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Carbohydrate intake, glycemic index and prostate cancer risk

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Abstract

BACKGROUND—Reported associations between dietary carbohydrate and prostate cancer (PC) risk are poorly characterized by race.

METHODS—We analyzed the association between carbohydrate intake, glycemic index (GI), and PC risk in a study of white (N=262) and black (N=168) veterans at the Durham VA Hospital. Cases were 156 men with biopsy-confirmed PC and controls (N=274) had a PSA test but were not recommended for biopsy. Diet was assessed before biopsy with a self-administered food frequency questionnaire. Logistic regression models were used to estimate PC risk.

RESULTS—In multivariable analyses, higher carbohydrate intake, measured as percent of energy from carbohydrates, was associated with reduced PC risk (3rd vs. 1st tertile, OR=0.41, 95% CI 0.21–0.81, p=0.010), though this only reached significance in white men (p-trend=0.029). GI was unrelated to PC risk among all men, but suggestively linked with reduced PC risk in white men (p-trend=0.066) and increased PC risk in black men (p-trend=0.172), however the associations were not significant. Fiber intake was not associated with PC risk (all p-trends >0.55).

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Disclosure of Potential Conflicts of Interest

The authors have nothing to disclose

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Higher carbohydrate intake was associated with reduced risk of high-grade (p-trend=0.016), but not low-grade PC (p-trend=0.593).

CONCLUSIONS—Higher carbohydrate intake may be associated with reduced risk of overall and high-grade PC. Future larger studies are needed to confirm these findings.

Keywords

carbohydrates; glycemic index; prostate cancer

INTRODUCTION

Diets high in carbohydrates have been hypothesized to increase the risk of prostate cancer (PC) by altering the insulin and insulin-like growth factor endocrine axis [1–4]. However, evidence from epidemiologic studies examining the relationship between consumption of carbohydrates and high glycemic foods and PC risk has been inconsistent [5–8]. Reasons for inconsistencies are difficult to discern, but may be in part due to the wide variability of diets in the different geographic regions. In addition, race and genetic components may also play a role in the discrepancy between studies.

The glycemic response to a diet rich in carbohydrate is not only influenced by the amount and type of carbohydrate intake, but also by other dietary components, such as fat, protein and fiber content. The effects of carbohydrate quality on blood glucose and insulin levels can be characterized by the diet's glycemic index (GI). The GI is a measure of how quickly blood glucose levels (i.e., blood sugar) rise after eating a particular type of food. Glucose, chosen as standard, has a glycemic index of 100. Thus, GI may better measure the body's blood sugar and insulin response to diet. High-GI foods cause high glucose spikes leading to rapid insulin release resulting in higher serum insulin levels. Alternatively, low-GI foods cause small glucose spikes and minimal insulin release [9,10].

Several studies examining the relationship between carbohydrate intake and PC risk incorporated measurements of GI. Out of seven recent epidemiologic studies that investigated the association between GI, carbohydrate intake, and PC risk [5,7,8, 11–14], four reported a positive association [7,8,11,13], whereas three found no associations [5,12,14]. Only one study included black men [5], however racial variations for the association between carbohydrate intake, GI and PC were not examined. We hypothesize that increased intake of carbohydrates would increase PC risk. Of note, black men are significantly more likely to develop PC [15]. Black men also have higher rates of insulin resistance [16], and therefore may respond with a higher insulin spike for a given dietary intake. Given insulin is a key PC growth factor [17], we hypothesized that the association between measures of carbohydrate intake and PC risk would be stronger in black men. We tested these hypotheses using a PC case-control study of black and white men conducted at the Durham Veteran Affairs Medical Center, in which PSA levels were available for both cases and controls. Furthermore, quality of carbohydrate intake, as indicated by GI, and PC risk was examined.

