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ORIGINAL ARTICLE

Nutrient intake in the GEICO multicenter trial: the effects of a multicomponent worksite intervention

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BACKGROUND/OBJECTIVES: To assess the effects on macro- and micronutrient intake of a nutrition intervention program in corporate settings across the United States.

SUBJECTS/METHODS: Two hundred and ninety-two individuals who were overweight or had type 2 diabetes were recruited from 10 sites of a US insurance company. Two hundred and seventy-one participants completed baseline diet recalls, and 183 participants completed dietary recalls at 18 weeks. Sites were randomly assigned to an intervention group (five sites) or to a control group (five sites) for 18 weeks. At intervention sites, participants were asked to follow a low-fat vegan diet and attend weekly group meetings. At control sites, participants continued their usual diets. At baseline and 18 weeks, participants completed 2-day diet recalls. Between-group differences in changes in nutrient intake were assessed using an analysis of covariance.

RESULTS: Compared with those in the control group, intervention-group participants significantly reduced the reported intake of total fat ($P = 0.02$), saturated ($P = 0.006$) and monounsaturated fats ($P = 0.01$), cholesterol ($P = 0.009$), protein ($P = 0.03$) and calcium ($P = 0.02$), and increased the intake of carbohydrate ($P = 0.006$), fiber ($P = 0.002$), β-carotene ($P = 0.01$), vitamin C ($P = 0.003$), magnesium ($P = 0.04$) and potassium ($P = 0.002$).

CONCLUSIONS: An 18-week intervention program in a corporate setting reduces intake of total fat, saturated fat and cholesterol and increases the intake of protective nutrients, particularly fiber, β-carotene, vitamin C, magnesium and potassium. The reduction in calcium intake indicates the need for planning for this nutrient.

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INTRODUCTION

Many US Americans consume diets that are overly high in energy and in constituents associated with disease risk, particularly saturated fat (SFA), cholesterol and sodium and low in protective components such as fiber or β-carotene.[1] Poorly balanced diets contribute to overweight, cardiovascular disease, type 2 diabetes and other conditions.[2–4]

In clinical research studies, individuals who adopt diets emphasizing vegetables, fruits, whole grains and legumes report significant reductions in the intake of fat and cholesterol and increases in fiber, β-carotene, magnesium, potassium and vitamin K intake.[5,6] Plant-based diets are associated with improvements in body weight, plasma lipid concentrations,[7] glycemic control[8] and blood pressure[9] and may assist in the management of prostate cancer.[10–12]

We tested a program designed to translate a plant-based dietary intervention from the research environment to the workplace. An initial controlled study at two corporate sites of the Government Employees Insurance Company, a large US insurer, showed that providing instruction in the use of plant-based diets tended to cause weight loss, improvements in plasma lipid concentrations and, for those with diabetes, improved blood glucose control.[13] A subsequent trial at 10 corporate Government Employees Insurance Company sites in diverse regions of the United States showed similar results.[14]

As plant-based diets may alter a wide range of macronutrient and micronutrient intakes affecting health in many ways, we sought to assess the nutrient changes associated with the intervention diet in the latter study. Those nutrient changes are the focus of the current report. We hypothesized that a plant-based dietary intervention would reduce the intake of energy, SFA and cholesterol and increase the intake of fiber, β-carotene, vitamin C and potassium.

MATERIALS AND METHODS

The study design and major physiological results have been described elsewhere.[14] Briefly, the overall study tested the hypothesis that a program including a low-fat vegan diet taught through group sessions at worksites in widely divergent areas of the United States would elicit improvements in body weight and other health indicators. The study was intended to translate the findings of intervention trials into a simple program

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that could be implemented for large groups of individuals at work. It was designed not to test individual program components (for example, a diet or a group of classes) but rather to assess the effect of the intervention program as a whole, similar to the design of the Diabetes Prevention Program, which tested the combined effects of diet and exercise interventions in individuals at risk for diabetes.[15]

Individuals aged 18 years or above with a body mass index of $\geqslant 25\,kg/m^2$ or a previous diagnosis of type 2 diabetes were recruited through employee notices at 10 Government Employees Insurance Company corporate offices in the United States: Tucson, Arizona; San Diego, California; Lakeland, Florida; Macon, Georgia; Chevy Chase, Maryland; Buffalo, New York; Woodbury, New York; Dallas, Texas; Fredericksburg, Virginia; and Virginia Beach, Virginia. Exclusion criteria were current alcohol or drug abuse, pregnancy, history of severe mental illness, unstable medical status, current adherence to a low-fat vegetarian diet, participation in the previous Government Employees Insurance Company study and inability to attend weekly meetings.

