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Associations of Red Meat, Fat, and Protein Intake With Distal Colorectal Cancer Risk

Christina Dawn Williams, **Jessie A. Satia**, **Linda S. Adair**, **June Stevens**, **Joseph Galanko**, **Temitope O. Keku**, and **Robert S. Sandler**
University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

Abstract

Studies have suggested that red and processed meat consumption elevate the risk of colon cancer; however, the relationship between red meat, as well as fat and protein, and distal colorectal cancer (CRC) specifically is not clear. We determined the risk of distal CRC associated with red and processed meat, fat, and protein intakes in Whites and African Americans. There were 945 cases (720 White, 225 African American) of distal CRC and 959 controls (800 White, 159 African American). We assessed dietary intake in the previous 12 mo. Multivariate logistic regression analyses were used to obtain odds ratios (OR) and 95% confidence intervals (95% CI). There was no association between total, saturated, or monounsaturated fat and distal CRC risk. In African Americans, the OR of distal CRC for the highest category of polyunsaturated fat intake was 0.28 (95% CI = 0.08–0.96). The percent of energy from protein was associated with a 47% risk reduction in Whites (Q4 OR = 0.53, 95% CI = 0.37–0.77). Red meat consumption in Whites was associated with a marginally significant risk reduction (Q4 OR = 0.66, 95% CI = 0.43–1.00). Our results do not support the hypotheses that fat, protein, and red meat increase the risk of distal CRC.

INTRODUCTION

Colorectal cancer (CRC) is the third most common cancer in the United States and accounts for approximately 9% of all cancer deaths (1). Diet is widely believed to be associated with CRC development and is a modifiable risk factor. Therefore, there is great interest in better understanding which dietary factors may be associated with higher or lower CRC risk. In particular, increased consumption of dietary fat and protein (mainly animal fat and protein) has shown strong correlations with CRC cancer incidence in ecological studies (2–5). Observational studies in the United States have generally reported that high intakes of red meat and processed meat may increase risk for CRC (6,7). A comprehensive review by the World Cancer Research Fund and the American Institute for Cancer Research concluded that there was convincing evidence that red meat and processed meat increases CRC risk but that the evidence regarding the role of foods containing animal fat is limited (8). Several hypotheses have been proposed to explain a possible relationship between red meat and CRC risk. These hypotheses relate to primary nutrients in red meat, that is, fat (9–11), protein (3,12), and heme iron (13) as well as components of processed red meat such as N-nitroso compounds (9,14) and factors produced while cooking red meat at high temperatures, namely, heterocyclic amines and polycyclic aromatic hydrocarbons (3,5,9,14).

Address correspondence to Christina Williams, Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, McGavran-Greenberg Hall, 135 Dauer Drive, CB #7400, Chapel Hill, NC 27599. Phone: 919-471-8393. Fax: 919-471-8393. cdpayne@email.unc.edu.

CRC consists of carcinomas of the colon and rectum, and rectal cancer comprises approximately one-third of all colorectal cancers. It has been suggested that there are different etiologies for colon and rectal cancer (15,16). CRC risk factors are thought to differ according to the proximal versus distal location of the cancer in the colorectum. Therefore, it is important to examine risk factors separately for both sites. Some investigators have studied associations between meat intake and subsites of the colorectum (17–19) and have suggested a stronger positive relationship between red meat and rectal cancer than red meat and colon cancer (9). We previously observed nonstatistically significant inverse associations with rectal cancer risk for high intakes of red meat in Whites and African Americans, whereas processed meat had a nonstatistically significant positive association with risk only among Whites (20). However, the currently available evidence regarding the associations of fat and protein with distal colorectal cancer risk remains inconclusive.

To expand our previous findings, in the present study, we examined associations of fat and protein intake, in addition to red and processed meat, with risk for distal CRC in African Americans and Whites in a large case-control study in North Carolina (NC). We further sought to examine the effect of fat and protein intake on the association between red and processed meat and distal CRC. This study adds to the literature in 2 ways: it contributes to the body of knowledge regarding diet and distal CRC risk and is, to our knowledge, the first study to examine these associations in African Americans.

