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Toward Improved Management of NIDDM: A Randomized, Controlled, Pilot Intervention Using a Lowfat, Vegetarian Diet[1]

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Objective. **To investigate whether glycemic and lipid control in patients with non-insulin-dependent diabetes (NIDDM) can be significantly improved using a lowfat, vegetarian (vegan) diet in the absence of recommendations regarding exercise or other lifestyle changes.**

Methods. **Eleven subjects with NIDDM recruited from the Georgetown University Medical Center or the local community were randomly assigned to a lowfat vegan diet (seven subjects) or a conventional lowfat diet (four subjects). Two additional subjects assigned to the control group failed to complete the study. The diets were not designed to be isocaloric. Fasting serum glucose, body weight, medication use, and blood pressure were assessed at baseline and biweekly thereafter for 12 weeks. Serum lipids, glycosylated hemoglobin, urinary albumin, and dietary macronutrients were assessed at baseline and 12 weeks.**

Results. **Although the sample was intentionally small in accordance with the pilot study design, the 28% mean reduction in fasting serum glucose of the experimental group, from 10.7 to 7.75 mmol/L (195 to 141 mg/dl), was significantly greater than the 12% decrease, from 9.86 to 8.64 mmol/L (179 to 157 mg/dl), for the control group ($P < 0.05$). The mean weight loss was 7.2 kg in the experimental group, compared to 3.8 kg for the control group ($P < 0.005$). Of six experimental group subjects on oral hypoglycemic agents, medication use was discontinued in one and reduced in three. Insulin was reduced in both experimental group patients on insulin. No patient in the control group reduced medication use. Differences between the diet groups in the reductions of serum cholesterol and 24-h microalbuminuria did not reach statistical significance; however, high-density lipoprotein concentration fell more sharply (0.20 mmol/L) in the experimental group than in the control group (0.02 mmol/L) ($P < 0.05$).**

Conclusion. **The use of a lowfat, vegetarian diet in patients with NIDDM was associated with significant reductions in fasting serum glucose concentration and body weight in the absence of recommendations for exercise. A larger study is needed for confirmation.**

Key Words: **diet; diet therapy; NIDDM; vegetarian diet; vegetarianism.**

INTRODUCTION

Approximately 8 million Americans have diabetes mellitus, the vast majority of whom have NIDDM [*1*]. Long-standing diabetes is often accompanied by severe and life-threatening complications, particularly cardiovascular disease, retinopathy, nephropathy, and neuropathy [*2–5*].

In epidemiologic studies, lowfat plant-based diets are associated with a markedly reduced prevalence of NIDDM and its complications, compared to unmodified diets, suggesting an important role for such diets in clinical practice [*6–11*]. Accordingly, studies using lowfat vegetarian and near-vegetarian diets have yielded excellent glycemic control, reduced need for hypoglycemic medications, and reduced neuropathic symptoms, but the interpretation of all such studies to date has been complicated by their inclusion of exercise recommendations [*12–14*]. The current study was designed as a pilot investigation of the effect of a dietary intervention alone using a randomized, controlled design.

METHODS

Thirteen outpatient subjects (six men, seven women) with NIDDM were recruited from the Georgetown University medical and endocrine clinics and through a

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newspaper advertisement. Inclusion criteria were non-insulin-dependent diabetes mellitus, age greater than 25 years, willingness to attend all components of the study, and residence within commuting distance of Georgetown University. Exclusionary criteria included smoking, regular alcohol use, current or past drug abuse, pregnancy, psychiatric illness, and medical instability. Each subject completed a medical history and physical examination, and laboratory specimens were collected for fasting serum glucose, hemoglobin A1C, serum lipids, and urinary microalbumin.

Subjects were randomly assigned to either an experimental lowfat vegan diet (seven subjects) or a control diet (six subjects) for a period of 12 weeks. Two control group subjects, both female, dropped out of the study due to an unrelated medical problem in one case and a family emergency in the other. Data from these subjects were not included in the analysis.

The vegan diet consisted of whole grains, vegetables, legumes, and fruits. Animal products, added oils, sugars, and refined carbohydrates, such as white bread or refined pasta, were proscribed. A typical menu consisted of lentil soup, cucumber salad, and rice crackers for lunch and garbanzo stew, bulgur, and leafy greens for dinner. The diet derived 10–15% of calories from protein and less than 10% of calories from fat, with the remaining calories coming from unrefined complex carbohydrates. Cholesterol content was zero. The diet was adequate in all nutrients except vitamin B_{12}. Vitamin B_{12} supplementation was recommended for those planning to continue the diet after the study's conclusion.