Interested individuals attended a group meeting with the research staff. Those who appeared to satisfy the participation criteria were scheduled for individual interviews to review the study procedures and confirm eligibility. These interested individuals were then asked to complete a practice 2-day online diet recall.

The study was approved by an external institutional review board (Independent Review Consulting, whose name was later changed to Ethical and Independent Review Services, Corte Madera, CA, USA.). All participants provided written informed consent.

Worksites were then pair-matched based on the number of volunteers per site. Each pair of sites represented a cluster, and, using a random-number table, the sites within each pair were randomly assigned to the intervention (fives sites) or control (five sites) groups. As the assignment was done by site rather than by individual, all participants at a given site were in the same assigned group. This method was used because of the likelihood that the intervention, which would be strongly apparent in the work environment, would tend to influence the behavior of individuals throughout the worksite, including those not assigned to the intervention group.

At intervention sites, participants were asked to follow a low-fat vegan diet and attend weekly group meetings. They received no monetary compensation. Individuals at control sites were given no dietary guidance and were not asked to make any dietary changes. They were given monetary compensation in the form of gift certificates to retail stores (Whole Foods Market or Target), totaling $50 for completion of all baseline and week-18 assessments. The rationale for compensation of control-group participants was that, unlike the intervention group, they received no other benefit from the study and had no contact with the investigators, aside from the assessments. All participants in both groups were asked to avoid changing exercise patterns during the study period.

Intervention diet

Participants at intervention sites were asked to avoid animal products (that is, meat, poultry, fish, dairy products and eggs) and to base their diets on whole grains, vegetables, legumes and fruits. They were also encouraged to minimize added oils and to favor foods with a low glycemic index, such as beans, fruit, pasta, rye and pumpernickel bread (rather than typical wheat breads), and oatmeal or bran cereal (rather than typical cold cereals). No restrictions were placed on portion sizes or on energy or carbohydrate intakes. Intervention-group participants were also asked to take a daily supplement of vitamin B_{12}, such as a multiple vitamin. At intervention sites with cafeterias, food service managers were asked to include low-fat plant-based menu options, such as oatmeal, minestrone or lentil soup, veggie burgers and portobello sandwiches, among the daily offerings. Whether and how to implement such menu additions were left to their discretion, and their progress in doing so was not formally assessed.

Participants at intervention sites were asked to follow the prescribed diet for 18 weeks. They were provided group support in the form of weekly lunch-hour classes at the worksite led by a registered dietitian, physician and/or a cooking instructor, following an established curriculum for the duration of the study. Classes included sessions on replacements for animal products, healthful snacking, dining out, travel, shopping and cooking, as well as nutrition-related health topics such as weight loss, diabetes, heart disease and cancer. Group discussions during each session focused on common diet challenges and successes. Participants were offered additional support through an interactive online message board on which they could ask or respond to questions. All instructors received training in study procedures and best practices for facilitating group discussion and used identical instruction materials (a standardized curriculum, handouts, videos, instructions for cooking, and so on).

Assessment of dietary intake and adherence to dietary intervention

The following measures were assessed at baseline and week 18:

A diet recall was used to assess nutrient intake over two 24-h periods at baseline and two 24-h periods at 18 weeks, using an online (Automated Self-administered 24-h Recall, ASA-24) program developed by the National Cancer Institute (Bethesda, MD, USA).[16]

The format and design of the ASA-24 are based on the interviewer-administered Automated Multiple Pass Method 24-h recall developed by the US Department of Agriculture. The online program has the advantages of ease of use and scoring and face validity; however, although the Automated Multiple Pass Method is a validated instrument, validation trials of ASA-24 remained in progress at the time of this study.[17] Subjects were asked to complete their diet records online as best they could. Subjects were advised of vegan items that ASA-24 does include, such as vegan burger, seitan and tofu, and of common vegan items that are not on ASA-24, such as quinoa and tempeh. Subjects were instructed not to skip any entries even if exact matches were not found in ASA-24. Instead, they were coached on how to find a suitable alterative, such as substituting brown rice for quinoa or vegetarian sub for vegan sandwich. Registered dietitians cross-checked data on ASA-24 by taking participant nutrient data and entering them into the USDA nutrient database to make sure nutrient intake numbers were relevant to ASA-24. Numbers that appeared erroneous were excluded, such as an intake of 500 calories reported for an entire day. Macronutrient intakes were reported as percentages of total energy intake, and fiber and micronutrients were reported as quantities per 1000 kcal.