MATERIALS AND METHODS

Study Design and Population

The North Carolina Colon Cancer Study–Phase II is a population-based study conducted between May 2001 and September 2006. Cases and controls were selected through a randomized recruitment approach that used age-, sex-, and race-specific incidence rates to calculate selection probabilities (21,22). African Americans were oversampled to increase their representation in the study. The eligibility criteria for all subjects were age 40 to 79 yr, resident in 1 of 33 target counties in central and eastern NC, a NC driver's license, no history of colon or rectal cancer, able to give informed consent, and able to complete the interview.

Distal CRC cases (including sigmoid colon, rectosigmoid, and rectal cancer) were selected through the rapid ascertainment system (23) of the NC Central Cancer Registry. Cases were diagnosed with a primary adenocarcinoma between May 2001 and September 2006. Our study pathologist confirmed these diagnoses using pathology slides and medical records. Controls were randomly selected from the NC Department of Motor Vehicles if under age 65 and the Centers for Medicare and Medicaid Services if 65 and older.

A total of 1,057 out of 1,417 eligible cases and 1,019 out of 1,827 eligible controls had an interview. Among those eligible to participate, the overall response rate (number interviewed/number eligible) for cases was 74% (76% for Whites, 70% African Americans) and 56% in controls (58% for Whites, 46% for African Americans). For this analysis, we further excluded 89 participants who did not complete all components of the study and an additional 86 participants who had implausible energy intake values (<800 kcal/day and >5,000 kcal/day for men and <600 kcal/day and >4,000 kcal/day for women (24). The final analytic sample included 945 cases (720 White, 225 African American) and 959 controls (800 White, 159 African American). This study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Data Collection

The National Cancer Institute's (NCI) Diet History Questionnaire (DHQ) was used to assess dietary intake. The DHQ is a 124-item food frequency questionnaire that includes questions on dietary supplement use and fat added to foods (25,26). The questionnaire was administered by trained nurse interviewers who asked subjects to recall their usual dietary intake over the 1 yr prior to diagnosis for cases or interview for controls. Nutrient intakes were determined using software provided by the NCI and were based on the nutrient content of each food item, the frequency of consumption, and portion size. The nutrients/foods of interest for this study were total fat, saturated fat, monounsaturated fat (MUFA), polyunsaturated fat (PUFA), protein, red meat, and processed meat. Red meat includes non-processed veal, lamb, beef steaks, beef roast, beef mixtures, burgers, ham (not luncheon meat), pork, and ribs; and processed meat includes sausage, bacon, hot dogs, and all cold cuts (i.e., luncheon meats made from beef, veal, ham, pork, chicken, and turkey). Interviewers administered a separate questionnaire to collect data on covariates including demographic and household information, medical history, medication use, physical activity, smoking status, and family history of CRC.

