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Impact of consumption of vegetable, fruit, grain, and high glycemic index foods on aggressive prostate cancer risk

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Abstract

Prostate cancer is a common but complex disease, and distinguishing modifiable risk factors such as diet for more aggressive disease is extremely important. Previous work has detected intriguing associations between vegetable, fruit, and grains and more aggressive prostate cancer, although these remain somewhat unclear. Here we further investigate such potential relationships with a case-control study of 982 men (470 more aggressive prostate cancer cases and 512 control subjects). Comparing the highest to lowest quartiles of intake, we found that increasing intakes of leafy vegetables were inversely associated with risk of aggressive prostate cancer (adjusted odds ratio (OR) =0.66, 95% CI: 0.46, 0.96, *P*-trend=0.02), as was higher consumption of high carotenoid vegetables (OR=0.71, 95% CI: 0.48, 1.04; *P*-trend=0.04). Conversely, increased consumption of high glycemic index foods were positively associated with risk of aggressive disease (OR=1.64, 95% CI: 1.05, 2.57; *P*-trend=0.02). These results were driven by a number of specific foods within the food groups. Our findings support the hypothesis that diets high in vegetables and low in high glycemic index foods decrease risk of aggressive prostate cancer.

Keywords

Diet; aggressive prostate cancer

INTRODUCTION

In 2009, there were approximately 192,280 new cases of prostate cancer and 27,360 prostate cancer deaths in the United States(1). Prostate cancer is approximately six times more prevalent in developed countries (56.2 cases/100,000 population) compared to less developed countries (9.4 cases/100,000 population)(2). Detection differences due to the use of prostate specific antigen (PSA) testing does not fully explain the international variation in incidence rates of prostate cancer as a 50-fold difference in incidence rates existed prior to the introduction of PSA testing (3–4). Moreover, there is substantial variation in the severity of prostate cancer: some tumors progress rapidly and may have a large impact on morbidity and mortality, whereas others remain latent for long periods of time. Therefore, it remains

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important to identify risk factors that may explain the variation in prostate cancer rates and morbidity.

Diet might explain why some countries have higher rates of disease, and why some tumors are more aggressive. Two previous epidemiologic studies have found inverse associations between high vegetable intake and risk of aggressive prostate cancer (5–6), although another study has not (7). Inconsistencies have been reported among case-control studies of all prostate cancer with inverse associations reported between total vegetables (8–11), green vegetables and cruciferous vegetables, tomatoes (12), and vitamin-C rich vegetables(13); no associations between vegetables as a group or with specific vegetable items (14–18); and increased risks reported with higher intakes dark leafy green vegetables (19). Inconsistent inverse associations with aggressive prostate cancer have been found for tomatoes, tomato-based foods (20–22), serum and plasma lycopene (23–25), and dietary lycopene (22, 26). A number of additional studies have found intriguing associations between tomato products and all prostate cancers, as recently reviewed in (27–28). No significant protective associations were found in studies investigating fruit and vegetable intake and aggressive disease (7, 19). Studies investigating all prostate cancer reported reduced risk (29) and no associations(13, 18, 30–31) with increased fruit and vegetable intake. Studies investigating all prostate cancer reported increased risks with diets high in glycemic index values (32) and high intakes of snacks and sweets (8). A recent study investigating total prostate cancer and subgroups found no associations between dietary glycemic index, glycemic load, insulin index, or fiber (33).

In light of the inconsistencies among epidemiological studies of vegetables, fruits, grains, and foods high in glycemic index values and prostate cancer, we present here results from a modest sized hospital based case-control study of aggressive disease. We focus on groups of foods because looking at nutrients may miss unmeasured, unknown, or interacting constituents within foods. We initially consider food groups since they may contain a large number and variety of compounds with potential cancer-promoting or -inhibiting properties. We then examine specific foods in these groupings to try and decipher their potential impact on aggressive prostate cancer.

METHODS

Subjects

Aggressive incident prostate cancer cases and controls were recruited between 2001 and 2004 from the major medical institutions in Cleveland, OH (The Cleveland Clinic, University Hospitals of Cleveland, and their affiliates). Aggressive prostate cancer cases were confirmed histologically and defined as having a Gleason score ≥ 7, tumor-node-metastatis stage ≥ T_{2c}, or prostate-specific antigen (PSA) at diagnosis > 10 nanograms per milliliter (ng/ml). Cases were contacted shortly following diagnosis with a median time between diagnosis and recruitment of 4.7 months.

