SHORT REPORT

Beneficial Effect of Low-Glycemic Index Diet in Overweight NIDDM Subjects

THOMAS M. S. WOLEVER, MD, PHD
DAVID J.A. JENKINS, MD, PHD
VLADIMIR VUKSAN, PHD
ALEXANDRA L. JENKINS, RPDT
GERALD S. WONG, MD
ROBERT G. JOSSE, MD

OBJECTIVE — To determine whether low-glycemic index (GI) diets have clinical utility in overweight patients with non-insulin-dependent diabetes mellitus (NIDDM).

RESEARCH DESIGN AND METHODS — Six patients with NIDDM were studied on both high- and low-GI diets of 6-wk duration with metabolic diets with a randomized crossover design. Both diets were of similar composition (57% carbohydrate, 23% fat, and 34 g/day dietary fiber), but the low-GI diet had a GI of 58 compared with 86 for the high-GI diet.

RESULTS — Small and similar amounts of weight were lost on both diets: 2.5 kg on high-GI diet and 1.8 kg on low-GI diet. On the low-GI diet, the mean level of serum fructosamine, as an index of overall blood glucose control, was lower than on the high-GI diet by 8% ($P < 0.05$), and total serum cholesterol was lower by 7% ($P < 0.01$).

CONCLUSIONS — In overweight patients with NIDDM, reducing diet GI improves overall blood glucose and lipid control.

Different foods may produce markedly different glycemic responses independent of the amount of carbohydrate that they contain (1). The differences in glycemic response are related to differences in the rates at which their carbohydrate is digested and absorbed (2). Classifying foods based on their glycemic responses with the glycemic index (GI) may be useful to supplement data about food composition in planning therapeutic diets for diabetes (3). However, it has been suggested that the GI has no clinical utility because the differences in glycemic response between foods, although statistically significant, are too small to have any clinical significance (4).

Therefore, our purpose was to use knowledge of the GI of foods to reduce the glycemic impact of the diet without changing macronutrient composition. We have studied this maneuver in overweight patients with non-insulin-dependent diabetes mellitus (NIDDM) to see whether there were beneficial effects on blood glucose and lipid control.

RESEARCH DESIGN AND METHODS

METHODS — Five obese subjects and one mildly overweight subject with NIDDM (3 men, 3 women; 63 ± 4 yr of age [range 53–72 yr]; body mass index 32.1 ± 2.4 kg/m^2 [range 24.5–39.3 kg/m^2]) took part in a randomized crossover dietary trial consisting of two 6-wk experimental periods separated by a 4- to 6-wk washout. For the 1st and last 2 wk of each period, subjects were provided with preweighed portions of all starchy foods, cheese, and tinned sauces in their diets. They provided their own milk, vegetables, fruit, and margarine according to specified daily meal plans. During the middle 2 wk, they provided their own foods according to a detailed menu plan similar to that during the metabolic periods. According to standard practice for overweight patients with NIDDM, diets were designed to be moderately reduced in energy to induce 0.5- to 1-kg weight loss/week.

The high- and low-GI diets had similar macronutrient contents: 1388 and 1388 kcal, 198 and 197 g carbohydrate (57%), 36 and 36 g (23%) fat, 66 and 67 g (20%) protein, 33 and 34 g total fiber, and 9.8 and 10.2 g soluble fiber, respectively (5,6). The GIs of the low- and high-GI diets were 58 and 86, respectively.

Subjects were seen at weekly intervals to be weighed and given their diets. Fasting blood samples were obtained before the start of each diet and every 2 wk over each dietary period for glucose, total and high-density lipoprotein (HDL) cholesterol, triglyceride (TG), and fruc-

FROM THE DEPARTMENT OF NUTRITIONAL SCIENCES, FACULTY OF MEDICINE, AND THE CLINICAL NUTRITION AND RISK FACTOR MODIFICATION CENTRE, ST. MICHAEL'S HOSPITAL, UNIVERSITY OF TORONTO, TORONTO, ONTARIO, CANADA.
ADDRESS CORRESPONDENCE AND REPRINT REQUESTS TO DR. THOMAS M.S. WOLEVER, DEPARTMENT OF NUTRITIONAL SCIENCES, UNIVERSITY OF TORONTO, TORONTO, ONTARIO, CANADA, M5S 1A8.
RECEIVED FOR PUBLICATION 20 FEBRUARY 1991 AND ACCEPTED IN REVISED FORM 2 OCTOBER 1991.