Statistical Analysis

Analyses were conducted using SAS (version 9.1; SAS Institute, Inc., Cary, NC) and based on 2-sided *P* values. Participants were stratified by race and case-control status. The Wilcoxon nonparametric rank sum test was used to assess differences in mean nutrient intakes between White and African American controls. We calculated adjusted odds ratios (OR) and 95% confidence intervals (95% CI) using unconditional logistic regression models. PROC LOGISTIC in SAS was used with an option in the MODEL statement to include offsets. The offset term takes into account the selection probabilities based on age, race, and sex, which were used to identify eligible participants (22). Quartiles (Q) were constructed for nutrient and red meat intakes based on the distribution among race-specific controls for stratified analyses. This was done to account for possible differences in the variation in range of intake for Whites and African Americans. The following covariates were considered for inclusion in the multivariate models: age (continuous), sex, education (≤ high school, some college, college graduate/advanced degree), smoking status (never, current, former), prior body mass index (BMI; i.e., in the 1 yr prior to interview for controls and diagnosis for cases: normal, overweight, obese), physical activity (continuous), first degree family history of CRC (yes, no), nonsteroidal anti-inflammatory drug (NSAID) use (yes, no), calcium (continuous), folate (continuous), and fiber (continuous). The standard multivariate method was used to adjust for total energy intake; the use of other methods (e.g., nutrient residuals) did not appreciably alter the results. Multivariate models were created using backward elimination and included covariates that changed the ORs of interest by ≥10%. All covariates met the criteria for inclusion except smoking status and folate. *P* values for trend were obtained using the median intake values in controls of each quartiles as a continuous variable in the model, which was weighted by the inverse of the variance. For each meat category, we constructed 3 multivariate models: model 1 included age, sex, education, prior BMI, family history, NSAID use, physical activity, calcium, fiber, and total energy; model 2 consisted of the covariates in model 1 and energy-adjusted saturated fat; model 3 consisted of the covariates in model 1 and energy-adjusted protein. We examined these 3 different models to determine the extent to which the association between red and processed meat and distal CRC can be attributed to overall saturated fat or protein intake since it has been suggested that these nutrients in red and processed meat contribute to the elevated risk of CRC. Therefore, these 3 different model specifications test the hypothesis that fat and protein intake mediate the association between red and processed meat and distal CRC.

RESULTS

Table 1 summarizes characteristics of cases and controls by race with respect to potential confounders and dietary intake. Cases in both race groups were younger, had less education, and a higher mean BMI than their respective controls (20). Among Whites, regular use of NSAIDs was much more frequent in controls compared to cases, and a greater proportion of African American cases had a family history of CRC than African American controls. Some nutrient intakes and meat consumption patterns varied by race; among controls, on average, Whites had significantly greater calcium, fiber, and alcohol intakes than African Americans. There were no appreciable differences by race in total energy, dietary folate, and fat. The percent of energy from protein was greater for Whites, although absolute intakes did not differ significantly by race. Whites reported a slightly higher mean intake of red meat than African Americans (52.1 vs. 50.1 g/day, respectively; $P = 0.05$), whereas African Americans had greater processed meat consumption than Whites (24.5 vs. 18.7 g/day, respectively; $P = 0.006$).

As shown in Table 2, absolute intakes of total fat and the percent of energy from total fat had null associations with risk in Whites and nonstatistically significant inverse associations in African Americans. The ORs for saturated fat and the percent of energy from saturated fat were not statistically significant in either race group; however, we observed a significant inverse trend in African Americans for the percent of energy from saturated fat (*P* value for trend = 0.004). With regards to the unsaturated fats (MUFA and PUFA), there were no statistically significant associations with risk in Whites. In African Americans, the highest category of PUFA intake was suggestive of lower risk (OR = 0.28, 95% CI = 0.08–0.96), yet there was not a significant linear trend. There was an inverse association for high protein intake in Whites only. In Whites, high absolute protein intake was suggestive of lower distal CRC risk (OR = 0.57, 95% CI = 0.32–1.01); whereas high percent of energy from protein also yielded a significant risk reduction (OR = 0.53, 95% CI = 0.37–0.77), and the ORs decreased progressively with increasing percent of energy from protein (*P* value for trend = 0.003). Although the point estimates were of a similar magnitude in African Americans, there was less statistical power to detect a statistically significant association.

Table 3 shows the relationship between distal CRC risk and red meat and processed meat. The model 1 ORs for the highest category of red meat consumption were similar in both race groups, yet only approached statistical significance in Whites (OR = 0.66, 95% CI = 0.43–1.00). There was a slightly stronger risk reduction in Whites when we controlled for energy from saturated fat (OR = 0.60, 95% CI = 0.39–0.93). Moderately high processed meat consumption had a significant positive association with risk in Whites (Q3 vs. Q1 OR = 1.43, 95% CI = 1.02–2.02), which was even stronger when we adjusted for energy from protein (Q3 vs. Q1 OR = 1.56, 95% CI = 1.10–2.20). However, neither Q4 ORs for processed meat nor the *P* value for a linear trend were statistically significant. There were no statistically significant associations in African Americans, although ORs suggest lower risk for both red and processed meat.