As animal products are the only significant source of dietary cholesterol, cholesterol intake reported at 18 weeks served as a rough gauge of adherence to the intervention diet. The numbers of group participants whose cholesterol intake was $\leqslant 50$ mg/day (the amount of cholesterol in ~ 2 ounces of typical meats or cheeses) and $\leqslant 75$ mg/day (the amount of cholesterol found in ~ 3 ounces of typical meats or cheeses) were calculated from 18-week diet recalls. The number of group participants whose fat intake was below 25 and 35% of the total calorie intake was also calculated. Use of low-glycemic-index foods was not tracked.

All participants were asked to continue their pre-existing medication regimens unless otherwise instructed by their personal physicians. No other restrictions were placed on medication use.

Statistical analysis

Student's *t*-tests and χ^2-tests were used to assess whether any demographic or clinical measures between groups at baseline were unbalanced. Nutrient data were examined for extreme values, and distributions of variables were examined for skewness using a normality plot and the Shapiro–Wilk test.

Statistical analyses of nutrient intake were performed on an intention-to-treat basis, including all participants who completed an initial diet recall, with the post-intervention values for dropouts set to the pre-intervention values. A second analysis was limited to participants who completed diet recalls at baseline and 18 weeks. The significance of within-group changes in dietary variables was determined using paired *t*-tests. A general linear model univariate analysis (analysis of covariance) was used to estimate the treatment effect and determine whether the changes in nutrient intake of the intervention and control groups during the 18-week trial were significantly different from each other. Diet group was included as a fixed factor in these models, with the baseline value of each nutrient as a covariate. In addition, the geographic site was added to the model as a random effect to account for within-site correlation in outcomes. As the number of sites was small, the significance of and confidence intervals for treatment effect were computed using the Kenward–Roger correction.

All analyses were conducted using the Statistical Analysis Software, SAS version 9.2. (SAS Institute Inc., Cary, NC, USA) *P*-values < 0.05 were considered significant.

RESULTS

The intervention sites were in Tucson, Macon, Chevy Chase, Buffalo and Lakeland. The control sites were in San Diego,

Fredericksburg, Woodbury, Dallas and Virginia Beach. Of 319 volunteers screened for eligibility, 292 (142 at intervention sites and 150 at control sites) met the participation criteria and were enrolled in the overall clinical trial. Of this group, 271 (130 at intervention sites and 141 at control sites) completed usable baseline diet recalls and constituted the baseline sample for the current inquiry. At 18 weeks, 183 (78 in the intervention group and 105 in the control group) completed diet recalls and were considered study completers for purposes of the nutrient analysis.

There were no significant demographic differences between the intervention and control groups at baseline, except for a somewhat greater percentage of women at control sites (Table 1). Among completers, the intervention-group and control-group completers differed only with regard to gender (76% women in the intervention group, 88% women in the control group, $P = 0.04$). Compared with noncompleters, study completers were older (45.5 versus 41.6 years, $P = 0.008$) and had a lower mean baseline body mass index (34.3 versus 37.3 kg/m^2, $P = 0.006$).

The median percentage of group sessions attended per participant (among the completers at intervention sites) ranged from 33% in Macon to 75% in Chevy Chase, with an overall median of 50%.

Adherence to the intervention

Among study completers, cholesterol intake at 18 weeks was $\leqslant$75 mg/day for 85% (66/78) of intervention-group participants and 21% (22/105) of control-group participants ($P < 0.001$). Cholesterol intake was $\leqslant$50 mg/day for 74% (58/78) of intervention-group participants but only 13% (14/105) of control-group participants ($P < 0.001$).

Total fat intake was $\leqslant$35% of the total calorie intake for 86% (67/78) of intervention-group participants compared with 40% (42/105) of the control-group participants ($P < 0.001$). Fat intake was $\leqslant$25% for 49% (38/78) of intervention-group participants and for 8% (8/105) of control-group participants ($P < 0.001$).

SFA intake was $\leqslant$10% of total calorie intake for 88% (69/78) of intervention-group participants and 38% (40/105) of control-group participants ($P < 0.001$). SFA intake was $\leqslant$5% of total calorie intake for 51% (40/78) of intervention-group participants but only for 5% (5/105) of control-group participants ($P < 0.001$).

