated Spearman correlations comparing the second FFQ to the 24HRs ranged from 0.05 to 0.82 among men (median: r=0.50) and women (median: r=0.52). Validity was highest for coffee, alcohol, and total dairy, and lowest for pasta and regular-fat yogurt products. Median validity across food groups varied by race/ethnicity and was highest among white (r=0.54) followed by Hispanic (r=0.49) and then African American (r=0.45) participants. The diet quality score had good validity in all subgroups examined, but was higher among men (r=0.70) than women (r=0.60), and lower among white (r=0.62) than Hispanic (r=0.64) or African American (r=0.73) participants. The median attenuation factor among the 63 food groups was 0.51 among men (range: 0.09 – 0.92) and women (range: 0.11 – 0.93), after adjusting for energy and age. The median attenuation factors by race/ethnicity were 0.54, 0.44, and 0.43 among white, African American, and Hispanic participants, respectively. After adjusting for age, the attenuation factor for the diet quality score was higher, indicating less potential attenuation of risk estimates, among men (γ=0.75) than women (γ=0.65), and lower among white participants (γ=0.66) than Hispanic (γ=0.68) or African American (γ=0.79) participants.

Overall, the results of Aim 1 indicated that the modified FFQ for use in the CPS-3 cohort had good reproducibility and validity for most major food groups, though not all (e.g., pasta, regular-fat yogurt products), and for the ACS diet quality score, in all sex and race/ethnicity groups examined, although validity for food groups tended to be lower for minority groups.

In Aim 2, we investigated the association of post-diagnosis body mass index (BMI) and weight change with prostate cancer-specific mortality (PCSM), cardiovascular disease-related mortality (CVDM), and all-cause mortality among non-metastatic prostate cancer survivors. To do this, we identified all male participants in the Cancer Prevention Study-II Nutrition Cohort (CPS-II) who were diagnosed with non-metastatic prostate cancer between 1992 and 2013. After we implemented the relevant exclusion criteria, analyses of BMI and weight change included 8,330 and 6,942 participants, respectively. CPS-II study participants self-reported current weight on follow-up questionnaires approximately every two years. We calculated post-diagnosis BMI using data from the first survey completed 1-<6 years post-diagnosis. Weight change was the difference in weight between the first and second post-diagnosis surveys. To mitigate the potential for index-event bias and account for pre-diagnosis BMI, first, pre-diagnosis BMI was calculated using weight from the first questionnaire completed $\geq$1 year before prostate cancer diagnosis (median = 2.4 years, interquartile range: 1.8 years). Second, pre-diagnosis BMI was combined with post-diagnosis BMI to create a 7-level categorical variable: healthy weight/healthy weight, healthy weight/overweight, overweight/healthy weight, overweight/overweight, overweight/obese, obese/overweight, and obese/obese (representing the various combinations of pre- and post-diagnosis BMI, respectively). We excluded deaths occurring within 4-years of the follow-up to reduce bias from reverse causation.

In this aim, we found that post-diagnosis obesity, relative to healthy weight, was associated with a higher hazard of PCSM (HR=1.28, 95%CI: 0.97, 1.69), CVDM (HR=1.24, 95%CI: 1.03, 1.49), and all-cause mortality (HR=1.23, 95%CI: 1.11, 1.36). In addition, we found that post-diagnosis weight gain (>5% of body weight), compared with stable weight (± <3%), was associated with a higher risk of PCSM (HR=1.64, 95%CI: 1.20, 2.24) and all-cause mortality (HR=1.27, 95%CI: 1.11, 1.44), but not CVDM. Compared to healthy weight men both before and after being diagnosed with prostate cancer, men who were obese at both time points had higher hazards of CVDM (HR=1.38, 95%CI: 1.10, 1.73) and all-cause mortality (HR=1.25, 95% CI: 1.10, 1.41), but not PCSM (HR=1.14, 95%CI: 0.79, 1.63). However, the hazard of PCSM appeared higher among men who went from being overweight pre-diagnosis to obese post-diagnosis (HR=1.69, 95%CI: 1.12, 2.57).