DISCUSSION

In this large case-control study of 945 distal CRC cases (including sigmoid colon, rectosigmoid, and rectal cancers) and 959 controls, we did not find any evidence of associations between total and saturated fat and distal CRC risk, although PU-FAs appeared to reduce risk in African Americans. Protein intake was associated with lower risk of distal colorectal cancer in Whites. Our study does not support the hypothesis that high red meat or processed meat consumption increases the risk of distal colorectal cancer. Interestingly, our

findings suggest that red meat consumption may reduce the risk of distal CRC in Whites, whereas moderately high intakes of processed meat possibly elevate risk.

The results for total fat intake are in agreement with several previous case control (27,28) and cohort (29,30) studies, which have generally found no statistically significant association with rectal cancer risk. Several investigations found the relationship between overall fat intake and rectal cancer to vary by gender. For example, an early study by Freudenheim et al. (31) observed an approximately twofold higher rectal cancer risk in males (OR = 1.96, 95% CI = 1.19–3.24) but no clear association in females. Similarly, a more recent and larger case-control study in Canada found a positive association among male participants (OR = 1.7, 95% CI = 1.1–2.6) but no association in females (32). We did not find evidence of effect modification by gender in our analyses of total fat and distal CRC.

When examining the association between dietary fat and distal colorectal cancer, it is important to consider different types of fatty acids because they can have different and opposite effects on risk. Experimental studies have shown that high saturated fat and omega-6 PUFAs increase the incidence of chemically induced colon cancer in animal models (33), whereas omega-3 PUFAs inhibit colorectal carcinogenesis in rodents (34,35). It has been suggested that the fat content, particularly saturated fat, in red meat may influence CRC risk by increasing the production of secondary bile acids that can promote colon carcinogenesis (11,36). Postulated mechanisms regarding the protective role for omega-3 PUFAs include their ability to inhibit tumor growth and modulate the expression of proinflammatory genes (37,38). There is limited evidence that foods containing animal fat increase the risk of CRC (8). For example, a combined analysis of 13 case-control studies found no evidence of an association between CRC and saturated fat, PUFAs, or MUFAs (39). This is also the case for rectal cancer specifically, as studies have observed no association between saturated fat and rectal cancer (27–30,40) as we did in this study for distal CRC. High intake of PUFAs in our study was inversely related to risk but only reached statistical significance in African Americans. However, it is possible that this was a chance finding. Unfortunately, we were not able to distinguish between omega-3 and omega-6 PUFAs.

Total consumption of protein was significantly associated with a significant risk reduction in Whites and had a nonstatistically significant association with lower risk in African Americans in this study. There is limited epidemiologic evidence for a relationship between overall protein intake and distal CRC risk. A few studies have reported no association between protein intake and rectal cancer risk (28,30), whereas a case-control study in Italy reported a marginally significant risk reduction of rectal cancer for 100 calories/day from protein (41). These results are contrary to the hypothesis that increased protein intake may elevate CRC risk due to components of protein degradation such as ammonia, phenolic compounds, amines, N-nitroso compounds, and possibly sulfides that are known to exert toxic effects in animal models and in vitro (12). However, an animal study by Corpet et al. (42) found that bacterial metabolites of protein did not promote colorectal carcinogenesis, which challenges the previously mentioned hypothesis.