Nutrient intake at baseline and 18 weeks

At baseline, there were significant differences between participants in the two study arms with respect to the percentage of energy from fat ($P = 0.04$) and vitamin B_{12} per 1000 kcal ($P = 0.05$). During the 18-week intervention, both groups reduced the reported energy intake but the between-group difference was not significant (Table 2). Comparing nutrient intake changes over time between the two groups in the intention-to-treat analysis, adjusting for baseline values and accounting for within-site correlations in outcome, the intervention group significantly reduced the mean reported intake of fat, particularly of SFA but also of monounsaturated fat (Table 2). It increased carbohydrate and fiber intake and reduced protein and cholesterol intake. The intervention group also increased the reported intake of β-carotene, vitamin C, magnesium and potassium. The calcium intakes of both groups were below the recommended levels at baseline, and calcium intake fell further in the intervention group.

Limiting the analysis to study completers, results were similar to those in the intention-to-treat analysis (Table 3). Overall reported energy intake fell in both groups. Compared with changes in the control group, the intervention group reduced the reported intake of fat (total, monounsaturated fat and SFA), protein and cholesterol and increased carbohydrate and fiber intake. In addition, retinol intake fell, which was compensated for by an increase in β-carotene. Reported intakes of vitamin K, vitamin B6,

Table 1. Baseline demographic and clinical characteristics by group assignment for participants in the GEICO[a] multicenter trial

Characteristics	*All subjects* (n = *271*)	*Intervention* (n = *130*)	*Control* (n = *141*)	P-*value*[b]
Age, years (s.d.)	44.2 (11.1)	43.3 (10.6)	45.1 (11.5)	0.19
Gender, n *(%)*				
Men	44 (16%)	27 (21%)	17 (12%)	0.052
Women	227 (84%)	103 (79%)	124 (88%)	
Race, n *(%)*				
White	171 (63%)	79 (61%)	92 (65%)	0.24
Black	73 (27%)	33 (25%)	40 (28%)	
Asian	12 (4%)	8 (6%)	4 (3%)	
Other	15 (6%)	10 (8%)	5 (4%)	
Ethnicity, *n (%)*				
Hispanic	24 (9%)	15 (12%)	9 (6%)	0.14
Non-Hispanic	247 (91%)	115 (88%)	132 (94%)	
Occupation, n *(%)*				
Sales/service	183 (68%)	83 (64%)	100 (71%)	0.30
Supporting staff	53 (20%)	30 (23%)	23 (16%)	
Professional	14 (5%)	5 (4%)	9 (6%)	
Unknown	21 (8%)	12 (9%)	9 (6%)	
Body mass index, kg/m^2 (s.d.)	35.2 (7.7)	35.0 (7.0)	35.5 (8.3)	0.55
Alcohol consumption, n *(%)*				
None	86 (36%)	45 (40%)	41 (33%)	0.28
Moderate	142 (60%)	63 (56%)	79 (63%)	
Frequent	9 (4%)	4 (4%)	5 (4%)	
Diabetes at entry	40 (15%)	18 (14%)	22 (16%)	0.70

[a]The Government Employees Insurance Company (GEICO) is a major US vehicle insurance company. [b]*P*-values refer to differences between groups, using χ^2-tests for categorical variables and *t*-tests for continuous variables.

Table 2. Nutrient intakes at baseline and 18 weeks for participants in the GEICO[a] multicenter trial, including all participants, using baseline data for noncompleters