Overall, the results from this aim suggest that among non-metastatic prostate cancer survivors with largely localized disease, post-diagnosis obesity is associated with higher CVDM and all-cause mortality, and possibly higher PCSM, and that post-diagnosis weight gain may be associated with a higher mortality due to all causes and prostate cancer. We also found that while men who were obese both before and after diagnosis did not have a higher hazard of PCSM, men who went from being overweight pre-diagnosis to obese post-diagnosis did have a substantially higher hazard of PCSM. This may suggest that weight gain plays a larger role in PCSM than obesity in general. However, the deterministic relation between BMI and weight change makes it difficult to separate out their effects.

In Aim 3, we investigated the separate and combined associations of post-diagnosis diet, physical activity, and body fatness with breast cancer recurrence, breast cancer-specific mortality, and all-cause mortality among a cohort of women diagnosed with invasive breast cancer. We did using data from breast cancer survivors who participated in the Kaiser Permanente Northern California's Pathways Study. Women in the Pathways Study were enrolled approximately 2 months after breast cancer diagnosis from January 2006 to April 2013. Breast cancer cases were identified using methods for rapid case ascertainment. We created two analytic cohorts, the mortality cohort (n=1,964) and the recurrence cohort (n=1,924) to conduct this analysis. We calculated a total lifestyle score based on concordance with 9 recommendations related to diet, physical activity, and body weight from the *American Cancer Society/American Society of Clinical Oncology* (ACS/ASCO) *Breast Cancer Survivorship Guidelines*. Concordance with the 9 recommendations were self-reported approximately 2-years after breast cancer diagnosis, with the exception of body weight, which was also assessed at baseline. We used multivariable Cox proportional hazards regression models to produce cause-specific hazard ratios (HR) and their corresponding 95% confidence intervals (CI) to estimate associations of the total lifestyle score, as well as each of its 9 components, with all-cause mortality, breast cancer-specific mortality, and breast cancer recurrence. We also accounted for the influence of pre-diagnosis lifestyle, by calculating the lifestyle score as well as concordance with 8 of the 9 recommendations (BMI was excluded from this analysis since it already incorporated both time points) at both baseline (a survey in which much of the recall period occurred prior to diagnosis) and 2-years post-diagnosis. We then created a composite variable representing the change in lifestyle score calculated from the baseline and the 2-year follow-up surveys with the following levels: 1) high concordance at both time points; 2) partial concordance at both time points; 3) low concordance at both time points; 4) improved concordance from baseline to follow-up; and 5) worsened concordance from baseline to follow-up.

In this aim, we found that the overall lifestyle score was inversely associated with all-cause mortality (HR per 2-point increase=0.89, 95%CI: 0.82, 0.98), and breast cancer-specific mortality (HR=0.78, 95%CI: 0.65, 0.94), but not breast cancer recurrence. In our component model that included each of the 9 recommendations together in a multivariable model, higher intake of legumes and alcohol as well as higher levels of aerobic physical activity and strength training exercises appeared inversely related with all-cause mortality. Trends for recommendations regarding fruit/vegetable intake, whole grain consumption, saturated fat intake, and sedentary behavior with all-cause mortality were less clear. We had too few events to enable meaningful interpretation of component results for the breast cancer-specific mortality models. Higher intake of legumes and higher levels of aerobic physical activity appeared inversely associated with breast cancer recurrence, while fruit/vegetable consumption appeared positively associated with breast cancer recurrence. We did not observe any trends for any of the other recommendations with breast cancer recurrence that appeared meaningful.

In multivariable models that accounted for the influence of pre-diagnosis lifestyle, women with the highest levels of concordance with the lifestyle guidelines at both baseline (representing pre-diagnosis lifestyle) and approximately 2-years post-diagnosis had approximately half the risk of all-cause mortality relative to women who with lowest levels of concordance at both time points (HR=0.50, 95%CI: 0.32, 0.79). Relative to women with the lowest levels of concordance at both time points, the risk of all-cause mortality was lower among women with partial concordance at both time points (HR=0.80, 95%CI: 0.57, 1.12), and women who were less concordant post-diagnosis than they were at baseline (e.g., went from high to low concordance; HR=0.61, 95%CI: 0.41, 0.91). In our models examining changes in concordance for each of the recommendations, the hazard of all-cause mortality among women who maintained medium or high levels of aerobic physical activity at both baseline and post-diagnosis and women who changed their physical activity levels was less than half that of women who reported no recreational physical activity at both time points (e.g., increasing physical activity levels HR=0.43, 95%CI: 0.24, 0.78). Similar trends were found for legumes, saturated fats, and strength training, though associations were weaker and less precise than those with aerobic physical activity (e.g., changing % of energy from saturated fats from >11.8% at diagnosis to ≤11.8% post-diagnosis vs >11.8% at both time points: HR=0.74, 95%CI: 0.43, 1.25).