Meta-analyses of meat consumption and CRC risk have concluded that red meat and processed meat increase the risk of CRC, colon cancer, and rectal cancer (3,9,43) and that processed meat may be a stronger risk factor than fresh red meat (43,44). In contrast, findings from individual studies have not been consistent (17,19,27,45–48); therefore, the biological mechanisms relating red meat intake to CRC risk remain speculative. Individual studies investigating the relationship between red meat and rectal cancer specifically are also conflicting. Some studies have reported a significantly higher risk of rectal cancer with

increased red meat consumption (17,46,48) whereas others did not find any statistically significant associations (18,19,27,30,47,49,50). Our study did not suggest that red meat intake elevates the risk of distal CRC, although moderately high intakes of processed meat appear to be associated with significantly higher risk in Whites. Surprisingly, we found high red meat consumption to be associated with lower risk in Whites.

It was initially hypothesized that the saturated fat and protein content of red meat increases CRC risk for reasons previously mentioned. This hypothesis has been explored in animal studies, and it was found that lean beef did not promote colon carcinogenesis in rats on high calcium diets (51); therefore, the hypothesis may hold true when the diet is not overloaded with calcium (13). This further suggests that other nutrients may modify the association between red meat and CRC. When we controlled for energy from saturated fat in our analyses of the risk estimates, there was a trend toward a slightly stronger risk reduction for high red meat consumption in Whites. Therefore, there was little evidence indicating that the association of red meat and distal CRC was mediated by saturated fat intake. Protein metabolism is another mechanism to explain the relationship between CRC risk and red meat intake. Meat is a major source of protein, and products of protein metabolism such as ammonia and N-nitroso compounds are known to have toxic effects (12). High protein intakes in this study appeared to reduce the risk of distal colorectal cancer in Whites, mainly as the percent of total energy. Controlling for protein intake in the analyses of red meat and distal CRC risk in Whites removed the significant risk reduction for high red meat intake and strengthened the magnitude of the association with processed meat consumption. Therefore, the protein content in red meat may contribute to distal CRC risk reduction in Whites. This surprising finding may reflect that those with high red meat and protein intake were generally more health conscious. For example, diets high in red meat and protein may have been low in carbohydrate intake, and thereby reduce risk. However, low red meat intake is usually associated with healthy dietary habits (52). In addition, this finding may reflect the type of red meat consumed and how it was cooked, possibly minimizing the presence of carcinogenic compounds in red meat cooked at high temperatures. No statistically significant changes for were observed in African Americans, although there were generally less favorable risk estimates when adjusting for protein.

Our findings do not support the hypotheses that fat, protein, and red meat increase the risk of distal CRC, although these dietary components have generally been associated with elevated colon cancer risk. There are several possible explanations for these findings. Our results may simply reflect differences in proximal vs. distal colorectal cancer development. There is evidence that colon and rectal cancer may have distinct etiologies (16,53) as well as differences with regards to the metabolism of bile acids (14), expression of metabolizing enzymes (15), bacterial composition and pH (54), and genetic profile (16,17). Another explanation may be that red meat intake in our study population was relatively low, and therefore perhaps below the level necessary to elevate risk. For example, Larsson and Wolk (9) reported a 63% increase in rectal cancer risk associated with 120 g/day of red meat; the mean total red meat intake in our study was 76 g/day. These results may also reflect our inability to determine the amount of red meat consumed according to doneness and cooking methods and thereby estimate the amount of heterocyclic amines and polycyclic aromatic hydrocarbons in the red meat. These mutagenic compounds may be the culpable substances more so than overall red meat consumption.

The reasons why some of our results differed by race are not totally clear. No other available literature has reported the associations between diet and distal colorectal cancer in African Americans. An early study of diet and colon cancer in African Americans did not observe any statistically significant associations between colon cancer and beef and pork consumption (55). A population-based case-control study of colon cancer did not report any

associations between colon cancer risk in African Americans and energy-adjusted saturated fat, protein, or red meat intakes (56,57). They did, however, find a significant colon cancer risk reduction for high total fat intake in African Americans. We realize that the relatively small sample of African Americans in our study may have resulted in reduced power to detect real associations and resulted in unstable estimates. The risk differences remained after we estimated ORs using the same quartile cut points in Whites and African Americans; therefore, variation in the range of nutrient intake is also not a likely explanation for the racial differences in risk.