MATERIALS AND METHODS

Study Population

Methods for identification and accrual of participants have been described elsewhere [18,19]. Men who were screened for PC in the last 12 months with a PSA test were recruited to participate in an ongoing case-control study at the Durham Veterans Affairs Medical Center (DVAMC) in Durham, NC, from January 2007 to June 2012. Cases were 18 years or older with no history of PC who were scheduled for a prostate needle biopsy at the urology clinic. Of the 759 eligible men who underwent biopsy, 565 consented to participate; therefore the response rate was 74%. Among those, n=344 had a biopsy positive for PC and formed the cases series. Controls were identified through the urology and internal medicine clinics at the DVAMC and shared the same eligibility criteria as cases including a PSA in the past 12 months, with the exception of not being recommended for a prostate needle biopsy. Of the 768 eligible controls contacted, 377 provided written consent to participate, yielding a 49% response rate. We excluded men who were neither black nor white (n=21). The present analyses are limited to the 156 cases and 274 controls for whom questionnaire, dietary and Gleason sum data were available. This study was approved by the Duke University and DVAMC Institutional Review Boards.

Data Collection

Trained interviewers collected questionnaire data, obtained anthropometric measurements (weight and height) and abstracted medical records. Weight was measured using a digital scale, and a stadiometer was used to measure height [20]. These measurements were used to calculate body mass index (BMI), defined as weight (in kilograms) divided by the square of height (in meters squared). All questionnaires were self-administered and typically filled out the day of the scheduled clinic visit or returned shortly thereafter by mail prior to the patient knowing the outcome of their biopsy.

Dietary information was obtained using the Willett food frequency questionnaire (FFQ) [21]. This 61-item FFQ assessed the frequency of consumption as well as the portion size for each food and beverage item. Subjects reported their intake in the past 12 months, and this time period was selected to account for seasonal variation in consumption. Daily food, nutrient, and total energy intakes were determined using the reported frequency of consumption and portion sizes. We excluded participants who reported implausible caloric intake values (<800 or >4200 kcal/d, n=57). The foods of interest for this study were those containing carbohydrates. Daily nutrient intake level for each food item were computed by multiplying the relative frequency of consumption by the nutrient content of the specified portion size using USDA food composition sources [22] and data from manufacturers [23, 24]. GI values for each carbohydrate-containing FFQ-item (with glucose as reference tool) was assigned by the Harvard's team as previously described [12]. Percent of energy derived from carbohydrates, protein and fat were calculated by multiplying the number of grams eaten by caloric density (4kcal/g for protein and carbohydrates; 9kcal/g for fat) and dividing by the total caloric intake.

Statistical Analysis

Our primary objective was to test the association between total carbohydrate intake and PC risk and whether the association varied by race or tumor grade. Secondary objectives included testing the association between dietary GI and fiber intake with PC risk and whether these associations varied by race or tumor grade.

To test our primary objective, carbohydrate nutrient intakes derived from FFQs were estimated for all foods containing carbohydrates. The dietary variables of interest were categorized into tertiles using data from the controls. For our secondary objectives, we defined low-grade PC as Gleason sum ≤ 6 and high grade as Gleason sum ≥ 7 . Race was self-reported and categorized as black vs. white. Potential confounders such as age and body mass index (BMI) were normally distributed in the controls and were treated as continuous variables in modeling. Family history of PC was categorized as yes (i.e. father, brother, or maternal or paternal uncle had PC) or no. Data on diabetes history (self-reported) was also categorized as yes or no. Drinking and smoking habits were self-reported and categorized into current, former and never categories. We calculated the metabolic equivalent (MET) hours of total current exercise level, as previously described [25]. Physical activity was categorized as <3 , 3–8.9, 9–17.9 and ≥ 18 METs per week, and log-transformed when used as a continuous variable.

Clinical and dietary features were compared between cases and controls and between black and white men using X^2 tests for categorical variables and Wilcoxon rank sum test for continuous variables. Unconditional logistic regression was used to estimate the odd ratios (ORs) and 95% confidence intervals (95%CI) for the associations between dietary intake (3rd and 2nd tertiles vs. 1st tertile) and PC risk. Potential confounders adjusted for in all models were age, race (black vs. white), BMI (continuous), family history of PC (yes vs. no), drinking and smoking status (current, former, never), physical activity in MET hours (<3 , 3–8.9, 9–17.9, ≥ 18), diabetes (yes vs. no) and total caloric intake (continuous from the FFQ). We calculated p-values of tests for trend using logistic regression and the contrast statement, which allows for customized hypothesis tests. We also tested for the significance of interaction terms between carbohydrate intake and race, and carbohydrate intake and diabetes as diabetes is a condition of abnormal insulin sensitivity which may alter the associations between carbohydrates (i.e. insulin) and PC risk. All analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC).