Our findings from Aim 3 suggest that overall, a healthier lifestyle, assessed in concordance with the ACS/ASCO breast cancer survivorship guidelines approximately 2 years after breast cancer diagnosis, was associated with a lower risk of mortality due to all causes, especially due to breast cancer, but not with breast cancer recurrence. Many of the individual lifestyle behaviors we considered appeared to contribute to the inverse association of the lifestyle score with all-cause mortality, including aerobic physical activity, legume/nut intake, strength training, and possibly body weight. While the overall lifestyle score was not associated with breast cancer recurrence, some components appeared associated with a lower risk of recurrence, such as legume/nut intake, saturated fats, and aerobic physical activity. Importantly, while women who reported healthier lifestyle behaviors both around and after the time of diagnosis had the lowest risk of mortality, there appeared to be some survival advantage when certain behaviors, such as aerobic physical activity levels, were improved after diagnosis.

Implications for Public Health

Overall, the findings of this dissertation have several important implications for public health. In Aim 1, we found that the CPS-3 FFQ had adequate validity and reproducibility for assessing most major food groups and overall diet quality. Our results will help inform researchers using the CPS-3 cohort to assess diet and cancer-related outcomes as to which food groups have relatively high validity and should be considered for future analyses, as well as which food groups researchers should exercise caution in using, as they have a high degree of measurement error. In addition, we produced attenuation factors for many food groups and an overall diet quality score, which should enable future researchers to correct for measurement error in future CPS-3 analyses involving continuous FFQ estimates of food group intake or the ACS diet quality score. In Aim 2, we found that post-diagnosis obesity and weight gain are associated with poorer prognosis among prostate cancer survivors. These results highlight the importance of studying prostate cancer-specific mortality, and may be used to inform recommendations specific to prostate cancer survivors. In Aim 3, we found that overall, concordance with the current ACS/ASCO recommendations for breast cancer survivorship was associated with a lower risk of mortality, especially mortality due to breast cancer. However, not all of the individual recommendations appeared associated with mortality in the expected directions, and future research is still needed in order to optimize recommendations specific to breast cancer survivors. Perhaps our most important findings are those supporting the potential benefits of changing certain behaviors (e.g., increasing aerobic activity, and possibly increasing legume/nut intake or decreasing saturated fat intake) after a breast cancer diagnosis. Many women diagnosed with breast cancer wonder what they can do in order to improve prognosis, and these results suggest that there may be behaviors women can adopt, even after being diagnosed with breast cancer, that may reduce their risk of mortality.

Future Directions

While the findings of this dissertation have contributed to the paucity of evidence regarding the role of lifestyle in cancer prognosis, future research is still needed to optimize cancer-specific recommendations for cancer survivors. First, future studies are needed to determine whether intentional weight loss (potentially through changes in diet and physical activity levels) provides health benefits among overweight and obese breast and prostate cancer survivors. Second, as body mass index does not differentiate between fat mass and fat-free mass, which may be independent predictors of health, further research is needed to determine whether an increase in fat mass, largely due to diet and lack of physical activity, is what drives associations of body mass index and mortality or if observed associations are due to a decrease in fat-free mass (potentially due to cancer and its treatments), or some combination of both. Last, future studies, particularly well-conducted randomized controlled trials, are needed to confirm the role of post-diagnosis lifestyle on breast cancer prognosis and post-diagnosis body weight on prostate cancer prognosis, as well as investigate ways to motivate and maintain behavior change, a current major challenge.

Chapter 6 − References

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