The population-based design and large sample size are among the strengths of this study. It is noteworthy that this is among the first published reports of associations between fat, protein, red and processed meat, and distal CRC risk in African Americans. All data were collected in person using standard questionnaires administered by our nurse interviewers, thereby minimizing the potential for misclassification. Recall and response bias could have been introduced in our study and affected our results. Specifically, the low response rate in controls could have possibly inflated our risk estimates if they were healthier than the general population. Also, the delay between cancer diagnosis and interview could have contributed to recall bias. We also cannot exclude the possibility of measurement error due to the use of the food frequency questionnaire. Given the multiple analyses in this study, the statistically significant associations may have been due to chance and should be interpreted with caution.

In summary, this study did not provide evidence that total or saturated fat is related to distal CRC risk in Whites and African Americans. High intake of polyunsaturated fatty acids may reduce distal CRC risk in African Americans, whereas protein intake may lower risk in Whites. Red meat appeared to reduce risk, whereas processed meat may elevate risk in Whites. These findings highlight the importance of examining these associations in large racially diverse populations and add to the knowledge base for dietary risk factors for distal CRC.

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TABLE 1

Characteristics of cases and controls, by race: North Carolina Colon Cancer Study–Phase II[a]

	Whites (*N* = 1,520)		African Americans (*N* = 384)		
	Cases	**Controls**	**Cases**	**Controls**	***P* Value[b]**
N	720	800	225	159	
Mean age (yr)	59.6 (10.3)	61.7 (9.8)	58.0 (10.0)	60.3 (9.8)	
Male (%)	58.3	60.5	52.4	52.2	
>High school education (%)	49.7	61.0	38.2	41.5	
Mean BMI (kg/m^2)	29.2 (6.3)	28.0 (5.5)	31.6 (7.7)	29.9 (6.5)	
Mean physical activity (MET-min/day)[c]	2,250 (661)	2,152 (473)	2,178 (545)	2,152 (494)	
Current smokers (%)	15.6	13.5	22.7	17.0	
Regular NSAID use (%)[d]	35.1	45.7	24.4	22.8	
Family history of CRC (%)	13.2	11.3	11.8	5.2	
Mean daily intake					
Total energy (kcal)	2,245 (826)	2,143 (790)	2,423 (953)	2,207 (891)	0.56
Calcium (mg)	814 (351)	860 (393)	788 (354)	725 (354)	< 0.0001
Dietary folate (mcg)	432 (157)	450 (176)	483 (205)	432 (177)	0.20
Fiber (g)	21.0 (8.2)	22.1 (8.5)	22.1 (10.4)	20.7 (9.0)	0.02
Alcohol (g)	8.8 (22.2)	8.3 (17.1)	7.9 (24.1)	4.8 (13.3)	< 0.0001
Total fat (g)	91.1 (39.2)	86.0 (39.3)	93.1 (43.7)	89.8 (43.5)	0.43
Total fat (% energy)	36.2 (6.7)	35.5 (7.0)	34.1 (7.0)	36.0 (6.8)	0.40
Saturated fat (g)	28.2 (13.2)	26.3 (13.4)	28.0 (13.6)	26.9 (14.2)	0.76
Saturated fat (% energy)	11.2 (2.7)	10.8 (2.8)	10.3 (2.5)	10.6 (2.4)	0.94
Monounsaturated fat (g)	35.5 (15.9)	33.3 (15.7)	36.1 (17.7)	35.0 (17.5)	0.38
Polyunsaturated fat (g)	20.8 (9.3)	20.0 (9.2)	22.0 (10.7)	21.2 (10.4)	0.27
Protein (g)	78.0 (29.5)	79.9 (31.9)	82.3 (44.8)	78.1 (36.8)	0.24
Protein (% energy)	14.1 (2.7)	15.0 (2.8)	13.6 (2.8)	14.2 (3.1)	0.001
Red meat (g)	55.3 (40.7)	52.1 (40.5)	52.7 (44.8)	50.1 (46.2)	0.05
Processed meat (g)	20.8 (19.3)	18.7 (18.2)	25.2 (25.9)	24.5 (25.3)	0.006

[a] Abbreviations are as follows: BMI, body mass index; NSAID, nonsteroidal anti-inflammatory drug; CRC, colorectal cancer. *N* = 1,904. Values represent means (SD) and percents.