RESULTS

Demographics and Population Description

The demographic characteristics of the 156 cases and 274 controls are detailed in Table I. Cases and controls were similar in age but cases had a lower BMI ($p=0.006$). As expected, cases were more likely to be black (56% vs. 30%, $p<0.001$), and more likely to have family history of PC (24% vs. 16%, $p=0.027$). In addition, cases were more likely to be current smokers ($p=0.009$), and were less likely to be diabetic ($p=0.003$) than controls. There were no differences between cases and controls in drinking status or exercise amount. Among cases, 54% had low-grade PC (Gleason ≤ 6) while 46% had high-grade PC (Gleason ≥ 7).

Medians for caloric intake, carbohydrate intake, percent of energy from carbohydrates, protein and fat, and GI were similar in cases and controls (Table II). Fiber intake was significantly lower in cases compared to controls ($p=0.021$). Results were similar in race-specific analyses, in that most dietary factors were similar between cases and controls in both white and black men with one exception: black cases reported significantly less fiber intake than black controls ($p=0.028$) – a finding not observed in white men ($p=0.724$) (Tables III and IV). Fiber intake was highly correlated to carbohydrate intake among both whites and blacks ($\rho=0.67$, $p<0.0001$, $\rho=0.72$, $p<0.0001$, respectively).

Dietary Intake and Risk of Prostate Cancer

After adjusting for age, race, family history, caloric intake, fiber intake, BMI, diabetes, physical activity, alcohol and smoking status, a higher percent of calories from carbohydrates was associated with reduced risk of PC (3rd vs. 1st tertile; OR=0.41, 95% 0.21–0.81, p -trend=0.010) among all men (Table V). After stratifying by race, though higher carbohydrate intake remained linked with decreased PC risk in both races, the association was more pronounced in white men (p -trend=0.029), compared to black men (p -trend=0.175), however the p -value for the interaction between race and carbohydrates was not significant ($p>0.11$) (Table V). Though GI was unrelated to PC risk in the total group, there was a tendency for high GI to be associated with reduced PC risk in white men and increased PC risk in black men, however the associations were not significant ($p=0.066$; $p=0.172$, respectively; Table V).

Sensitivity analysis excluding men with diabetes ($n=133$) did not materially change the results in that higher carbohydrate intake remained associated with decreased PC risk in all men with stronger associations in white than in black men. However, when diabetic men were excluded, there was no longer a suggestion of higher PC risk with higher GI in black men (p -trend=0.536). Furthermore, the association between higher GI and reduced PC risk in white men became significant (p -trend=0.024).

Dietary Intake and Risk of Low- and High-Grade Prostate Cancer

When analyzing the relationship between percent of calories from carbohydrates and PC risk by tumor grade, we observed that a higher carbohydrate intake was associated with reduced risk of high-grade (3rd vs. 1st tertile, OR=0.34, 95%CI 0.14–0.81, p -trend=0.016), but not low-grade PC (3rd vs. 1st tertile, OR=0.45, 95%CI 0.19–1.05, p -trend=0.064), after multivariable adjustment (Table VI). Fiber intake and GI were unrelated to either low- or high-grade PC, (all p -trends >0.526).

After excluding men with diabetes the inverse association between higher carbohydrate intake and PC became significant for low-grade PC (p -trend=0.039), and remained significant for high-grade PC (p -trend=0.043), however the interaction was not significant ($p>0.11$).

DISCUSSION

In this VA-based case-control study including black and white men, and contrary to our hypothesis, we found higher intake of carbohydrates was associated with reduced overall

risk of PC. However, as predicted, associations varied by race. In black men, though the direction of the association was for lower risk with increased carbohydrate, none of these associations approached nor reached significance. When stratified by grade, higher carbohydrate intake was associated with reduced risk of high-grade PC, with low patient numbers prohibiting us from conducting race-specific analyses for tumor grade. Fiber intake and GI were not associated with overall PC risk or PC grade, though there was a tendency for higher GI to be associated with increased PC risk in black men and reduced PC risk in white men. These findings suggest that there may be a racial difference with regards to carbohydrate metabolism in the context of PC risk; however, as the interaction between race and carbohydrate intake and PC risk was not significant, these differences by race must be interpreted with caution.

