Fiber and C-Reactive Protein in Diabetes, Hypertension, and Obesity

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Elevated levels of C-reactive protein (CRP) have been associated with increased risk of cardiovascular disease among the general population (1–6). People with diabetes (7), hypertension (8), and obesity (9) have CRP levels that are higher than those in people without these conditions in the general population.

Previous studies indicate an inverse association between dietary fiber intake and levels of inflammatory biomarkers (10,11). Acknowledging that individuals with certain conditions (e.g., diabetes) are at higher risk for elevated CRP, it is unclear whether intake of dietary fiber may have more impact on inflammatory markers among such people. To investigate the relationship between dietary fiber and inflammatory markers in people with diabetes, hypertension, and obesity, we conducted a study using the nationally representative 1999–2002 National Health and Nutrition Examination Survey (NHANES).

RESEARCH DESIGN AND METHODS

— We conducted an analysis of the 1999–2002 NHANES (http://www.cdc.gov/nchs/nhanes.htm). Our sample was limited to participants ≥20 years of age who had valid high-sensitivity CRP measurements and dietary information (unweighted n = 7,891). The study was approved by the institutional review board at the Medical University of South Carolina.

Individuals were considered to have a previous diagnosis of diabetes or hypertension based on questions asking whether the individual had ever been told by a doctor that he or she had the condition. People with a BMI ≥30 kg/m^2 were defined as obese.

Dietary intake in the NHANES was based on 24-h diet recall coupled with known nutritional content of each of these foods; the use of fiber supplements was not included in the daily totals. We established fiber groups using quartiles (grams per day) for the entire U.S. adult population: ≤8.8, 8.9–13.5, 13.6–19.9, and ≥20.0 g/day.

Several control variables were included in the analysis, including age, race, sex, current smoking status, alcohol use (>1/month), physical activity (none, moderate, or vigorous), taking cholesterol-lowering medication, a history of heart disease (congestive heart failure, coronary heart disease, angina, heart attack, or stroke), total calories, and total serum cholesterol (9,12,13).

In the statistical analyses, we used weighted variables to account for the complex sampling design of the NHANES and to allow us to make population estimates for the U.S. (14,15). We calculated the median CRP for each fiber quartile in the entire population and in three subpopulations: people with none, one, or two or more of the cardiovascular risk conditions (diabetes, hypertension, or obesity).

Multivariate logistic regression analyses were conducted and included the control variables previously mentioned. Analyses were performed for the general population and each subpopulation according to the number of high-risk conditions present.

RESULTS

— Individuals who consumed above the 75th percentile of fiber (≥20 g/day) had significantly lower median CRP than people who consumed lesser amounts of fiber (Table 1). People with two or more high-risk conditions had a significantly higher median CRP than people without these conditions.

In the adjusted logistic regression models, adults with fiber intake in the lowest two quartiles were at a significantly greater risk of having elevated CRP than those in the highest quartile, regardless of the number of conditions present (Table 1). Among individuals who consumed ≤8.8 g/day fiber, those who had two or more risk conditions nearly doubled their likelihood of having elevated CRP compared with adults with no risk conditions. There were no consistent associations found between CRP elevation and intake of total fat, polyunsaturated fat, saturated fat, protein, carbohydrate, or cholesterol ($P > 0.05$, data not shown). Only dietary fiber intake showed a consistent association with CRP in the general population and in those with high-risk conditions.

CONCLUSIONS

— The results of this study suggest that CRP levels are highest in people with two or more high-risk conditions (obesity, hypertension, or diabetes) consuming <8.8 g/day fiber, and are approximately four times higher than in those people without these conditions. Even after controlling for potential confounding variables, having two or more high-risk conditions doubled the likelihood of CRP being increased compared with not having any of these con-

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Received for publication 4 March 2005 and accepted 10 March 2005.

Abbreviations: CRP, C-reactive protein; NHANES, National Health and Nutrition Examination Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Median CRP level in the entire population and among adults who have none or one or more of the following conditions: diabetes, hypertension, obesity*

	All adults	No conditions	One condition	Two to three conditions
Dietary fiber				
≤8.8 g/day	2.39 ± 0.11*	1.36 ± 0.09*	3.59 ± 0.30*	4.54 ± 0.49*
8.9–13.5 g/day	2.23 ± 0.08*	1.27 ± 0.09*	3.35 ± 0.20*	4.58 ± 0.33*
13.6–19.9 g/day	2.05 ± 0.10*	1.37 ± 0.10*	2.65 ± 0.14	4.08 ± 0.52
≥20 g/day	1.52 ± 0.07	1.01 ± 0.07	2.32 ± 0.16	3.11 ± 0.28
Dietary fiber†				
≤8.8 g/day	1.53 (1.29–1.80)	1.38 (1.04–1.84)	1.51 (1.12–2.03)	2.25 (1.38–3.67)
8.9–13.5 g/day	1.53 (1.31–1.80)	1.43 (1.10–1.87)	1.48 1.12–1.96)	2.62 (1.54–4.44)
13.6–19.9 g/day	1.41 (1.17–1.69)	1.61 (1.22–2.11)	1.12 (0.83–1.51)	1.49 (0.90–2.46)
≥20 g/day	1 (1)	1 (1)	1 (1)	1 (1)

Data are median ± SE CRP or odds ratio (95% CI). *Significantly greater than the highest quartile of fiber consumption ($P < 0.05$). †Logistic regression model, adjusted results from the logistic regression models' odd ratios and 95% CIs of the likelihood of elevated CRP. All models are adjusted for age, race, sex, smoking status, alcohol consumption, exercise, medications, history of heart disease, total serum cholesterol, and total caloric intake.

ditions. Further investigation of the relationship between fiber intake and CRP in people with high-risk conditions may be warranted because such people are at twice the risk for cardiovascular disease compared with the general population (16).

The biological mechanisms underlying the relationship among fiber, CRP, and other markers of inflammation have not been completely explained but may relate to the nutritional content of cofactors for enzymes that mediate the oxidative and inflammatory response in the vascular endothelium (17). Dietary fiber may enhance the body's defenses against oxidative stress (18). Recent evidence suggests that fiber may have a favorable effect on the intestinal flora in such patients and reduce the production of inflammatory cytokines by altering the intralumen bacterial environment (19). If fewer inflammatory cytokines are produced in the bowel and released into the colonic circulation, including interleukin-6 (a precursor of CRP), then less CRP may be produced by the liver, resulting in lower systemic and circulating levels of CRP (20).

The limitations of this study include the possibility of uncontrolled or unknown factors that could confound the association between fiber and CRP. However, we have accounted for the most likely demographic and cardiovascular risk factors. Misclassification bias is also possible because we used self-reported 24-h recall of dietary information; however, 24-h recall provides reasonably accurate estimates at the population level (21). Individuals may have overestimated their intake of fruits and vegetables, thus favoring an overestimate of their dietary fiber intake as well. If so, then our results are biased toward the null and actual fiber intakes are even lower. Finally, because of the cross-sectional nature of the data, no definitive statement can be made regarding cause and effect. Nevertheless, it is more likely that fiber intake precedes changes in CRP rather than the reverse.

In conclusion, the current study found a significant association between dietary fiber intake and levels of inflammatory markers in individuals with diabetes, hypertension, or obesity and an even stronger relationship among people with two or more of these conditions.

Acknowledgments— This work is supported in part by grant 1 R01 HL076271-01 from the National Heart, Lung, and Blood Institute and by the National Center for Research Resources grant RR01070 for the Medical University of South Carolina General Clinical Research Center.

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