[b] Based on Wilcoxon rank sum test for comparisons between White and African American controls.

[c] Metabolic equivalent minutes per day.

[d] Greater than or equal to 15 NSAIDs per month in the last 5 yr.

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TABLE 2

Odds ratios (ORs) and 95% confidence intervals (CIs) for fat and protein intake and risk of distal colorectal cancer: North Carolina Colon Cancer Study–Phase II[a]

	Whites (*n* = 1,520)				African Americans (*n* = 384)			
Nutrient Quartiles (Q)	**Cases/Controls**	**Median Intake/Day in Controls**	**OR**	**95% CI**	**Cases/Controls**	**Median Intake/Day in Controls**	**OR**	**95% CI**
Total fat (g)								
Q1	146/200	45.2	1.00		55/40	42.7	1.00	
Q2	156/200	67.7	0.98	0.68–1.39	46/40	69.8	0.55	0.26–1.14
Q3	206/200	91.5	1.21	0.80–1.82	67/40	99.6	0.55	0.23–1.36
Q4	212/200	132.3	1.01	0.56–1.81	57/39	145.2	0.32	0.10–1.15
P for linear trend				0.97				0.89
Total fat (% energy)								
Q1	144/200	27.3	1.00		70/40	28.1	1.00	
Q2	207/201	33.6	1.36	0.98–1.90	70/40	34.5	1.07	0.56–2.01
Q3	169/199	38.1	0.92	0.65–1.30	50/40	38.4	0.55	0.29–1.07
Q4	200/200	43.3	1.00	0.71–1.42	35/39	44.3	0.59	0.29–1.21
P for linear trend				0.25				0.27
Saturated fat(g)								
Q1	144/200	12.9	1.00		46/40	11.8	1.00	
Q2	156/200	20.0	0.96	0.67–1.37	58/40	19.4	0.81	0.39–1.66
Q3	202/200	27.9	1.14	0.76–1.70	55/40	29.6	0.54	0.22–1.34
Q4	218/200	42.1	1.05	0.61–1.81	66/39	44.0	0.60	0.18–1.97
P for linear trend				0.66				0.56
Saturated fat (%energy)								
Q1	133/200	7.7	1.00		64/40	7.8	1.00	
Q2	184/200	9.7	1.12	0.80–1.58	71/40	9.8	1.13	0.60–2.15
Q3	173/202	11.5	0.95	0.67–1.35	43/40	11.4	0.52	0.26–1.04
Q4	230/198	13.8	1.27	0.88–1.84	47/39	13.6	0.69	0.33–1.42
P for linear trend				0.27				0.004
Monounsaturated fat(g)								
Q1	151/200	17.2	1.00		57/40	15.5	1.00	
Q2	161/200	26.4	0.98	0.69–1.39	48/40	27.1	0.56	0.27–1.13

