Glycemic Index, Dietary Fiber, and Risk of Type 2 Diabetes in a Cohort of Older Australians

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The role of glycemic index (GI) in the prevention of diabetes remains controversial. Some, but not all, prospective cohort studies have yielded positive relationships (1–8). A significant limitation of studies to date has been the fact that the food frequency questionnaires (FFQs) used were not validated for their ability to accurately assess GI. The purpose of this study was to assess the relationship of GI and fiber with incidence of type 2 diabetes in older Australians whose dietary intake was estimated by a fully validated FFQ.

RESEARCH DESIGN AND METHODS

In 1991, 4,433 residents aged 49+ years were identified, of which 3,654 (82%) participated in detailed examinations during 1992–1994 (9,10). Of these, 2,335 (75% of survivors) returned for 5-year and 1,952 (76%) for 10-year examinations (2002–2004). Individuals were largely of Caucasian origin and broadly representative of the older Australian population (11).

Diagnostic criteria were either self-reported diabetes and current use of diabetes medications or fasting glucose concentration ≥126 mg/dl (12). Diabetes incidence was defined in participants without diabetes at baseline who were diagnosed with diabetes before or at the 5- or 10-year follow-up. In total, 2,564 individuals were followed from baseline. After excluding 163 participants with existing diabetes and 52 with missing data, 2,349 were considered at risk of incident diabetes. An additional 226 participants did not have fasting blood tests at either the 5- or 10-year follow-up due to failure to fast or refusal on the day, leaving 2,123 with data for the assessment of 10-year incident diabetes.

Participants were sent a questionnaire that included items on diet and physical activity. The 145-item semiquantitative FFQ was modified from an earlier FFQ (13). FFQs with over 12 items missing or with implausible values (<500 calories/day or >4,000 calories/day) were excluded (14). Data were entered into a database (15) using Australian food composition tables (16) and published GI values (glucose = 100) (17). The average GI for each participant was calculated by summing the weighted GI of individual foods, with weighting proportional to the contribution to total carbohydrate intake. A validation study determined a correlation coefficient of 0.82 and correct classification of 85% of people within one quintile for dietary fiber and a coefficient of 0.57 and correct classification of 74% within one quintile for GI (18). Physical activity (as metabolic equivalents) was based on self-reported time spent walking and performing moderate and/or vigorous activities, using the International Physical Activity Questionnaire (19).

Using SAS, version 9.1 (20), multivariate-adjusted discrete logistic models were constructed to assess factors associated with diabetes using three time points at which presence/absence of the outcome event was recorded (21). When incident cases were identified, lifestyle data from the preceding survey were used. Participants with incomplete data were excluded. Variables tested for association with diabetes included age, sex, family history, smoking, blood pressure, HDL cholesterol, triglycerides, BMI, METs, GI, and total dietary fiber and its fractions. GI and fiber (and its fractions) were measured as continuous variables in 10-unit and 5-g increments, respectively. Further analyses were conducted by age stratification (<70 and ≥70 years). $P < 0.05$ was used for statistical significance. Hazard ratios (HRs) and 95% CIs are shown.

RESULTS

During 10 years of follow-up, 138 incident cases of type 2 diabetes were identified among 1,833 participants. The incidence in this sample was 0.9% per year, compared with 0.8% per year among individuals aged 25+ years in the broader Australian population (22). Total carbohydrate, starch, sugar, and total fiber intake were not associated with diabetes risk in the age- and sex-adjusted model or the multivariate-adjusted model (Table 1).

Vegetable fiber had a significant inverse association with risk of type 2 diabetes in the age- and sex-adjusted and multivariate-adjusted models. After stratifying by age, a significant negative association between vegetable fiber and risk of incident diabetes was found in the age- and sex-adjusted model, but not after multivariate adjustment, in individuals aged <70 years at baseline. No associations were found for those aged ≥70 years at baseline (26% of the cohort).

For all ages combined, there were positive trends of association between GI and risk of diabetes, but none reached statistical significance. In the age-stratified

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Abbreviations: FFQ, food frequency questionnaire; GI, glycemic index.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—HRs (95% CIs) for carbohydrate fractions, GI, and incidence of type 2 diabetes in a cohort of older Australians

		Age and sex adjusted			Multivariate adjusted*		
Nutrient	Amount	HR	95% CI	*P*	HR*	95% CI	*P*
Carbohydrate	200 g/day	1.06	0.45–2.50	0.898	1.14	0.43–3.00	0.792
Sugar	100 g/day	1.02	0.62–1.67	0.949	1.09	0.63–1.88	0.767
Starch	100 g/day	1.04	0.53–2.02	0.920	1.08	0.60–1.97	0.795
Fiber	5 g/day	0.90	0.81–1.01	0.068	0.90	0.79–1.02	0.109
Cereal fiber	5 g/day	0.96	0.80–1.16	0.698	0.96	0.78–1.20	0.742
Fruit fiber	5 g/day	0.95	0.79–1.13	0.531	0.94	0.78–1.15	0.566
Vegetable fiber	5 g/day	0.72	0.57–0.93	0.010	0.76	0.57–0.99	0.048
<70 years of age†	5 g/day	0.72	0.54–0.96	0.027	0.78	0.56–1.07	0.123
≥70 years of age‡	5 g/day	0.72	0.44–1.17	0.188	0.69	0.40–1.21	0.199
GI	10 units	1.38	0.92–2.07	0.124	1.50	0.95–2.36	0.082
<70 years of age†	10 units	1.47	0.93–2.34	0.103	1.75	1.05–2.92	0.031
≥70 years of age‡	10 units	1.14	0.48–2.68	0.765	0.80	0.29–2.24	0.671

*Adjusted for age, sex, family history of diabetes, smoking, triglycerides, HDL cholesterol, and METs, as well as vegetable fiber for the GI analyses. †n = 1,575; ‡n = 560.

and multivariate analyses, a significant positive association between GI and incident diabetes was found for individuals aged <70 years at baseline, but no association was found for those aged ≥70 years.

CONCLUSIONS — In a representative sample of older Australians, only vegetable fiber was independently associated with reduced risk of type 2 diabetes over a 10-year period. In a secondary analysis of people under 70 years of age, a high-GI carbohydrate diet was also linked to increased risk of diabetes. Our study is the first to use a FFQ validated specifically to assess GI.

Our study has limitations, including a relatively small sample size and relatively few incident diabetes cases. While the FFQ was not originally designed to assess GI, our analyses suggest that the tool reliably ranks individuals for fiber and GI. A similar FFQ was used in six earlier studies, but they have not been directly validated for their ability to measure GI (1,2,4,5,7,8).

Plausible mechanisms link certain types of carbohydrate to increased risk of diabetes (23). "Fast-acting" carbohydrates from high-GI foods increase blood glucose spikes and insulin demand. Insufficient β-cell capacity can result in impaired glucose tolerance and eventually type 2 diabetes (24). Diets high in cereal fiber and legumes may also improve insulin economy by "second meal" effects on postprandial glycemia (25). In the present study, peas, baked beans, and other legumes were classified as vegetables. It is therefore difficult to separate any protective effect of vegetable fiber per se from potential benefits related to reduced glycemia (i.e., low GI).

Our study supports the hypothesis that the type or quality of carbohydrate plays an important role in the etiology of type 2 diabetes. These findings, and those of similar studies, suggest that a dietary pattern characterized by high fiber and low-GI carbohydrates is sustainable over time and may represent an effective strategy to prevent type 2 diabetes.

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