Controls were men who underwent standard annual medical examinations at the collaborating medical institutions. Controls had no diagnosis of prostate cancer or any other non-skin cancer. At the onset of the study, all controls were screened with a serum PSA test, and if their PSA value was > 4.0 ng/ml, patients underwent a formal prostate cancer evaluation and biopsy. Follow-up on the 50 patients having PSA > 4 ng/ml led to the diagnosis of two new prostate cancer cases. Both patients met our criteria for aggressive disease and were subsequently included as cases in our study. Controls were frequency matched to cases by age (within five years), ethnicity, and medical institution. Data were collected on various dietary, clinical, anthropometric, and demographic factors during an in-person computer-aided interview. Institutional review board approval was obtained from the

participating medical institutions. Informed consent was obtained from all study participants.

Collection of dietary information

Food intake information was collected using a validated semi-quantitative food frequency questionnaire (FFQ) developed by the Nutrition Assessment Shared Resource of the Fred Hutchinson Cancer Research Center(34–35). The FFQ consists of 122 foods or food groups, with questions on usual frequency of intake (from "never or less than once per month" to "2 + per day" for foods and "6+ per day for beverages) and portion size (small, medium, or large compared to the stated medium size portion size). The weekly intake of each food was estimated from these responses; when the questionnaire specified a range of possible intake values, we used the midpoint. Cases were asked about their intake of food in the year prior to their diagnosis, while controls were asked about their food intake during the year prior to study recruitment. In these analyses 21 subjects were excluded due to implausible values for total calorie intake (<500 or >5000 kilocalories per day (kcal/d)). In total this study included 470 case and 512 control subjects.

Supplementary Table 1 lists all foods contained in each grouping. Food group intake levels represent the summation of the intake (servings per week) across items in these groups. We defined 13 food groups based on prior hypotheses and previous studies' findings (5–7, 14, 16–17, 19, 32). In addition to major food groups, we also grouped foods as those with high glycemic index values. The glycemic index is a ranking of carbohydrates on a scale from 0 to 100 according to the extent to which they raise blood sugar levels after eating(36). Tables of glycemic index values (37–38) were consulted and those foods with glycemic index values 55 or higher were included in the high glycemic index food grouping.

Calculations and statistical methods

Mean intake levels of food groups and calories were calculated for cases and controls. Pearson product-moment correlation coefficients among the 13 log transformed food groups with and without adjustment for total energy intake were calculated. Associations between intake of food groups and aggressive prostate cancer risk were examined using logistic regression models. All food groups were categorized into quartiles based on their distribution among controls.

We also examined individual servings of foods across three or four levels of servings per week, where the levels were determined based on the distribution food servings. In these analyses we did not examine fish or meat intakes. This study has previously reported decreased risk of aggressive prostate cancer with increasing intake (39) of fish. The unique preparation methods associated with meats and the potential introduction of carcinogens, makes them interesting on their own and therefore they are studied separately.

All logistic regression models were initially adjusted for the matching variables (age, ethnicity, and medical institution). We then adjusted for energy intake, incorporating calories as a continuous variable into the regression models. Furthermore, to evaluate potential confounding due to other factors that might impact healthy behavior and prostate cancer screening, we examined in our regression models the following covariates: family history of prostate cancer in first degree relatives (prostate cancer in brother and/or father), smoking (never, former, or current), body mass index (kilograms per meter squared (kg/m^2)), prior history of PSA testing for prostate cancer (never/once/twice or more), and education level (4 categories of levels of schooling). The only additional covariate that materially influenced the food-prostate cancer associations was family history of prostate cancer in first degree relatives; therefore, our second set of regression models adjusted for

age, ethnicity, medical institution, calories, and family history of prostate cancer. We calculated two-sided *P*-trend values with the food group and individual foods modeled continuously. All models were undertaken with SAS software (version 9.1; SAS Institute).

RESULTS

Table 1 shows the characteristics of cases and controls and eighty-three percent of subjects were Caucasian and 17% were African-American. Controls had significantly higher levels of education than cases (p-value <0.01). Cases were more likely than controls to have a family history of prostate cancer (prostate cancer in at least one first-degree relative, p-value <0.01). Cases and controls had similar body mass index values and smoking histories. Cases had an average PSA level of 14.1 ng/ml at diagnosis and 44% of them had a PSA level greater than 10 ng/ml. The majority of cases (85%) had a Gleason score ≥ 7 while few cases (5.5%) had a clinical stage greater than T_2.

