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A Vegetarian Dietary Pattern as a Nutrient-Dense Approach to Weight Management: An Analysis of the National Health and Nutrition Examination Survey 1999-2004

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ABSTRACT

Background Population-based studies have shown that vegetarians have lower body mass index than nonvegetarians, suggesting that vegetarian diet plans may be an approach for weight management. However, a perception exists that vegetarian diets are deficient in certain nutrients.

Objective To compare dietary quality of vegetarians, nonvegetarians, and dieters, and to test the hypothesis that a vegetarian diet would not compromise nutrient intake when used to manage body weight.

Design Cross-sectional analysis of National Health and Nutrition Examination Survey (1999-2004) dietary and anthropometric data. Diet quality was determined using United States Department of Agriculture's Healthy Eating Index 2005. Participants included adults aged 19 years and older, excluding pregnant and lactating women (N=13,292). Lacto-ovo vegetarian diets were portrayed by intakes of participants who did not eat meat, poultry, or fish on the day of the survey (n=851). Weight-loss diets were portrayed by intakes of participants who consumed 500 kcal less than their estimated energy requirements (n=4,635). Mean nutrient intakes and body mass indexes were adjusted for energy, sex, and ethnicity. Using analysis of variance, all vegetarians were compared to all nonvegetarians, dieting vegetarians to dieting nonvegetarians, and nondieting vegetarians to nondieting nonvegetarians.

Results Mean intakes of fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, and iron were higher for all vegetarians than for all nonvegetarians. Although vegetarian intakes of vitamin E, vitamin A, and magnesium exceeded that of nonvegetarians (8.3±0.3 vs 7.0±0.1 mg; 718±28 vs 603±10 μg; 322±5 vs 281±2 mg), both groups had intakes that were less than desired. The Healthy Eating Index score did not differ for all vegetarians compared to all nonvegetarians (50.5±0.88 vs 50.1±0.33, $P=0.6$).

Conclusions These findings suggest that vegetarian diets are nutrient dense, consistent with dietary guidelines, and could be recommended for weight management without compromising diet quality.

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A vegetarian diet as an approach for weight management has been suggested by several studies that report that vegetarians tend to be leaner than nonvegetarians (1-4). Body mass index (BMI) can differ as much as 1.9 for vegetarian men and 2.1 for vegetarian women compared to nonvegetarians, and the difference can be even greater between nonvegetarians and vegans. Lower energy intake, lower protein as a percent of energy, and higher fiber intake are dietary factors that have been associated with lower BMIs (2,4).

Dietary patterns of participants in the National Weight Control Registry who have maintained at least a 30-lb weight loss for more than 5 years include low intakes of energy and fat with moderate carbohydrate intakes (5,6), and this is a pattern recommended by the National Institutes of Health (7) and the Dietary Guidelines (8). Low energy and fat intakes along with high fruit, vegetable, and whole-grain carbohydrate consumption are also characteristic of vegetarian dietary patterns (9). Energy intakes of vegetarians have been shown to be as much as 464 kcal lower than those of nonvegetarians (1,2,10), suggesting that a vegetarian diet is a version of a low-energy diet that could be used for weight control. However, there exists a perception that vegetarian diets are deficient in important nutrients, including protein, calcium, iron, and vitamin B-12 (11).

Data from recent population-based studies that have reported nutrient intake patterns for vegetarians have supported few of these concerns (9,10,12). A comparison of the Dietary Reference Intakes (DRIs) to usual intakes for the general US population showed an increased risk for inadequate intake of fiber, potassium, vitamins A, C, and E, calcium, and magnesium (13), and, with few exceptions, vegetarians typically have higher intakes of these nutrients than nonvegetarians (9,10,12). Comparisons of vegan diets to the National Cholesterol Education Program Step II (14) and American Diabetes Association diets (15) have shown that omnivorous subjects who changed to a low-fat vegan diet for 14 or 22 weeks improved their intakes of fiber, vitamin A, vitamin C, folate, magnesium, and potassium.