Among white men, we found a significant association between carbohydrate amount and PC risk. Our results are in disagreement with prior studies which found no association between carbohydrate intake and PC risk in predominantly white men [5, 12, 14]. On the contrary, several studies found increased carbohydrate intake was associated with increased PC risk [7, 8, 11, 13]. A prospective study including 8,128 Swedish men concluded that high intake of refined carbohydrates may be associated with an increased risk of overall PC, but not high-grade PC [8]. Analyses from the Health Professionals Follow-up Study (HPFS) (n=5,112) showed a positive association only between dietary intake of whole grains and total PC [12]. A case-control study of 982 US men, similarly found that those who reported higher intake of bagels, rolls, whole wheat bread, french fries, potato chips, chocolate, cookies and cakes, or regular soft drinks were at an increased risk of PC [13]. Moreover, increased consumption of those foods was associated with risk of aggressive disease [13]. Interestingly, the direction of the association in our study, favored decreased risk for high carbohydrate intake. More studies are needed to better assess carbohydrate intake and quality with risk and aggressiveness of PC among white men.

Among black men, we found higher carbohydrate intake was not significantly associated with reduced risk of PC. To our knowledge, the only longitudinal study to examine carbohydrate intake and PC risk that included PC cases in black men (5% of the total sample or n=112) was within the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (PLCO) [5]. Though no associations between dietary whole grains and risk of PC were reported, as black men were not analyzed separately, this study was not informative as to risks in black men [5]. Thus, to our knowledge, this is the first report of the associations between the amount of carbohydrate intake and PC risk in a group of black men.

It is unclear why eating more carbohydrates would be associated with lower PC risk, the direct opposite of our hypothesis. In addition, there were no men consuming a low-carbohydrate diet, which we previously hypothesized may be beneficial for PC [26]. In general, as each increase in carbohydrate intake is accompanied by an equal decrease in fat and/or protein intake, increased carbohydrate intake may simply be a proxy of reduced fat intake. Indeed, some [27–29], but not all [30–32], data suggest reducing fat intake (i.e. increasing carbohydrate intake) may lower PC risk. Given this, our data would seem to support an alternative hypothesis to our initial hypothesis that among certain men, increasing carbohydrates at the expense of fat and protein may lower PC risk.

While our data suggested more carbohydrates may lower PC risk, not all carbohydrates are created equal. To examine whether the quality of dietary carbohydrate could in part explain these discrepancies, we investigated the GI of the diet. In white men, we found no associations between GI and PC risk. These results are in agreement with those of others [5, 12, 14], including one study in the PLCO cohort [5]. Shikany et al. found no associations between GI and incident PC in a large cohort (n=30,482) of PLCO participants [5], similar to findings from the HPFS (n=51,529) cohort where GI was not associated with PC risk [12]. Finally, results from the National Institutes of Health–AARP Diet and Health Study, which included 262,642 men, also found no associations between GI and PC risk [14]. However, our results contrast with reports from other case-control studies including mostly white men, which found positive associations between high glycemic foods and risk of both low and high grade PC [7,11,13]. Hu et al. found that among 11,101 Canadian men, a higher GI was positively associated with PC risk when compared to the lowest quartile [7]. Similarly, a multicenter case-control study of 2,556 Italian men found a direct positive association between dietary GI and low- and high-grade PC risk [11]. Lastly, a smaller case-control study (n=982) also reported that increased consumption of high GI foods were statistically significantly associated with aggressive PC [13]. Discrepancies between those studies and ours could be due to a smaller sample size in our study. Alternatively, the food sources used to determine GI may also differ between our population and those of other studies. Finally, other dietary factors not examined in these studies may also contribute to the discrepancies.

Although a higher GI was not statistically significantly associated with increased overall PC risk in black men, we observed a trend for significance. Given that dietary GI is an estimate of how much each gram of available carbohydrate minus fiber raises glucose levels in the blood, and black men with PC reported statistically significant less fiber intake compared to black men with no PC, our results lend some evidence to suggest that a better carbohydrate quality i.e. high in fiber, may be associated with lower PC risk in black men. To support this, we found fiber intake was highly correlated with carbohydrate intake. However, the results did not formally reach statistical significance and thus further studies are needed to confirm these findings. Although, in our study fiber intake was not associated with PC risk, one case-only study found dietary fiber intake was inversely associated with highly aggressive PC, but not with intermediate aggressive PC among both black and white men [33]. Given that we had limited number of men with very aggressive cancers (i.e. 4+3 Gleason and 8–10), we were unable to examine alternative end-points of aggressive disease. Thus, it remains possible that associations seen in this study may differ for very aggressive disease.