Nutrients	*Intervention group (n = 130)*			*Control group (n = 141)*			*Estimated treatment effect (95% CI)*[b]	P-*value*[c]
	Baseline mean (s.e.)	*18 weeks Mean (s.e.)*	*Within-group changes Mean (s.e.)*	*Baseline Mean (s.e.)*	*18 weeks Mean (s.e.)*	*Within-group changes Mean (s.e.)*		
Energy (kcal)	1978 (83.4)	1647 (64.2)	− 331 (79.1)*	1835 (77.8)	1712 (58.2)	− 124 (77.0)	− 112 (− 409 to 185)	0.41
Energy from fat (%)	34.9 (0.9)	30.8 (1.0)	− 4.1 (0.9)*	37.5 (0.8)	36.9 (0.7)	− 0.5 (0.9)	− 5.4 (− 9.8 to − 0.9)	0.02
Energy from carbohydrate (%)	50.3 (1.2)	56.7 (1.3)	6.4 (1.2)*	47.5 (1.0)	47.3 (0.9)	− 0.2 (1.0)	8.6 (3.2 to 13.9)	0.006
Energy from protein (%)	15.8 (0.4)	14.7 (0.4)	− 1.1 (0.4)**	16.5 (0.4)	17.1 (0.5)	0.7 (0.5)	− 2.4 (− 4.4 to − 0.4)	0.03
Energy from MUFA (%)	12.6 (0.4)	10.9 (0.4)	− 1.7 (0.4)*	13.6 (0.4)	13.4 (0.3)	− 0.3 (0.4)	− 2.2 (− 3.8 to − 0.6)	0.01
Energy from PUFA (%)	7.3 (0.3)	7.8 (0.3)	0.5 (0.3)	7.8 (0.3)	7.9 (0.3)	0.1 (0.3)	0.1 (− 1.4 to 1.6)	0.92
Energy from SFA (%)	11.3 (0.4)	8.5 (0.5)	− 2.8 (0.4)*	12.0 (0.4)	11.6 (0.4)	− 0.4 (0.4)	− 2.9 (− 4.7 to − 1.1)	0.006
Cholesterol (mg per 1000 kcal)	136 (9.7)	84.3 (11.2)	− 51.7 (10.7)*	137(7.7)	134(8.6)	− 2.8 (9.6)	− 50.2 (− 83.6 to − 16.8)	0.009
Fiber (g per 1000 kcal)	10.2 (0.5)	14.8 (0.7)	4.6 (0.6)*	9.9 (0.5)	10.3 (0.4)	0.4 (0.4)	4.5 (2.3 to 6.7)	0.002
Retinol (μg per 1000 kcal)	213 (28.0)	158 (12.6)	− 54.6 (28.8)	176 (9.5)	193(12.0)	17.1 (12.7)	− 39.3 (− 80.3 to 1.8)	0.06
β-carotene (μg per 1000 kcal)	1348 (161)	2102 (202)	754 (219)*	1706 (218)	1345 (154)	− 361(197)	891 (221 to 1560)	0.01
Vitamin E as α-tocopherol (mg per 1000 kcal)	4.0 (0.2)	4.6 (0.2)	0.6 (0.3)***	4.2 (0.2)	4.3(0.3)	0.1 (0.3)	0.4 (− 0.7 to 1.4)	0.43
Vitamin K (μg per 1000 kcal)	71.0 (9.9)	89.5 (10.4)	18.5 (11.5)	84.0 (13.8)	66.9 (7.3)	− 17.1(12.3)	25.9 (− 5.8 to 57.6)	0.10
Vitamin B_6 (mg per 1000 kcal)	1.1 (0.1)	1.2 (0.1)	0.2 (0.1)***	0.9 (0.04)	1.1(0.1)	0.1 (0.1)	0.1 (− 0.05 to 0.3)	0.16
Vitamin B_{12} (μg per 1000 kcal)	2.8 (0.3)	2.2 (0.3)	− 0.6 (0.3)***	2.0 (0.2)	2.3 (0.2)	0.3 (0.3)	− 0.6 (− 1.6 to 0.5)	0.24
Folate (μg per 1000 kcal)	230 (11.1)	274 (11.5)	44.8 (12.4)*	209 (8.8)	224 (10.0)	14.9 (11.9)	52.7 (− 8.1 to 114)	0.08
Vitamin C (mg per 1000 kcal)	44.8 (3.6)	64.5 (4.7)	19.6 (4.2)*	49.0 (4.4)	49.5 (4.2)	0.5 (4.7)	17.0 (5.9 to 28.1)	0.003
Calcium (mg per 1000 kcal)	396 (16.6)	354 (14.1)	− 41.6 (13.7)**	394 (15.8)	415 (15.8)	21.2 (16.6)	− 63.0 (− 112 to − 14.3)	0.02
Iron (mg per 1000 kcal)	8.1 (0.3)	9.2 (0.4)	1.1 (0.4)**	7.5 (0.3)	7.9 (0.3)	0.4 (0.4)	1.2 (− 0.4 to 2.9)	0.12
Magnesium (mg per 1000 kcal)	152 (4.6)	187 (7.0)	34.7 (5.9)*	150 (5.6)	157 (4.5)	6.9 (5.2)	29.2 (2.4 to 56.1)	0.04
Potassium (mg per 1000 kcal)	1373 (41.9)	1576 (53.6)	203 (51.4)*	1365 (55.8)	1387 (36.7)	22.2 (52.7)	185 (69.7 to 301)	0.002
Selenium (μg per 1000 kcal)	53.6 (1.9)	50.7 (2.0)	− 2.8 (1.9)	54.7 (1.8)	54.7 (1.8)	− 0.05 (1.8)	− 3.3 (− 7.9 to 1.3)	0.16
Sodium (mg per 1000 kcal	1860 (60.6)	1946 (56.8)	86.3 (67.3)	1834 (50.5)	1854 (50.2)	19.2(55.3)	83.6 (− 55.0 to 222)	0.24
Zinc (mg per 1000 kcal	5.6 (0.2)	5.2 (0.2)	− 0.4 (0.2)	5.6 (0.2)	5.7 (0.2)	0.1 (0.3)	− 0.4 (− 1.2 to 0.3)	0.19