The control diet emphasized the use of fish and poultry, rather than red meat. It was designed to derive 55–60% of calories from carbohydrate and less than 30% of calories from fat, with approximately 200 mg of cholesterol per day.

For all lunches and dinners during the 12-week study, subjects in both groups were offered prepared meals conforming to their respective diet guidelines and requiring only reheating at home. Menus were analyzed using Nutritionist IV for Windows (First Databank Division, Hearst Corporation, San Bruno, CA, April 1995). Because the vegan diet was much lower in fat, the diets were not designed to be isocaloric. The mean energy content of a prepared vegan lunch and dinner was 1,050 kcal (4,390 kJ) and 1,200 kcal (5,030 kJ) for the control diet. Participants were responsible for preparing their own breakfast and were free to add any desired quantities of foods to their diets at any time of day without caloric restriction, provided that they adhered to the prescribed guidelines. Subjects were permitted to prepare their own meals if they so chose, although most used the catered meals.

Subjects completed a 3-day dietary record, including 2 weekdays and 1 weekend day, at baseline and 12 weeks. The 3-day dietary record is considered to be a qualitative representation of nutrient intake [*15*]. Records were analyzed in the Department of Nutrition and Food Science at the University of Maryland, using Nutritionist IV for Windows. In addition, dietary compliance was assessed weekly through self-report questionnaires handed out at the group meals.

The groups attended separate half-day orientation sessions explaining the general role of nutrition in diabetes, the overall study structure, and the diet to which they were assigned. Thereafter, subjects attended twice-weekly support groups, stratified by treatment assignment, which included cooking and nutrition classes and a shared meal, for the remainder of the study. Subjects were encouraged to invite a spouse, sibling, parent, or friend to join them in their assigned diets and in group sessions.

Subjects met with the medical director or nurse-project coordinator every 2 weeks. Medication needs were assessed at these visits and as needed between visits, according to an established protocol. Blood pressure was measured biweekly using a standard cuff of a size appropriate to the subject's arm, with subjects in a seated position after resting at least 5 min, averaging the results of two to three measurements. Weight was measured biweekly to the nearest 0.1 kg, with indoor clothing but without shoes, using a digital scale. Duration of exercise per week was ascertained for each participant at baseline and 12 weeks, but no exercise recommendations were made.

Fasting serum glucose was measured at baseline and biweekly thereafter using an Abbott Spectrum analyzer (Abbott Park, IL) with a glucose oxidase method [*16*]. Fasting serum lipids were measured at baseline and 12 weeks. Cholesterol and triacylglycerol concentrations were measured using an Abbott Spectrum analyzer by enzymatic methods [*17,18*]. High-density lipoprotein (HDL) cholesterol concentration was measured after double precipitation with dextran and $MgCl_2$ [*19*]. Low-density lipoprotein (LDL) cholesterol concentration was estimated using the Friedewald equation [*20*].

Glycosylated hemoglobin was assayed at baseline and 12 weeks using affinity chromatography on an Abbott IMx analyzer [*21*]. Urinary microalbumin was assayed at baseline and 12 weeks using a double antibody radioimmunoassay kit provided by Diagnostic Products Corporation (Los Angeles, CA). Laboratory tests were performed at Georgetown University.

Analysis of covariance was used to test the effect of diet on glycosylated hemoglobin, 24-h urinary microalbuminuria, serum total cholesterol, LDL, HDL, and triacylglycerol concentrations. The 12-week measure was the outcome variable, and the baseline measure was the covariate. Thus, the analysis examined the effect of diet on the 12-week values, adjusting for the baseline values.

TABLE 1

Baseline Demographic and Clinical Characteristics

	Experimental (n = 7)	Control (n = 4)
Mean age (years)	51	60
Age range	34–62	51–74
Women	3	2
On oral hypoglycemic agents	6	4
On insulin	2	0
History of hypertension	5	4
Receiving antihypertensives	5	4
History of coronary artery bypass graft surgery	1	1

All other variables were tested using multivariate analysis of covariance due to the use of multiple measurements during the intervention. In these analyses, the baseline measure was a covariate, diet group was the independent variable, and the repeated measurements over the intervention were the dependent variables. A two-tailed p of $<.05$ was used as the criterion for statistical significance. Analyses were performed using SAS 6.10 for Microsoft Windows (Cary, NC, 1995).