Table 2 presents descriptive information on diet by case and control status. The mean intake of total calories was higher in cases than controls. Nevertheless, the cases had significantly lower consumption of fruits, without juices than the controls (9.9+/−7.7 versus 11.1+/−9.6 *P*-value=0.04). Cases also ate more high glycemic index foods than controls: 26.6 versus 23.4 servings per week (*P*-value <0.01). The fruit, vegetable and fruit juice groupings were modestly correlated ($r^2 \geq 0.30$) and as expected, processed grains were correlated with high glycemic index foods ($r^2 = 0.39$).

Table 3 presents adjusted ORs for associations between aggressive prostate cancer and food groups. Increasing intake of vegetables exhibited a significant trend with decreasing risk (*P*-trend =0.04). Leafy vegetables were inversely associated with aggressive prostate cancer: comparing the highest versus lowest quartile of intake gave an OR=0.66 (95% CI 0.46–0.96; *P*-trend=0.02). High intake of high carotenoid vegetables was also inversely associated with aggressive prostate cancer, albeit slightly weaker: OR=0.71 (95% CI 0.48, 1.04; *P*-trend=0.04). Weak inverse associations were also found for the highest intake of legumes (OR=0.70 95% CI 0.48, 1.03; *P*-trend=0.10), and high vitamin C fruits (OR=0.69 95% CI 0.47, 1.00; *P*-trend=0.09).

From Table 3 we can also see that a number of the food groups were associated with increased risk of aggressive prostate cancer. High intake of fruit juices (OR=1.42 95% CI 1.01–1.99; *P*-trend=0.06) and whole grains (OR=1.62 95% CI 1.13, 2.32; *P*-trend=0.05) were positively associated with increased risk of aggressive disease. When additionally adjusting for energy intake and a positive family history of prostate cancer, however, these associations were weakened. Increasing intake of high glycemic index foods were also positively associated with risk of aggressive prostate cancer: OR=1.64 (95% CI 1.05, 2.57; *P*-trend=0.02).

Table 4 presents individual foods that were significantly associated with aggressive prostate cancer. Inverse associations were observed for several vegetables: cooked greens, summer squash/ zucchini, garlic, red peppers, and bean soups. For all of these foods except red peppers, having a high intake versus none suggested an approximate 30 percent reduction in risk of being diagnosed with aggressive prostate cancer (*P*-trend≤0.02). The highest intake category for red peppers exhibited an even stronger inverse association with disease (OR=0.51, 95% CI (0.37, 0.73, *P*-trend<0.01). Similarly, high consumption of fruits, specifically berries and cantaloupe were both inversely associated with aggressive prostate cancer (*P*-trend<0.01).

From Table 4 we also see that a large number of individual foods contained in the high glycemic index food group were associated with increased risk of aggressive prostate

cancer. In particular, dark breads (including bagels, rolls, and whole wheat bread), high intake of french fries, potato chips, chocolate, cookies and cakes, and regular soft drinks all exhibited positive associations with aggressive prostate cancer in the most complete adjusted regression model. These suggested increased risks of approximately 40 to almost 90%.

DISCUSSION

We detected inverse associations between increased intake of leafy and high carotenoid vegetables and aggressive prostate cancer. Focusing on specific vegetables, we found decreased risks for each level of consumption of cooked greens (spinach, mustard greens, or collards) and bean soups while the highest intakes of summer squash, garlic, and red peppers conferred decreased risk also. High intakes of berries and orange melon were also inversely associated with aggressive prostate cancer. We found increased risks associated with the following high glycemic index foods: dark breads (including bagels, rolls, and whole wheat bread), french fries, potato chips, chocolate, cookies and cakes, or regular soft drinks.

Previous findings for the potential impact of vegetables and fruits on aggressive prostate cancer are inconsistent. In a multiethnic case-control study (6) increased intake of all vegetables were inversely associated with decreased risk, and non-significant associations tending towards decreased risk were found for dark green vegetables and all legumes. In a prospective study (7) of Japanese men no statistically significant associations were found for total vegetables and aggressive prostate cancer; nevertheless, non-significant inverse associations were found among every non referent quartile of green leafy vegetable intake. These results suggest protective effects between green leafy vegetable intake with aggressive prostate cancer. The Japanese study reported no association with fruits and aggressive prostate cancer but did not list or investigate specific types of fruits. A large screening trial (5) showed no association between any quintile of intake of vegetables and aggressive prostate cancer, but exhibited a statistically significant inverse association in the fourth quintile only for dark green vegetables. There were no clear associations between any intake of mustard, turnip greens, collard, kale; however a significant trend with decreasing risk was observed with increasing intake of spinach and aggressive prostate cancer (5). The screening trial did not report any association between citrus, melon, berry fruits nor for all fruits combined in relation to aggressive prostate cancer.