Abbreviations: MUFA, monounsaturated fat; PUFA, polyunsaturated fat; SFA, saturated fat. [a]The Government Employees Insurance Company (GEICO) is a major US vehicle insurance company. [b]Geographical site and baseline value adjusted (analysis of covariance). [c]*P*-value for analysis adjusted for geographical site and baseline value. **P* < 0.001, ***P* < 0.01, ****P* < 0.05 for unadjusted *t*-test assessing significance of within-group changes.

folate, vitamin C, iron, magnesium and potassium increased, whereas calcium intake decreased.

DISCUSSION

A nutrition intervention program at the workplace yielded clinically important changes in nutrient intake. These changes were similar to those previously reported in clinical research settings, suggesting that these research findings effectively translated into an intervention implemented at worksites in widely divergent areas of the United States.

The overall reported energy intake fell in both groups. Part of this reduction may be because of underreporting, which is common in clinical trials of non-institutionalized participants.[18,19] Another possible explanation is that because ASA-24 does not contain common vegan food items, subjects may have omitted these foods, resulting in lower energy intake reports. However, it is likely that the reduced energy intake of the intervention group is, at least in part, on account of increased fiber intake and reduced fat intake, both of which would tend to reduce the energy density of the diet. In turn, a reduction in energy intake favors weight loss, which has been observed in prior studies using low-fat, plant-based diets[20] and was observed in the current study.[14] Reductions in reported energy intake and weight loss commonly occur with plant-based diets, even in the absence of specific limitations on energy intake or specific guidance regarding portion control.[20]

Diets high in fiber may also facilitate removal of cholesterol,[21,22] with favorable effects for individuals at risk of cardiovascular disease. In a 5-year study of patients with heart disease, a low-fat vegetarian diet as a part of a program of lifestyle changes has been shown to reverse atherosclerosis and reduce the risk of cardiac events.[23]

Reported protein intake decreased in the intervention group, but the percentage of energy from protein remained within the range recommended by the Institute of Medicine.[24]

Among micronutrients, the intervention group increased the reported intake of β-carotene, vitamin C, magnesium and potassium. As expected, vitamin B_{12} from food sources fell in the intervention group. However, participants were asked to take supplemental B_{12}. For both groups, calcium intake was below the levels recommended by the Institute of Medicine at baseline and again at 18 weeks, and was dropped in the intervention group. In estimating calcium requirements, committees have used varying methods to calculate skeletal accretion and turnover rates, resulting in a considerable worldwide debate about whether currently recommended intakes of calcium are adequate to maximize peak bone mass and to minimize bone loss and fracture risk in later life.[25] However, this may indicate the need for further instruction on plant-based sources of calcium, such as green leafy vegetables and legumes. Reported iron intake increased in the intervention group, reflecting the increased intake of plant-based sources of iron.

The 18-week nutrient intake data indicate that some intervention group participants continued to include some animal products in their diets and consumed more fat than had been recommended. Nonetheless, the two groups diverged markedly in their reported dietary behavior, suggesting that the intervention elicits significant changes even for those participants who do not fully adhere to the prescribed guidelines. As previously reported, these nutrient changes are reflected in improvements in body weight, plasma lipid concentrations, and, for those with diabetes, improvements in glycemic control.[14]

The tendency of plant-based diets to favorably influence nutrient intake and clinical measures related to disease risk raises the question of their sustainability over the long term. A University of Pittsburgh survey of young women who had tried both vegetarian and various calorie-restricted diets[26] found that the mean duration of adherence to vegetarian diets was at least 2 years, compared with only 4 months for calorie-restricted diets. In the course of dietary intervention trials, adherence, attrition and