	Whites (n = 1,520)				African Americans (n = 384)			
Nutrient Quartiles (Q)	**Cases/Controls**	**Median Intake/Day in Controls**	**OR**	**95% CI**	**Cases/Controls**	**Median Intake/Day in Controls**	**OR**	**95% CI**
Q3	192/200	35.1	1.03	0.69–1.53	60/40	39.0	0.57	0.24–1.37
Q4	216/200	51.8	0.89	0.51–1.55	60/39	56.7	0.41	0.12–1.40
P for linear trend				0.62				0.68
Polyunsaturated fat (g)								
Q1	150/200	10.3	1.00		45/40	10.3	1.00	
Q2	180/200	15.8	1.12	0.79–1.58	57/40	16.5	0.77	0.38–1.58
Q3	185/201	21.4	1.03	0.70–1.51	76/40	23.0	0.78	0.33–1.86
Q4	205/199	30.6	0.94	0.58–1.55	47/39	31.8	0.28	0.08–0.96
P for linear trend				0.68				0.78
Protein (g)								
Q1	187/200	47.0	1.00		45/40	38.4	1.00	
Q2	176/200	66.1	0.90	0.64–1.27	55/40	60.7	1.05	0.51–2.16
Q3	183/200	84.4	0.86	0.57–1.30	66/40	85.0	0.81	0.32–2.05
Q4	174/200	115.4	0.57	0.32–1.01	59/39	122.0	0.58	0.16–2.10
P for linear trend				0.74				0.93
Protein (% energy)								
Q1	272/200	11.9	1.00		67/40	10.7	1.00	
Q2	191/201	14.2	0.82	0.60–1.12	61/40	13.0	0.99	0.51–1.92
Q3	140/199	15.6	0.65	0.47–0.91	59/40	15.2	0.95	0.47–1.88
Q4	117/200	18.1	0.53	0.37–0.77	38/39	17.2	0.60	0.28–1.30
P for linear trend				0.003				0.59

[a]Adjusted for age, sex, education, body mass index, family history, nonsteroidal anti-inflammatory drug use, physical activity, calcium, fiber, and total energy.

TABLE 3

Odds ratios (ORs) and 95% confidence intervals (CIs) for red and processed meat consumption and risk of distal colorectal cancer: North Carolina Colon Cancer Study–Phase II

	Whites (*n* = 1,520)						African Americans (*n* = 384)					
	Cases/Controls	**Median Intake/Day in Controls**	**OR[a]**	**95% CI**	**OR[b]**	**OR[c]**	**Cases/Controls**	**Median Intake/Day in Controls**	**OR[a]**	**95%CI**	**OR[b]**	**OR[c]**
Red meat (g)												
Q1	149/207	16.2	1.00		1.00	1.00	58/41	12.7	1.00		1.00	1.00
Q2	186/195	32.9	1.09	0.78–1.52	1.06	1.17	39/39	27.8	0.54	0.27–1.09	0.61	0.58
Q3	199/198	53.6	1.05	0.74–1.49	0.99	1.23	65/40	45.5	0.83	0.42–1.63	0.95	0.95
Q4	186/200	94.8	0.66	0.43–1.00	0.60[4]	0.92	63/39	108.6	0.64	0.27–1.50	0.80	0.84
P for linear trend				0.90						0.94		
Processed meat (g)												
Q1	131/204	3.4	1.00		1.00	1.00	44/41	3.7	1.00		1.00	1.00
Q2	178/202	9.6	1.15	0.82–1.62	1.14	1.21	85/40	12.2	1.47	0.76–2.85	1.65	1.54
Q3	208/198	19.1	1.43	1.02–2.02	1.42[d]	1.56[d]	42/40	24.9	0.54	0.24–1.18	0.62	0.59
Q4	203/196	37.7	1.16	0.80–1.68	1.14	1.36	54/38	42.7	0.86	0.38–1.96	0.59	1.02
P for linear trend				0.57						0.54		

[a] $N = 1{,}904$. Adjusted for age, sex, education, body mass index (BMI), family history, nonsteroidal anti-inflammatory drug (NSAID) use, physical activity, calcium, fiber, and total energy.

[b] Adjusted for age, sex, education, BMI, family history, NSAID use, physical activity, calcium, fiber, total energy, and energy-adjusted saturated fat.

[c] Adjusted for age, sex, education, BMI, family history, NSAID use, physical activity, calcium, fiber, total energy, and energy-adjusted saturated protein.

[d] $P < 0.05$.