These somewhat equivocal results may in part reflect differences in definitions of advanced or aggressive prostate among studies. For example, a multiethnic study (6) defined advanced prostate cancer as men whose disease had extended beyond the capsule of the gland or whose disease was localized but the tumor was poorly differentiated. Another study defined aggressive prostate cancer as stage III or IV tumors or tumors with a Gleason score of ≥ 7 (5). And yet another conducted in Japan defined advanced prostate cancer as those subjects with diagnoses of extraprostatic metastatic cancer involving lymph nodes or other organs or subjects with high Gleason scores of 8–10 or poor differentiation (7). Results may also differ between these studies due to variations in the categorizations of food groups. The Japanese study (7) included six green leafy vegetables, while in the multiethnic study (6) the dark green vegetable group included 16 different vegetables. Finally, the foods in the all vegetables group in the screening trial were not reported (5).

Associations between vegetables and all prostate cancer have also been ambiguous. No associations have been reported for vegetables among several case-control studies (14–17) examining all prostate cancer. A case-control study reported slightly increased risks with dark leafy vegetables and no association with tomato consumption and all prostate cancer and reported increased risk with dark leafy vegetables and aggressive prostate cancer (19). In study containing over 100,000 men no significant associations were observed between

fruit and vegetable consumption combined and all prostate cancer (18). Intake of fruit was not associated with all prostate cancer while vegetable intake decreased risk in a case-control study of men under 65 years of age (9). Inverse associations have been reported with consumption of vegetables (8, 12–13, 40–41), fruit (11, 29), and vegetables and fruits combined (10–11).

We found statistically significantly decreased risks of aggressive prostate cancer at every level of cooked greens such as spinach, mustard greens, or collards. At least 13 different flavonoid compounds can be found in spinach and these compounds function as antioxidants and as anti-cancer agents. A study found that neoxanthin, a carotenoid in spinach and other green leafy vegetables, reduced cell viability through apoptosis induction in human prostate cancer cells (42).

Legumes are high in fiber and contain phytoestrogens, including isoflavonoids found in tofu products made from soybeans. Estrogens are used in prostate cancer therapy and may lower the risk of prostate cancer; therefore there is strong rationale for hypothesizing an inverse relationship to prostate cancer. The only legume food that we found to be inversely associated with aggressive prostate cancer risk was bean soups. While the models with green or string beans and tofu did not reach statistical significance, the estimates were suggestive of decreased risks of aggressive prostate cancer. The low levels of consumption of these foods may have limited our ability to detect statistically significant associations.

We found positive associations between many foods high in glycemic index loads and aggressive prostate cancer. Significantly increased risks were reported for the upper quintiles of average daily glycemic load in a study of all prostate cancer (32). In a small prospective study of eight men it was reported that adopting a lower glycemic load diet altered human prostate cancer gene expression and several of these were related to cell migration and tissue remodeling, whereas others were involved in intracellular signal transduction (43).

A limitation of this study is the recruitment of cases with aggressive prostate cancer only and exclusion of men with less aggressive disease. Focusing recruitment on aggressive cases could introduce detection bias if the likelihood of being diagnosed is related to the exposure; specifically if aggressive prostate cancer cases eat fewer fruits and vegetables and also visit their physician less frequently they may be diagnosed with more aggressive disease. This bias could confound associations found in this study, however to control for this all regression models were assessed for confounding due to factors that might impact healthy behavior and prostate cancer screening. The only additional covariate that materially influenced food-prostate cancer associations was family history of prostate cancer in first degree relatives.

Limitations of this study and many studies of diet include the retrospective nature of dietary recall (i.e., following diagnosis among cases). Cases may have recalled their diets differently from controls, potentially resulting in differential recall bias. The FFQ used in this study is very similar to a questionnaire (34) that has been reported to have high inter-rater reliability with diet histories and therefore the potential for recall bias in this study is minimal. Another weakness in using any FFQ is that dietary covariates may be highly correlated and therefore use of multivariate models may result in unpredictable results (44) and for this reason we did not adjust models for multiple correlated dietary factors simultaneously. Another limitation is that the semi-quantitative FFQ only approximates consumption (45), and may have overestimated intake of certain food groups due to the large number of items included in the questionnaire or over reporting of foods perceived as healthy. To help address the possibility of measurement error, the cases were recruited and interviewed shortly after entry into the

study and the questionnaire specifically asked about food consumption in the year prior to diagnosis for cases and entry into the study for controls.