Others have reported on genetic and racial differences in carbohydrate metabolism [34]. A small study of paired-matched white and black healthy men, showed black men have a statistically significant higher carbohydrate oxidation rate than white men [34]. It has also been reported that black men have a higher metabolic flexibility after insulin stimulation when compared to white men [35]. In other words, the ability of the body to switch from fat to carbohydrate metabolism after an insulin/glucose infusion is greater in black than in white men [35]. Mechanisms underlying these associations are still not known; however, the lower rate of fat oxidation found in black compared to white men has been proposed [34]. A

multiethnic cross-sectional study on the effects of race on insulin sensitivity found that men of African descent living in the Western world are more hyperinsulinemic and insulin resistant when compared to white American men [36]. This was confirmed by others [16]. Ultimately, how these data help explain our findings is unclear. However, they do provide evidence supporting the hypothesis that carbohydrate metabolism may differ between black and white men, which may underscore racial differences in the associations between carbohydrate intake and PC risk.

Our results should be interpreted in the context of the study limitations. Controls were recruited from out-patients seen in a hospital setting. Thus, the diet and comorbidities of these controls may not be representative of the general population. The sample size was limited and thus though the interaction testing suggested differences, the interaction between race and carbohydrate was not significant. As statistical testing for interactions is a high bar, whether this reflects lack of an interaction or limited power is unknown. Moreover, because of this we were unable to perform analyses simultaneously stratified by PC grade and race, or to define grade as Gleason 4+3 or >8, given that the numbers were small. FFQs, including the one we used, may not be optimal to capture the true range of GI, and its variability over time [37], and we cannot exclude the possibility of recall bias. However participants completed questionnaires prior to the biopsy when they did not know whether they had PC or not.

In summary, our findings suggest higher carbohydrate may be associated with reduced risk of overall PC and high-grade PC. More studies are needed to confirm these results and to investigate potential racial differences in carbohydrate metabolism in relation to PC.

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Table 1

Characteristics of study participants

Risk Factor	Controls n=274 n (%)	Cases n=156 n (%)	p-value
	Mean (SD)	Mean (SD)	
Age	62 (7.1)	63 (6.0)	p=0.105
BMI (kg/m²)	31 (5.4)	29 (5.1)	p=0.006
Race			p<0.001
Black	81 (30)	87 (56)	
White	193 (70)	69 (44)	
Family History PC			p=0.027
Yes	43 (16)	38 (24)	
No	231 (84)	118 (76)	
Drinking Status			p=0.323
Current drinker	119 (43)	77 (49)	
Former drinker	147 (53)	77 (49)	
Never drinker	8(3)	2(1)	
Tobacco use			p=0.009
Current smoker	63(23)	55(35)	
Former smoker	203 (74)	100 (64)	
Never smoker	8(3)	1(1)	
Diabetes			p=0.003
Yes	97 (39)	36 (24)	
No	154 (61)	113 (76)	
MET			p=0.396
<3	140 (67)	86 (69)	
3–8.9	7(3)	3(2)	
9–17.9	1(1)	3(2)	
18	62(29)	33 (26)	
Gleason Sum			
6	N/A	85 (54)	
7		71 (46)	

Numbers do not necessarily add up due to missing values

* p-value for Wilcoxon rank sum test for differences in medians between cases and control

Table 2

Median and interquartile range values of caloric intake, carbohydrate intake, fiber intake, glycemic index, and percent of energy from carbohydrate, protein and fat by case-control status