Table 3. Nutrient intakes at baseline and 18 weeks for participants in the GEICO[a] multicenter trial, completers only

Nutrients	*Intervention group* (n = 78)			*Control group* (n = 105)			*Estimated treatment effect (95% CI)*[b]	P-*value*[c]
	Baseline Mean (s.d.)	*18 weeks Mean (s.d.)*	*Within-group changes Mean (s.d.)*	*Baseline Mean (s.d.)*	*18 weeks Mean (s.d.)*	*Within-group changes Mean (s.d.)*		
Energy (kcal)	2053 (118)	1502 (75.0)	− 551 (126)*	1887 (98.5)	1721 (70.6)	− 166 (103)	− 257 (− 634 to 121)	0.14
Energy from fat (%)	33.0 (1.3)	26.2 (1.2)	− 6.8 (1.5)*	38.0 (1.0)	37.3 (0.8)	− 0.7 (1.2)	− 10.6 (− 15.8 to − 5.3)	0.001
Energy from carbohydrate (%)	52.6 (1.6)	63.4 (1.5)	10.7 (1.8)*	47.4 (1.2)	47.1 (1.0)	− 0.3 (1.3)	15.8 (9.5 to 22.1)	< 0.001
Energy from protein (%)	15.4 (0.4)	13.5 (0.5)	− 1.9 (0.7)**	16.2 (0.5)	17.0 (0.5)	0.9 (0.6)	− 3.8 (− 6.4 to − 1.2)	0.01
Energy from MUFA (%)	11.7 (0.5)	8.8 (0.5)	− 2.9 (0.6)*	13.8 (0.4)	13.5 (0.4)	− 0.4 (0.6)	− 4.6 (− 6.6 to − 2.6)	< 0.001
Energy from PUFA (%)	7.3 (0.3)	8.0 (0.4)	0.8 (0.5)	7.9 (0.4)	8.0 (0.4)	0.1 (0.4)	0.3 (− 2.0 to 2.5)	0.80
Energy from SFA (%)	10.4 (0.6)	5.7 (0.4)	− 4.7 (0.6)*	12.4 (0.5)	11.8 (0.5)	− 0.5 (0.6)	− 5.7 (− 7.3 to − 4.1)	< 0.001
Cholesterol (mg per 1000 kcal)	118 (11.3)	31.7 (11.6)	− 86.2 (16.7)*	137 (9.0)	134 (10.3)	− 3.8 (12.9)	− 105 (− 149 to − 61.2)	< 0.001
Fiber (g per 1000 kcal)	11.4 (0.7)	19.0 (0.8)	7.7 (0.9)*	9.9 (0.6)	10.4 (0.5)	0.5 (0.6)	8.1 (6.4 to 9.7)	< 0.001
Retinol (μg per 1000 kcal)	221 (45.6)	130 (17.4)	− 91.0 (47.7)	177 (11.3)	200 (14.9)	23.0 (17.0)	− 79.6 (− 152 to − 7.7)	0.03
β Carotene (μg per 1000 kcal)	1592 (238)	2848 (286)	1256 (354)*	1732 (265)	1247 (163)	− 485 (263)	1625 (1024 to 2227)	< 0.001
Vitamin E as α-tocopherol (mg per 1000 kcal)	4.0 (0.3)	5.0 (0.3)	1.0 (0.4)***	4.2 (0.3)	4.3 (0.3)	0.1 (0.4)	0.8 (− 0.7 to 2.3)	0.24
Vitamin K (μg per 1000 kcal)	83.7 (15.0)	115 (15.4)	30.9 (19.0)	84.6 (17.2)	61.7 (6.8)	− 22.9 (16.4)	52.7 (14.8 to 90.7)	0.01
Vitamin B_6 (mg per 1000 kcal)	1.1 (0.1)	1.4 (0.1)	0.3 (0.1)***	1.0 (0.05)	1.1 (0.1)	0.1 (0.1)	0.25 (0.06 to 0.44)	0.01
Vitamin B_{12} (μg per 1000 kcal)	2.5 (0.3)	1.5 (0.2)	− 1.0 (0.4)***	2.0 (0.2)	2.4 (0.3)	0.4 (0.3)	− 0.9 (− 2.2 to 0.4)	0.13
Folate (μg per 1000 kcal)	250 (15.3)	325 (13.9)	74.7 (20.1)*	211 (10.7)	231 (12.4)	20.1 (16.0)	99.7 (14.1 to 185)	0.03
Vitamin C (mg per 1000 kcal)	43.3 (4.1)	76.0 (6.2)	32.7 (6.7)*	47.2 (5.0)	47.9 (4.7)	0.7 (6.3)	28.9 (14.1 to 43.8)	< 0.001
Calcium (mg per 1000 kcal)	380 (22.0)	311 (14.8)	− 69.4 (22.4)**	391 (17.5)	419 (17.6)	28.5 (22.3)	− 108 (− 168 to − 47.8)	0.003
Iron (mg per 1000 kcal)	8.6 (0.4)	10.4 (0.5)	1.8 (0.7)**	7.8 (0.3)	8.3 (0.3)	0.5 (0.5)	2.1 (0.1 to 4.1)	0.04
Magnesium (mg per 1000 kcal)	162 (6.3)	220 (9.1)	57.9 (9.0)*	148 (7.1)	157 (5.4)	9.3 (7.0)	57.6 (39.0 to 76.2)	< 0.001
Potassium (mg per 1000 kcal)	1416 (55.6)	1753 (72.4)	338 (82.3)*	1383 (69.8)	1413 (40.8)	29.8 (70.9)	335 (183 to 486)	< 0.001
Selenium (μg per 1000 kcal)	52.3 (2.0)	47.6 (2.3)	− 4.7 (3.1)	53.2 (1.9)	53.1 (1.9)	− 0.1 (2.5)	− 6.0 (− 14.4 to 2.5)	0.14
Sodium (mg per 1000 kcal)	1889 (84.7)	2033 (75.6)	144 (112)	1843 (56.1)	1869 (55.6)	25.8 (74.4)	156 (− 82.4 to 395)	0.17
Zinc (mg per 1000 kcal	5.7 (0.3)	5.1 (0.2)	− 0.7 (0.3)	5.7 (0.3)	5.8 (0.2)	0.1 (0.3)	− 0.8 (− 1.8 to 0.3)	0.12