Another limitation is our inability to assess preparation methods for most foods, since the nutritional content may substantially differ in important ways, for example between steamed versus raw foods. In addition, we focus here only on non-meat food groups; meats have unique preparation methods that have been reported (46–48) to introduce carcinogens and may increase risk of prostate cancer.

Finally, while our study detected several associations with aggressive prostate cancer, due to the number of associations assessed some of these may be false positives. In order to address the potential for chance associations due to the number of comparisons we chose to examine 13 food groups rather than the 122 individual food items, minimizing the number of comparisons and therefore false associations.

In summary, this moderate-sized case-control study detected inverse associations between numerous vegetables and fruits and prostate cancer, as well as positive associations for a handful of high glycemic index foods. Since the intake of the vegetables and fruits may be highly correlated, the former may reflect the overall benefits of a heavily plant based diet. These results suggest that a diet higher in intakes of certain vegetables and fruits and lower in high glycemic index foods may lower the risk of developing more aggressive prostate cancer.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of Study Population (Aggressive Prostate Cancer Cases and Controls)

	Cases (n=470)		Controls (n=512)		P-value
Age (years), mean (SD)	65.8	(8.3)	65.9	(8.5)	0.87
Ethnicity, n (%)					0.63
African-American	78	(16.6)	91	(17.8)	
Caucasian	392	(83.4)	421	(82.2)	
Education[1], n (%)					<0.01
< 12 years	43	(9.2)	45	(8.8)	
12 years or high school	105	(22.3)	68	(13.3)	
Some college	98	(20.9)	91	(17.8)	
≥College graduate	223	(47.5)	306	(59.8)	
Family history of prostate cancer[1], n (%)					<0.01
Negative	359	(76.4)	452	(88.3)	
Positive[2]	110	(23.4)	55	(10.7)	
Smoking[1], n (%)					0.35
Never	192	(40.9)	208	(40.6)	
Former	224	(47.7)	255	(49.8)	
Current	53	(11.3)	45	(8.8)	
Body mass index (kg/m^2) mean (SD)	26.2	(3.7)	26.4	(3.8)	0.55
Prior history of PSA test[1], n (%)					0.02
Never	100	(22.3)	113	(24.2)	
Once	53	(11.8)	68	(14.6)	
Twice or more	296	(65.9)	286	(61.2)	
Serum PSA value (ng/ml), mean (SD)	14.1	(24.8)	1.7	(1.7)	<0.01
Clinical stage[1], n (%)					
T1	294	(65.0)			
T2	133	(29.4)			
T3 & T4	25	(5.5)			
Histologic tumor grade: Gleason score, n (%)					

	Cases (n=470)		Controls (n=512)	P-value
≤ 6	69	(14.7)		
7	298	(63.4)		
≥ 8	103	(21.9)		

Abbreviations: SD, standard deviation.

[1] Totals do not add to 100% due to missing data.

[2] Positive family history of prostate cancer was defined as prostate cancer in a first degree relative.

Table 2

Mean Intake of Food Groups and Calories

	Cases (n=470)		Controls (n=512)		P-value
	mean	SD	mean	SD	
Total calories (kcal/d)	2278	879	2080	787	<0.01
Food Group (servings/week)					
Vegetables					
All Vegetables	18.5	12.2	19.0	11.6	0.59
Cruciferous Vegetables	2.6	2.4	2.8	2.7	0.14
Leafy Vegetables	3.5	2.5	3.6	2.5	0.30
High Carotenoid Vegetables	13.0	8.7	13.2	8.4	0.64
Tomato	5.9	4.1	5.6	3.6	0.28
Legumes	4.4	3.1	4.5	3.6	0.61
Fruits					
All Fruits, no juices	9.9	7.7	11.1	9.6	0.04
High Vitamin C Fruits	5.7	5.5	6.4	6.8	0.09
High Carotenoid Fruits	6.5	6.1	7.2	7.6	0.13
Fruit Juices	5.5	6.4	5.0	6.3	0.22
Grains					
Whole Grains	3.5	3.9	3.1	3.7	0.14
Processed Grains	9.0	5.5	8.9	5.3	0.70
High Glycemic Index Foods	26.6	12.8	23.4	11.6	<0.01

Abbreviations: SD, standard deviation.