	Controls (N=274) Median (IQR)	Cases (N=156) Median (IQR)	p-value*
Caloric intake	1838.7 (1422.0–2395.3)	1691.7 (1290.9–2419.1)	0.273
Carbohydrate intake (g)	224.4 (167.5–298.0)	203.5 (149.1–281.7)	0.069
Fiber intake (g)	16.9 (12.3–23.2)	15.4 (10.5–19.8)	0.021
Glycemic index	54.3 (51.8–56.9)	55.2 (51.3–57.6)	0.283
Carbohydrate (%energy)	49.2 (42.9–54.6)	48.6 (41.2–53.6)	0.114
Protein (%energy)	15.8 (13.6–18.1)	15.2 (12.8–18.2)	0.208
Fat (%energy)	34.2 (29.3–38.4)	34.2 (29.6–37.9)	0.924

* p-value for Wilcoxon rank sum test for differences in medians

Table 3

Median and interquartile range intake values in White men

	Controls (N=193) Median (IQR)	Cases (N=69) Median (IQR)	p-value*
Caloric intake	1891.2 (1486.2–2393.3)	1826.6 (1381.3–2514.7)	0.809
Carbohydrate intake (g)	225.9 (171.5–296.9)	207.4 (145.0–290.5)	0.379
Fiber intake (g)	17.3 (12.4–22.7)	18.1 (11.0–21.2)	0.724
Glycemic index	54.2 (52.3–56.9)	54.9 (50.7–57.6)	0.845
Carbohydrate (%energy)	49.1 (42.6–54.3)	47.7 (40.6–53.6)	0.305
Protein (%energy)	15.9 (13.6–18.0)	14.6 (12.7–17.6)	0.063
Fat (%energy)	34.5 (29.1–38.9)	34.7 (30.4–37.6)	0.782

* p-value for Wilcoxon rank sum test for differences in medians

Table 4

Median and interquartile range intake values in Black men

	Controls (N=81) Median (IQR)	Cases (N=87) Median (IQR)	p-value*
Caloric intake	1744.3 (1401.6–2399.5)	1616.9 (1269.7–2307.8)	0.414
Carbohydrate intake (g)	221.2 (160.7–300.17)	196.6 (153.1–256.2)	0.173
Fiber intake (g)	16.2 (12.1–23.9)	14.6 (10.2– 17.8)	0.028
Glycemic index	54.4 (51.5–56.8)	55.6 (51.9– 57.6)	0.096
Carbohydrate (%energy)	49.3 (45.2–55.1)	48.7 (42.4–53.6)	0.134
Protein (%energy)	15.8 (13.8– 18.2)	15.7 (13.2–18.5)	0.865
Fat (%energy)	33.9 (29.5– 37.9)	33.7 (29.5–40.0)	0.905

*
p-value for Wilcoxon rank sum test for differences in medians

Table 5

ORs and p-values for the associations between carbohydrate intake, percent of energy from carbohydrates, and glycemic index, and PC

	All (N=430)			Whites (N=262)			Blacks (N=168)		
	OR (95%CI)	p-value	p-trend	OR (95%CI)	p-value	p-trend	OR (95%CI)	p-value	p-trend
Carbohydrate (%energy)									
Crude (unadjusted)			0.137			0.652			0.039
1 st tertile	reference			reference			reference		
2 nd tertile	0.59 (0.36–0.96)	0.032		0.56 (0.28–1.14)	0.110		0.44 (0.20–0.93)	0.032	
3 rd tertile	0.67 (0.44–1.12)	0.137		0.86 (0.45–1.63)	0.653		0.45 (0.21–0.96)	0.039	
Adjusted*			0.010			0.029			0.175
1 st tertile	reference			reference			reference		
2 nd tertile	0.34 (0.18–0.67)	0.002		0.38 (0.14–1.01)	0.052		0.33 (0.12–0.87)	0.025	
3 rd tertile	0.41 (0.21–0.81)	0.010		0.35 (0.16–0.89)	0.029		0.49 (0.20–1.37)	0.175	
Glycemic index									
Crude (unadjusted)			0.155			0.911			0.034
1 st tertile	reference			reference			reference		
2 nd tertile	0.86 (0.52–1.43)	0.574		0.59 (0.29–1.20)	0.148		1.78 (0.79–4.00)	0.156	
3 rd tertile	1.41 (0.87–2.26)	0.155		0.96 (0.49–1.86)	0.911		2.16 (1.06–4.42)	0.034	
Adjusted*			0.899			0.066			0.172
1 st tertile	reference			reference			reference		
2 nd tertile	0.87 (0.44–1.70)	0.679		0.42 (0.16–1.08)	0.072		1.62 (0.58–4.51)	0.355	
3 rd tertile	0.96 (0.49–1.87)	0.899		0.41 (0.16–1.06)	0.066		2.06 (0.73–5.78)	0.172	
Fiber intake									
Crude (unadjusted)			0.046			0.625			0.044
1 st tertile	reference			reference			reference		
2 nd tertile	1.01 (0.64–1.61)	0.944		1.08 (0.56–2.09)	0.801		1.11 (0.54–2.26)	0.773	
3 rd tertile	0.59 (0.36–0.99)	0.046		0.84 (0.42–1.69)	0.625		0.45 (0.20–0.98)	0.044	
Adjusted**			0.612			0.790			0.552