Table 1—*Body weight, blood glucose, and serum lipids of 6 patients with non-insulin-dependent diabetes mellitus on 6-wk high- and low-glycemic-index (GI) diets*

	High-GI Diet (wk)				Low-GI Diet (wk)			
	wk 0	wk 2	wk 4	wk 6	wk 0	wk 2	wk 4	wk 6
Weight (kg)	85.7 ± 2.7	84.1 ± 2.7	84.1 ± 2.5	83.2 ± 2.5	84.9 ± 3.2	83.6 ± 3.2	83.2 ± 3.0	83.1 ± 2.8
Fasting blood glucose (mM)	9.3 ± 0.7	9.0 ± 0.8	8.8 ± 0.7	8.4 ± 0.6	9.5 ± 0.9	8.9 ± 0.7	9.0 ± 1.1	8.4 ± 0.7
Fructosamine (mM)*	5.06 ± 0.66	5.00 ± 0.60	4.95 ± 0.62	5.12 ± 0.58	5.13 ± 0.49	4.75 ± 0.45	4.53 ± 0.50	4.56 ± 0.53
Total cholesterol (mM)†	6.49 ± 0.73	6.53 ± 0.81	6.44 ± 0.78	6.74 ± 0.91	6.51 ± 0.77	6.20 ± 0.79	6.17 ± 0.82	6.00 ± 0.69
Triglyceride (mM)	3.29 ± 0.49	3.54 ± 0.64	3.67 ± 0.72	3.61 ± 0.72	3.31 ± 0.57	3.38 ± 0.45	3.28 ± 0.62	2.81 ± 0.35
High-density lipoprotein cholesterol (mM)	0.79 ± 0.06	0.74 ± 0.07	0.75 ± 0.06	0.70 ± 0.06	0.79 ± 0.05	0.69 ± 0.05	0.68 ± 0.06	0.69 ± 0.05
Low-density lipoprotein cholesterol (mM)	4.20 ± 0.64	4.18 ± 0.64	4.03 ± 0.61	4.41 ± 0.87	4.22 ± 0.64	3.98 ± 0.76	4.00 ± 0.79	4.04 ± 0.68

Values are means ± SE.
*$P < 0.05$, †$P < 0.01$, low- vs. high-GI diet.

tosamine with previously described methods (7). Low-density lipoprotein (LDL) cholesterol (mM) was derived from the equation LDL = total cholesterol − (HDL + TG/2.2). Two subjects did not complete the last week on both periods because they had to leave town, and blood samples were obtained at 0, 2, 4, and 5 wk.

Results are means ± SE. Data were subjected to analysis of variance with subject, time, and diet as variables and $P < 0.05$ taken as the criterion for significance. The protocol for these studies was approved by the Human Subjects Review Committee at the University of Toronto.

RESULTS— Weight loss over the 6-wk study periods was small, being 2.5 kg on the high-GI diet and 1.8 kg on the low-GI diet (Table 1). Fasting blood glucose (FBG) fell by a similar amount on both diets (Table 1). Serum fructosamine and cholesterol levels fell significantly on the low-GI diet with no change on the high-GI diet (Fig. 1). The mean levels of fructosamine and cholesterol on the low-GI diet (4.61 ± 0.48 and 6.12 ± 0.76 (237 ± 29 mg/dl), respectively) were significantly less than those on the high-GI diet (5.02 ± 0.60, $P < 0.05$ and 6.57 ± 0.83 (254 ± 32 mg/dl), $P <$ 0.01). A change in very-low-density lipoprotein cholesterol presumably contributed to the fall in total cholesterol because the changes in LDL and HDL were not significant (Table 1). The reduction in serum TG on the low-GI diet was not significant in the entire group. However, in the five subjects with TG >2.2 mM, the serum TG level was 22.4 ± 5.6% ($P < 0.02$) lower at the end of the low-GI diet than at the end of the high-GI diet.

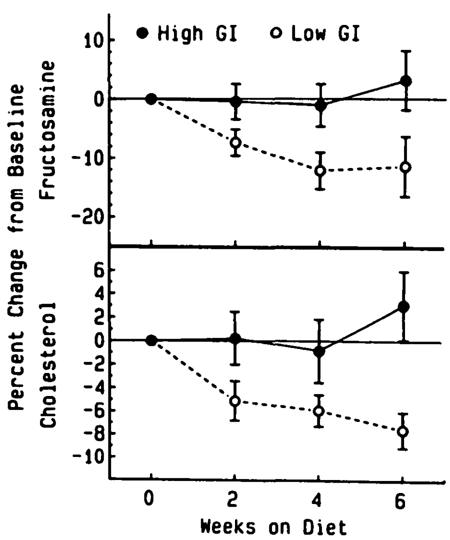

Figure 1—*Mean ± SE percentage of changes from baseline (wk 0) in fasting serum fructosamine and cholesterol levels of 6 subjects with non-insulin-dependent diabetes mellitus on high- and low-glycemic index (GI) diets for 6 wk.*

CONCLUSIONS— Reducing the overall glycemic impact of the diet without changing nutrient composition or dietary fiber content resulted in clinically significant improvements in blood glucose and lipid control despite a modest weight reduction during both the high- and low-GI diet periods. Because a similar amount of weight was lost on both diets, the differences in blood glucose and lipid control between the high- and low-GI diets is not due to weight reduction.

Weight reduction was presumably the reason for the small falls in FBG seen on both diets. Reduced energy intake may reduce FBG before appreciable amounts of weight are lost (8). However, the fall in FBG on the high-GI diet was not accompanied by a fall in fructosamine as an index of overall blood glucose control, and the changes in FBG were similar on both diets. Therefore, the reduction in fructosamine on the low-GI diet cannot be accounted for by a change in FBG and is presumably due to reduced postprandial blood glucose responses. Although not shown here, we and others have shown that reducing the GI of mixed meals results in predictable reductions in postprandial glycemic responses (3).