Table 3

Odds Ratios for Aggressive Prostate Cancer by Quartiles of Intake of Food Groups

Exposure	Quartiles							*P*-Trend
	1		2		3		4	
All Vegetables								
Median[1]	7.0		13.5		20.2		32.0	
Cases (N)	121	124		112		113		
Controls (N)	124	122		133		133		
OR (95% CI)[2]	1.00	1.02	0.71, 1.46	0.85	0.59, 1.22	0.85	0.59, 1.22	0.25
OR (95% CI)[3]	1.00	0.91	0.63, 1.32	0.69	0.48, 1.01	0.71	0.48, 1.05	0.04
Cruciferous Vegetables								
Median[1]	0.6		1.4		2.5		5.2	
Cases (N)	103	145		110		112		
Controls (N)	128	119		129		136		
OR (95% CI)[2]	1.00	1.52	1.07, 2.17	1.06	0.73, 1.52	1.03	0.72, 1.48	0.57
OR (95% CI)[3]	1.00	1.50	1.04, 2.16	0.96	0.66, 1.41	0.91	0.62, 1.33	0.20
Leafy Vegetables								
Median[1]	0.8		2.0		3.7		6.1	
Cases (N)	123	94		119		134		
Controls (N)	120	98		137		157		
OR (95% CI)[2]	1.00	0.92	0.63, 1.35	0.83	0.58, 1.18	0.81	0.57, 1.15	0.20
OR (95% CI)[3]	1.00	0.83	0.56, 1.23	0.72	0.50, 1.05	0.66	0.46, 0.96	0.02
High Carotenoid Vegetables								
Median[1]	4.7		9.3		13.9		22.6	
Cases (N)	119	126		115		110		
Controls (N)	127	119		130		136		
OR (95% CI)[2]	1.00	1.11	0.77, 1.59	0.93	0.64, 1.33	0.84	0.59, 1.22	0.24
OR (95% CI)[3]	1.00	0.99	0.69, 1.43	0.79	0.54, 1.16	0.71	0.48, 1.04	0.04
Tomato								

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Exposure	Quartiles							*P*-Trend
	1		2		3		4	
Median[1]	1.8		4.2		6.1		9.8	
Cases (N)	103	125		120		122		
Controls (N)	136	125		127		124		
OR (95% CI)[2]	1.00	1.32	0.92, 1.89	1.25	0.86, 1.80	1.30	0.90, 1.88	0.24
OR (95% CI)[3]	1.00	1.28	0.88, 1.86	1.15	0.79, 1.68	1.12	0.76, 1.67	0.74
Legumes								
Median[1]	1.3		2.7		4.8		8.0	
Cases (N)	123	108		124		115		
Controls (N)	129	126		125		132		
OR (95% CI)[2]	1.00	0.90	0.63, 1.28	1.04	0.73, 1.48	0.91	0.64, 1.29	0.80
OR (95% CI)[3]	1.00	0.81	0.56, 1.17	0.84	0.58, 1.21	0.70	0.48, 1.03	0.10
All Fruits, no juices								
Median[1]	2.1		6.4		11.3		19.9	
Cases (N)	121	111		129		109		
Controls (N)	124	135		116		137		
OR (95% CI)[2]	1.00	0.84	0.59, 1.19	1.13	0.79, 1.61	0.81	0.56, 1.16	0.55
OR (95% CI)[3]	1.00	0.80	0.56, 1.16	1.02	0.70, 1.48	0.70	0.48, 1.03	0.18
High Vitamin C Fruits								
Median[1]	0.7	3.0	7.0	11.1				
Cases (N)	121	119		121		109		
Controls (N)	123	128		123		138		
OR (95% CI)[2]	1.00	0.94	0.66, 1.34	0.99	0.69, 1.41	0.79	0.55, 1.14	0.27
OR (95% CI)[3]	1.00	0.84	0.58, 1.21	0.91	0.63, 1.31	0.69	0.47, 1.00	0.09
High Carotenoid Fruits								
Median[1]	1.0		3.6		7.5		12.7	
Cases (N)	116	121		122		111		
Controls (N)	129	125		124		134		
OR (95% CI)[2]	1.00	1.08	0.76, 1.54	1.09	0.76, 1.55	0.92	0.64, 1.32	0.69