	All (N=430)			Whites (N=262)			Blacks (N=168)		
	OR (95%CI)	p- value	p- trend	OR (95%CI)	p- value	p- trend	OR (95%CI)	p- value	p- trend
1 st tertile	reference			reference			reference		
2 nd tertile	1.07 (0.56–2.06)	0.834		0.96 (0.36–2.54)	0.938		1.23 (0.48–3.12)	0.667	
3 rd tertile	0.79 (0.31–1.97)	0.612		0.84 (0.24–2.95)	0.790		0.64 (0.15–2.75)	0.552	

* Adjusted for age, race, family history, caloric intake, fiber intake, BMI, diabetes, physical activity, alcohol and smoking status

** Adjusted for age, race, family history, caloric intake, carbohydrate intake, BMI, diabetes, physical activity, alcohol and smoking status

ORs and p-values for the associations between carbohydrate intake, percent of energy from carbohydrates, and glycemic index, and Low grade and High grade PC

Table 6

	Low Grade (N=85)				High Grade (N=71)			
	OR (95%CI)	p-value	p-trend		OR (95%CI)	p-value	p-trend	
Carbohydrate (%energy)								
Crude (unadjusted)			0.526					0.084
1 st tertile	reference				reference			
2 nd tertile	0.74 (0.41–1.34)	0.323			0.45 (0.23–0.86)	0.016		
3 rd tertile	0.83 (0.46–1.48)	0.526			0.58 (0.31–1.07)	0.084		
Adjusted*			0.064					0.016
1 st tertile	reference				reference			
2 nd tertile	0.45 (0.20–1.00)	0.052			0.23 (0.10–0.57)	0.002		
3 rd tertile	0.45 (0.19–1.05)	0.064			0.34 (0.14–0.81)	0.016		
Glycemic index								
Crude (unadjusted)			0.461					0.126
1 st tertile	reference				reference			
2 nd tertile	0.86 (0.46–1.60)	0.635			0.87 (0.43–1.75)	0.699		
3 rd tertile	1.24 (0.69–2.32)	0.461			1.63 (0.87–3.06)	0.126		
Adjusted*			0.526					0.989
1 st tertile	reference				reference			
2 nd tertile	1.02 (0.45–2.31)	0.975			0.62 (0.24–1.59)	0.318		
3 rd tertile	0.86 (0.36–2.01)	0.724			0.99 (0.41–2.40)	0.989		
Fiber intake								
Crude (unadjusted)			0.212					0.068
1 st tertile	reference				reference			
2 nd tertile	1.39 (0.79–2.45)	0.250			0.69 (0.37–1.27)	0.232		
3 rd tertile	0.66 (0.34–1.27)	0.212			0.54 (0.28–1.05)	0.068		

	Low Grade (N=85)			High Grade (N=71)		
	OR (95%CI)	p- value	p- trend	OR (95%CI)	p- value	p- trend
Adjusted**						0.815
1st tertile	reference		0.593	reference		
2nd tertile	1.23 (0.55–2.72)	0.613		0.86 (0.36–2.04)	0.729	
3rd tertile	0.73 (0.24–2.28)	0.593		0.87 (0.26–2.85)	0.815	

* Adjusted for age, race, family history, caloric intake, fiber intake, BMI, diabetes, physical activity, alcohol and smoking status

** Adjusted for age, race, family history, caloric intake, carbohydrate intake, BMI, diabetes, physical activity, alcohol and smoking status