These results are consistent with previous data showing that obese poorly controlled subjects with NIDDM tend to have high serum TG levels, and that a low-GI diet consistently reduces blood lipids in hypertriglyceridemic subjects (9). Reductions in blood lipids may be mediated by reduced insulin secretion, which has been shown to occur with low-GI foods (1,10). Insulin regulates both cholesterol (11) and TG synthesis (12). Other maneuvers that reduce insulin secretion and lower blood lipids include lowering calorie intake (13) and reducing the rate of nutrient delivery by soluble fiber (14) or nibbling (7).

There has been concern that dietary guidelines for diabetes recommending increased carbohydrate intake may lead to increased blood glucose, insulin, and TG levels (15). Our results and those of others (16,17) suggest that these deleterious effects are less likely to occur when the carbohydrate is increased with low-GI starchy foods.

Acknowledgments— This study was supported by the Canadian Diabetes Association. T.M.S.W. was supported in part by a grant from the Bristol Myers Company, New York.

References

1. Krezowski PA, Nuttall FQ, Gannon MC, Billington CJ, Parker S: Insulin and glucose responses to various starch-containing foods in type II diabetic subjects. *Diabetes Care* 10:205–12, 1987
2. Jenkins DJA, Ghafari H, Wolever TMS, Taylor RH, Barker HM, Fielden H, Jenkins AL, Bowling AC: Relationship between the rate of digestion of foods and postprandial glycaemia. *Diabetologia* 22: 450–55, 1982
3. Jenkins DJA, Wolever TMS, Jenkins AL: Starchy foods and the glycemic index. *Diabetes Care* 11:149–59, 1988
4. Hollenbeck CB, Coulston AM, Reaven GM: Glycemic effects of carbohydrates: a different perspective. *Diabetes Care* 9:641–47, 1986
5. Paul AA, Southgate DAT: *McCance and Widdowson's The Composition of Foods*. 4th ed. London, UK, Her Majesty's Stationary Office, 1978, MRC Report Series no. 297
6. Anderson JW, Bridges SR: Dietary fiber content of selected foods. *Am J Clin Nutr* 47:440–47, 1988
7. Jenkins DJA, Wolever TMS, Vuksan V, Brighenti F, Cunnane SC, Rao AV, Jenkins AL, Buckley G, Patten R, Singer W, Corey P, Josse RG: Nibbling versus gorging: metabolic advantages of increased meal frequency. *N Engl J Med* 321:929–34, 1989
8. Henry RR, Scheaffer L, Olefsky JM: Glycemic effects of intensive caloric restriction and isocaloric refeeding in noninsulin-dependent diabetes mellitus. *J Clin Endocrinol Metab* 61:917–25, 1985
9. Jenkins DJA, Wolever TMS, Kalmusky J, Guidici S, Giordano C, Patten R, Wong GS, Bird JN, Hall M, Buckley G, Csima A, Little JA: Low-glycemic index diet in hyperlipidemia: use of traditional starchy foods. *Am J Clin Nutr* 46:66–71, 1987
10. Wolever TMS, Jenkins DJA, Collier GR, Lee R, Wong GS, Josse RG: Metabolic response to test meals containing different carbohydrate foods. I. Relationship between rate of digestion and plasma insulin response. *Nutr Res* 8:573–81, 1988
11. Lakshmanan RM, Nepokroeff CM, Ness GC, Dugan RE, Porter JW: Stimulation by insulin of rat liver β-hydroxy-β-methylglutaryl coenzyme A reductase and cholesterol-synthesizing activities. *Biochem Biophys Res Commun* 50:704–10, 1973
12. Bray GA: Lipogenesis in human adipose tissue: some effects of nibbling and gorging. *J Clin Invest* 51:537–48, 1972
13. Henry RR, Wiest-Kent TA, Scheaffer L, Kolterman OG, Olefsky JM: Metabolic consequences of very-low-calorie diet therapy in obese non-insulin-dependent diabetic and nondiabetic subjects. *Diabetes* 35:155–64, 1986
14. Wolever TMS, Jenkins DJA: Effect of fiber and foods on carbohydrate metabolism. In *Handbook of Dietary Fiber in Human Nutrition*. Spiller GA, Ed. Boca Raton, FL, CRC, 1985, p. 87–119
15. Reaven GM: Dietary therapy for non-insulin-dependent diabetes mellitus. *N Engl J Med* 319:862–64, 1988
16. Brand JC, Colagiuri S, Crossman S, Allen A, Roberts DCK, Truswell AS: Low-glycemic index foods improve long-term glycemic control in NIDDM. *Diabetes Care* 14:95–101, 1991
17. Fontvieille AM, Acosta M, Rizkalla SW, Bornet F, David P, Letanoux M, Tchobroutsky G, Slama G: A moderate switch from high to low glycaemic-index foods for 3 weeks improves metabolic control of type I (IDDM) diabetic subjects. *Diabetes Nutr Metab* 1:139–43, 1988