Exposure	Quartiles							*P*-Trend
	1		2		3		4	
OR (95% CI)[3]	1.00	1.00	0.70, 1.44	1.03	0.72, 1.49	0.79	0.54, 1.14	0.26
Fruit Juices								
Median[1]	0		1.5		4.0		8.0	
Cases (N)	95	109		94		172		
Controls (N)	133	115		94		170		
OR (95% CI)[2]	1.00	1.32	0.91, 1.92	1.40	0.95, 2.06	1.42	1.01, 1.99	0.06
OR (95% CI)[3]	1.00	1.28	0.87, 1.87	1.30	0.87, 1.95	1.32	0.93, 1.88	0.15
Whole Grains								
Median[1]	0		1.0		3.0		7.0	
Cases (N)	99	118		118		135		
Controls (N)	143	103		141		125		
OR (95% CI)[2]	1.00	1.67	1.16, 2.42	1.23	0.86, 1.76	1.62	1.13, 2.32	0.05
OR (95% CI)[3]	1.00	1.60	1.10, 2.33	1.21	0.84, 1.74	1.47	1.01, 2.14	0.15
Processed Grains								
Median[1]	3.1		6.8		9.7		15.1	
Cases (N)	115	118		120		117		
Controls (N)	128	130		125		129		
OR (95% CI)[2]	1.00	1.01	0.70, 1.44	1.07	0.75, 1.52	1.01	0.70, 1.45	0.89
OR (95% CI)[3]	1.00	0.97	0.67, 1.41	1.01	0.70, 1.46	0.86	0.58, 1.26	0.51
High Glycemic Index Foods								
Median[1]	12.8		19.8		26.6		38.1	
Cases (N)	100	108		122		140		
Controls (N)	145	138		124		105		
OR (95% CI)[2]	1.00	1.13	0.79, 1.62	1.42	1.00, 2.03	1.93	1.35, 2.77	<0.01
OR (95% CI)[3]	1.00	1.01	0.70, 1.48	1.28	0.86, 1.89	1.64	1.05, 2.57	0.02

Abbreviations: OR, odds ratio; CI, confidence interval.

[1]Medians given in servings per week.

[2] ORs adjusted for age, race, and institution.

[3] ORs adjusted for age, race, institution, energy intake, and history of first degree relative with prostate cancer.

Table 4

Odds Ratios for Foods Significantly Associated with Aggressive Prostate Cancer

Exposure	Categories							*P*-Trend
	1		2		3		4	
Vegetables								
Cooked Greens such as spinach, mustard greens, or collards								
Intake[1]	None		0.3		0.6		>0.6	
Cases (N)	232	80		81		77		
Controls (N)	210	105		104		93		
OR (95% CI)[2]	1.00	0.69	0.48, 0.97	0.69	0.48, 1.00	0.74	0.51, 1.07	0.05
OR (95% CI)[3]	1.00	0.67	0.47, 0.96	0.66	0.46, 0.96	0.67	0.45, 0.98	0.02
Summer squash, zucchini								
Intake[1]	None		0.3		>0.3			
Cases (N)	245	95		130				
Controls (N)	223	126		163				
OR (95% CI)[2]	1.00	0.67	0.49, 0.93	0.71	0.53, 0.96			0.02
OR (95% CI)[3]	1.00	0.66	0.48, 0.93	0.67	0.49, 0.91			<0.01
Fresh garlic, included in cooking								
Intake[1]	None		0.3–0.6		1.0–2.0		>2.0	
Cases (N)	187	112		79		92		
Controls (N)	168	123		117		104		
OR (95% CI)[2]	1.00	0.80	0.57, 1.12	0.58	0.40, 0.83	0.78	0.55, 1.11	0.04
OR (95% CI)[3]	1.00	0.78	0.55, 1.09	0.53	0.37, 0.77	0.66	0.46, 0.96	<0.01
Red peppers, chilies								
Intake[1]	None		0.3		0.6		>0.6	
Cases (N)	277	61		56		76		
Controls (N)	261	70		52		129		
OR (95% CI)[2]	1.00	0.81	0.55, 1.19	1.00	0.66, 1.52	0.54	0.39, 0.76	<0.01
OR (95% CI)[3]	1.00	0.79	0.53, 1.17	0.97	0.63, 1.49	0.51	0.37, 0.73	<0.01