Abbreviations: MUFA, monounsaturated fat; PUFA, polyunsaturated fat; SFA, saturated fat. [a]The Government Employees Insurance Company (GEICO) is a major US vehicle insurance company. [b]Geographic site and baseline value adjusted (analysis of covariance). [c]*P*-value for analysis adjusted for geographic site and baseline value. *$P < 0.001$, **$P < 0.01$, ***$P < 0.05$ for unadjusted *t*-test assessing significance of within-group changes.

eating behavior have been studied, and vegetarian and vegan regimens appear to be generally similar to other therapeutic diets within these parameters.[27]

Strengths of the study include participation by individuals from divergent geographical areas, whose tastes and dietary habits and whose access to healthful foods likely varied as well; the use of a dietary intervention that can be reproduced in other corporate locations; and sufficient statistical power to demonstrate significant changes.

The study also has several limitations. Its duration was limited to 18 weeks, primarily on account of the challenges of retaining untreated control-group participants over a longer period of time. Had the study design included an active comparison program within the control group, it may have permitted sufficient engagement for a longer study, although such a design would have eliminated the possibility of comparisons with an untreated control. Nutrient intakes were self-reported. Men were underrepresented in the participant sample for reasons that are unclear. Randomization was based on geographical site rather than on the individual participant. Although there appeared to be a reasonable balance among those variables that were reported, we cannot assume balance on other unreported or unmeasured variables. A number of participants failed to complete 18-week diet recalls. Possible reasons for a failure to complete nutrient records include limited access to the internet and difficulties in navigating through the ASA-24 online diet recall program.

CONCLUSION

In summary, the present study demonstrated that a simple nutrition education program using modest group support at the place of employment yields significant improvements in nutrient intakes. The worksite is a potentially important venue for nutrition teaching and lifestyle modification and merits increased attention. In interventions using plant-based diets, planning for adequate intake of vitamin B_{12} and calcium is important. Future studies should focus on the longer-term nutrient changes associated with worksite dietary intervention programs.

CONFLICT OF INTEREST

NDB, JG, JX, UA and SML are on the staff of the Physicians Committee for Responsible Medicine, a nonprofit organization that promotes the use of low-fat, plant-based diets and discourages the use of animal-derived, fatty and sugary foods. NDB also writes books and articles and delivers lectures about therapeutic diets, including vegan diets, and has received royalties and honoraria from these sources. The remaining authors declare no conflict of interest.

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