The study was approved by the Georgetown University Institutional Review Board.

RESULTS

Baseline demographic data are presented in Table 1. None of the subjects had major microvascular diabetic complications. Three vegan group participants and one control group participant were on lipid-lowering agents. None had had congestive heart failure or unstable angina in the 3 months prior to the study or any history of myocardial infarction, liver disease, or thyroid abnormalities.

Baseline diets were similar for the two groups (Table 2). During the course of the study, fat, cholesterol, and protein intakes decreased substantially for the experimental group, while carbohydrate and fiber intake increased. In the control group, total fat intake remained unchanged, fiber intake increased, and cholesterol intake decreased. Although verbal reports from all subjects during group meetings indicated good adherence to their diets, two experimental group subjects later indicated to the project coordinator several lapses in compliance.

The vegan group participants exercised somewhat more at baseline than did those in the control group (a mean of 3.4 and 2.2 h per week, respectively), and these figures remained essentially unchanged at 12 weeks (3.4 and 2.0 h per week, respectively).

In order to test the effect of diet group on body weight, a multivariate analysis of covariance was done with baseline weight as the covariate and six biweekly weight measures as the dependent variables. Diet exerted a significant effect on the six biweekly weight measures during the intervention ($F(1,5) = 20.9$, $p < .005$). The experimental group lost an average of 7.2 kg over 12 weeks, compared to a mean weight loss of only 3.8 kg in the control group (Table 3).

A similar analysis of fasting serum glucose revealed a significant difference between groups on six biweekly measures ($F(1,5) = 13.97$, $p < .05$). Because much of the improvement in fasting glucose occurs in the initial days following dietary change and because there is normally substantial variability in fasting values, an intervention mean was created for descriptive purposes by averaging the six biweekly intervention values. Fasting serum glucose values dropped 28% from baseline to the intervention mean for the experimental group, compared to a 12% decrease in the control group (Table 3). The effect of diet on glycosylated hemoglobin was not significant.

While there were substantial changes in serum lipid values, no significant effect was found for diet group on total cholesterol, LDL, or triacylglycerol concentrations. However, there was an effect of diet group on HDL, with a greater decrease in the experimental group ($F(1,8) = 7.13$, $p < .05$, Table 3). There were no changes in the use of lipid-lowering medications.

Most individuals in the experimental group showed

TABLE 2

Dietary Characteristics

	Experimental (n = 7)		Control (n = 4)	
	Baseline	12 weeks	Baseline	12 weeks
Total energy (kcal/day)	1683 (435)	1409 (549)	1430 (403)	1526 (314)
Protein (% of energy)	20 (5.9)	14 (1.6)	23 (9.7)	18 (1.4)
Carbohydrate (% of energy)	46 (7.0)	75 (4.4)	46 (10.1)	51 (3.5)
Fiber (g)	14 (4.3)	26 (8.2)	12 (2.4)	20 (2.7)
Total fat (% of energy)	34 (5.3)	11 (4.7)	31 (8.5)	31 (2.4)
Saturated fat (% of energy)	10 (2.4)	3 (2.0)	11 (2.2)	8 (1.8)
Cholesterol (mg)	289 (86)	4.4 (7.4)	310 (185)	122 (31)

Note. Standard deviations are indicated in parentheses.

TABLE 3

Clinical Changes from Baseline to 12 Weeks[a]

	Experimental (n = 7)		Control (n = 4)	
	Baseline	12 weeks	Baseline	12 weeks
Weight (kg)*	96.7 (13.3)	89.5 (14.4)	97.0 (22.9)	93.2 (22.2)
FSG (mmol/L)**	10.74 (2.85)	7.75 (2.07)	9.86 (1.63)	8.64 (0.20)
HbA1C (%)	8.3 (1.7)	6.9 (1.1)	8.0 (1.1)	7.0 (0.6)
Chol (mmol/L)	5.26 (1.09)	4.63 (1.32)	5.56 (0.61)	4.93 (0.46)
HDL (mmol/L)**	1.15 (0.32)	0.95 (0.28)	1.12 (0.17)	1.10 (0.17)
TG (mmol/L)	2.12 (0.78)	1.87 (0.63)	2.29 (1.92)	1.85 (1.14)
Syst BP (mm Hg)	136.6 (10.0)	126.2 (14.9)	149.5 (21.6)	130.6 (11.9)
Diast BP (mm Hg)	84.0 (4.5)	78.2 (9.7)	86.0 (15.8)	75.4 (11.6)
Microalbumin (mg/24 h)	434.8 (565.5)	155.2 (182.6)	82.9 (114.6)	169.2 (298.0)

Note. Standard deviations are indicated in parentheses.