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Exposure	Categories							P-Trend
	1	2		3		4		
Bean soups such as pea, lentil, and black bean								
Intake[1]	None	0.3		>0.3				
Cases (N)	244	115		111				
Controls (N)	231	138		143				
OR (95% CI)[2]	1.00	0.78	0.57, 1.06	0.73	0.53, 0.99			0.03
OR (95% CI)[3]	1.00	0.71	0.51, 0.97	0.63	0.46, 0.87			<0.01
Fruits								
Berries such as strawberries and blueberries								
Intake[1]	None	0.3		0.6		>0.6		
Cases (N)	138	124		89		119		
Controls (N)	132	108		112		160		
OR (95% CI)[2]	1.00	1.05	0.74, 1.51	0.72	0.49, 1.05	0.67	0.47, 0.95	<0.01
OR (95% CI)[3]	1.00	1.06	0.73, 1.53	0.75	0.51, 1.10	0.60	0.42, 0.87	<0.01
Cantaloupe, orange melon and mango (in season)								
Intake[1]	None	0.1 – 0.2		0.2		>0.2		
Cases (N)	124	102		108		136		
Controls (N)	106	101		127		178		
OR (95% CI)[2]	1.00	0.85	0.58, 1.25	0.72	0.50, 1.03	0.64	0.45, 0.90	<0.01
OR (95% CI)[3]	1.00	0.82	0.56, 1.21	0.69	0.47, 1.00	0.55	0.38, 0.79	<0.01
Grains and High Glycemic Index								
Dark breads, including dark bagels, rolls, and whole wheat bread								
Intake[1]	None	0.3–1.0		2.0–3.5		>3.5		
Cases (N)	133	131		109		97		
Controls (N)	162	153		126		69		
OR (95% CI)[2]	1.00	1.04	0.75, 1.44	1.06	0.75, 1.49	1.75	1.19, 2.58	0.02
OR (95% CI)[3]	1.00	1.02	0.73, 1.43	1.02	0.72, 1.46	1.60	1.07, 2.39	0.06
French fries, fried potatoes, and hash browns								
Intake[1]	None	0.3		0.6		≥1.0		

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Exposure	Categories							P-Trend
	1	2		3		4		
Cases (N)	95	81		125		169		
Controls (N)	129	118		124		141		
OR (95% CI)[2]	1.00	0.93	0.63, 1.38	1.38	0.95, 1.99	1.64	1.15, 2.33	<0.01
OR (95% CI)[3]	1.00	0.92	0.62, 1.36	1.27	0.87, 1.86	1.43	0.98, 2.07	0.02
Regular potato chips, tortilla chips, corn chips and puffs								
Intake[1]	None	0.3–0.6		≥1.0				
Cases (N)	148	166		156				
Controls (N)	188	212		111				
OR (95% CI)[2]	1.00	1.01	0.75, 1.36	1.82	1.30, 2.54			<0.01
OR (95% CI)[3]	1.00	0.95	0.70, 1.29	1.60	1.12, 2.27			0.01
Chocolate, candy bars and toffee								
Intake[1]	None	0.3		0.6		≥ 1.0		
Cases (N)	115	68		96		191		
Controls (N)	160	95		91		166		
OR (95% CI)[2]	1.00	1.00	0.67, 1.48	1.47	1.01, 2.13	1.60	1.16, 2.21	<0.01
OR (95% CI)[3]	1.00	1.02	0.68, 1.52	1.49	1.01, 2.18	1.43	1.02, 2.00	0.02
Cookies and cakes								
Intake[1]	None	0.3–0.6		1.0–2.0		>2.0		
Cases (N)	44	161		134		131		
Controls (N)	75	180		152		105		
OR (95% CI)[2]	1.00	1.52	0.99, 2.34	1.50	0.96, 2.33	2.13	1.35, 3.35	<0.01
OR (95% CI)[3]	1.00	1.51	0.97, 2.34	1.35	0.86, 2.13	1.87	1.16, 3.02	0.04
Regular soft drinks								
Intake[1]	None	0.5–0.6		≥1.0				
Cases (N)	211	71		187				
Controls (N)	278	82		152				
OR (95% CI)[2]	1.00	1.15	0.80, 1.66	1.66	1.25, 2.20			<0.01
OR (95% CI)[3]	1.00	1.18	0.82, 1.72	1.51	1.13, 2.03			<0.01

Abbreviations: OR, odds ratio; CI, confidence interval.

[1] Intakes given in servings per week.

[2] ORs adjusted for age, race, and institution using logistic regression.

[3] ORs adjusted for age, race, institution, energy intake, and history of first degree relative with prostate cancer.