[a] The table presents baseline and 12-week data only. The fasting glucose and blood pressure "12-week" values are means of biweekly intervention measures.

* $p < .005$ for the effect of diet, controlling for baseline, on six biweekly measures.

** $p < .05$ for the effect of diet, controlling for baseline, on six biweekly measures (fasting serum glucose) or at 12 weeks (HDL).

substantial decreases in 24-h microalbuminuria, in contrast with the mild to marked increases seen in most of the control subjects (Table 3). However, due to the wide range of baseline microalbuminuria values within each group, no significant effect of diet group was found on changes in this measurement over the 12 weeks. Diet group did not exert a significant effect on systolic and diastolic blood pressure.

Of six experimental group subjects on oral hypoglycemic agents, medication use was discontinued in one and decreased in three. Insulin doses decreased in both patients on insulin in the experimental group. Glycemic changes in the control group were insufficient to permit dosage reductions in any of the four control group subjects, all of whom were treated with oral hypoglycemic agents. No control subjects were taking insulin.

Antihypertensive medications were discontinued in two of five experimental group subjects on these medicines. All four control group subjects were on antihypertensive medicines, and one subject stopped one of four types he was on in the course of the study.

DISCUSSION

Despite the small sample size, the differences between the treatment groups in the reductions of fasting serum glucose and body weight reached statistical significance. The 28% reduction in fasting serum glucose in the experimental group, compared to only 12% in the control group, occurred even though most experimental group subjects reduced their use of hypoglycemic medications. The 7.2-kg weight loss experienced by the experimental group was achieved with no attempt to limit energy intake.

Previous studies using vegetarian or near-vegetarian diets have yielded substantial improvements in glycemic control and symptoms of neuropathy, although all such studies have used mixed interventions including exercise [*12–14,22*]. Although such a diet often causes weight loss [*23*], weight control is not the only mechanism by which it may improve glycemic management [*24*]. Anderson used a high-carbohydrate, high-fiber diet to achieve decreases in fasting serum glucose in 15 of 20 subjects with NIDDM on insulin, despite the use of meal portions that prevented decreases in body weight. Nine subjects discontinued the use of insulin, yet average fasting glucose decreased from 9.02 to 8.36 mmol/L over the 16-day trial [*25*].

The interpretation of the present study is limited by its small sample size and by the fact that participants, all of whom were willing to accept assignment to a vegetarian diet, may have been more motivated than other persons with diabetes. Also, our randomization procedures produced two groups that were dissimilar in urinary albumin concentration. Total reported energy intakes for both groups were low, suggesting underreporting of food consumption, which is common among individuals who are not extensively practiced in 3-day dietary records. Our study did not assess the sustainability of our dietary intervention over the longer term, nor did it control for the effect of socioeconomic status or waist-to-hip ratio.

Differences in energy intake cannot fully account for differences between the two groups in weight loss, which may also be affected by exercise, the thermic effect of food, and resting metabolic rate (which may be influenced by a vegetarian diet) [*26*].

The reduction in HDL which occurred in the experimental group is a common finding with lowfat and vegetarian diets and appears not to be associated with elevated atherosclerotic risk in the context of a low total serum cholesterol concentration [*23,27,28*].

Mean 24-h urinary protein losses decreased in the experimental group, in contrast to an increase in the control group, although the difference did not achieve statistical significance. This finding, along with the reductions in glycosylated hemoglobin and medication use in the experimental group, awaits examination with a larger sample.

In summary, we found that use of a lowfat vegan diet was associated with reductions in fasting serum glucose concentrations and body weight in a 12-week trial, despite decreased medication use in the experimental group and the small sample recruited for this trial. These benefits await confirmation by further studies.

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