Although some data suggest that a vegetarian diet could be recommended for weight management without compromising nutrient intake, more recent information about vegetarian nutrient intakes for the US population is needed. In addition, an analysis of nutrient intakes for low-energy dieters would provide further information about the effect of low energy intake on diet quality, and would provide a basis for a comparison to a vegetarian diet as an approach for weight management. Recent National Health and Nutrition Examination Survey (NHANES) reports do not specifically define vegetarian dietary patterns; however, data from participants who did not report eating meat, poultry, or fish on the day of the survey could be used to portray a lacto-ovo vegetarian dietary pattern. Similarly, "dieters" could be defined by energy intake reported as less than estimated energy requirements. The purpose of this study was to compare dietary quality of vegetarians, nonvegetarians, and dieters, and to test the hypothesis that a vegetarian diet would not compromise nutrient intake when used as a method for weight management.

METHODS

Research Design

This study is a cross-sectional analysis of dietary recall records and anthropometric data from NHANES 1999-2004. NHANES is a continuous annual survey conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention to obtain nationally representative information on the health and nutritional status of the US population. The NHANES design involves a stratified, multistage, probability sample, and includes oversampling of Mexican Americans, non-Hispanic blacks, children, and adolescents.

Dietary information for NHANES was obtained via a multiple pass 24-hour recall (four steps for 1999-2000 and five steps for 2001-2004). Dietary recalls were considered reliable if at least the first four steps were completed and all of the relevant variables associated with the recall contained a value. Only dietary interviews that were considered reliable as coded by the National Center for Health Statistics were included in this study. Before NHANES 2001-2002, vitamin A was expressed as micrograms of retinol equivalents and vitamin E was expressed as milligrams of α-tocopherol equivalents, whereas currently these nutrients are expressed as micrograms of retinol activity equivalents for vitamin A and milligrams of α-tocopherol for vitamin E. To permit data from the 1999-2000 survey to be combined with 2001-2002 and 2003-2004 data, a special database was released by the US Department of Agriculture that allows the 1999-2000 intake estimates for vitamin A and vitamin E to be calculated using the current units (16). This database was merged with the NHANES dietary intake data used in our study. The MyPyramid Equivalents Database Version 1 was used to convert NHANES 1999-2002 food intake data into guidance-based amounts defined by the MyPyramid Food Guidance System (17). Data obtained from NHANES 2003-2004 was hand matched to similar food in the MyPyramid database.

The US Department of Agriculture Healthy Eating Index (HEI) 2005 was used to determine diet quality. Scores were calculated for 12 components—nine for dietary adequacy (total fruit, whole fruit, total vegetables, dark-green and orange vegetables, total grain, whole grain, all milk products and soy beverages, meat and beans including soy, and oils) and three for dietary moderation (saturated fat; sodium; and solid fats, alcohol, and added sugar). The maximum score for the adequacy components is based on MyPyramid recommended intakes per 1,000 kcal, with intakes between the maximum and minimum rated proportionately. For the moderation components, maximum and minimum scores are based on probability distributions for nutrient intakes and prorated linearly. Higher scores for the adequacy components and lower scores for the moderation components indicate better compliance with dietary guidelines. The total score is a measure of overall diet quality in terms of dietary intake per 1,000 kcal.

Participants

The study sample consisted of participants in NHANES from 1999 to 2004. Adults aged 19 years and older with reliable dietary records were eligible for inclusion (N= 14,196). From this eligible sample, pregnant and lactating women were excluded, for a final sample size of 13,292. Participants were classified by vegetarian status and dieting status as shown in the Figure. Vegetarians were defined as participants who did not report eating meat, poultry, or fish on the day of the survey, a definition that was previously used by Kennedy and colleagues (1). Although all of these participants may not be vegetarians, their dietary intakes on the day of the survey reflected the nutrient content of a lacto-ovo vegetarian dietary

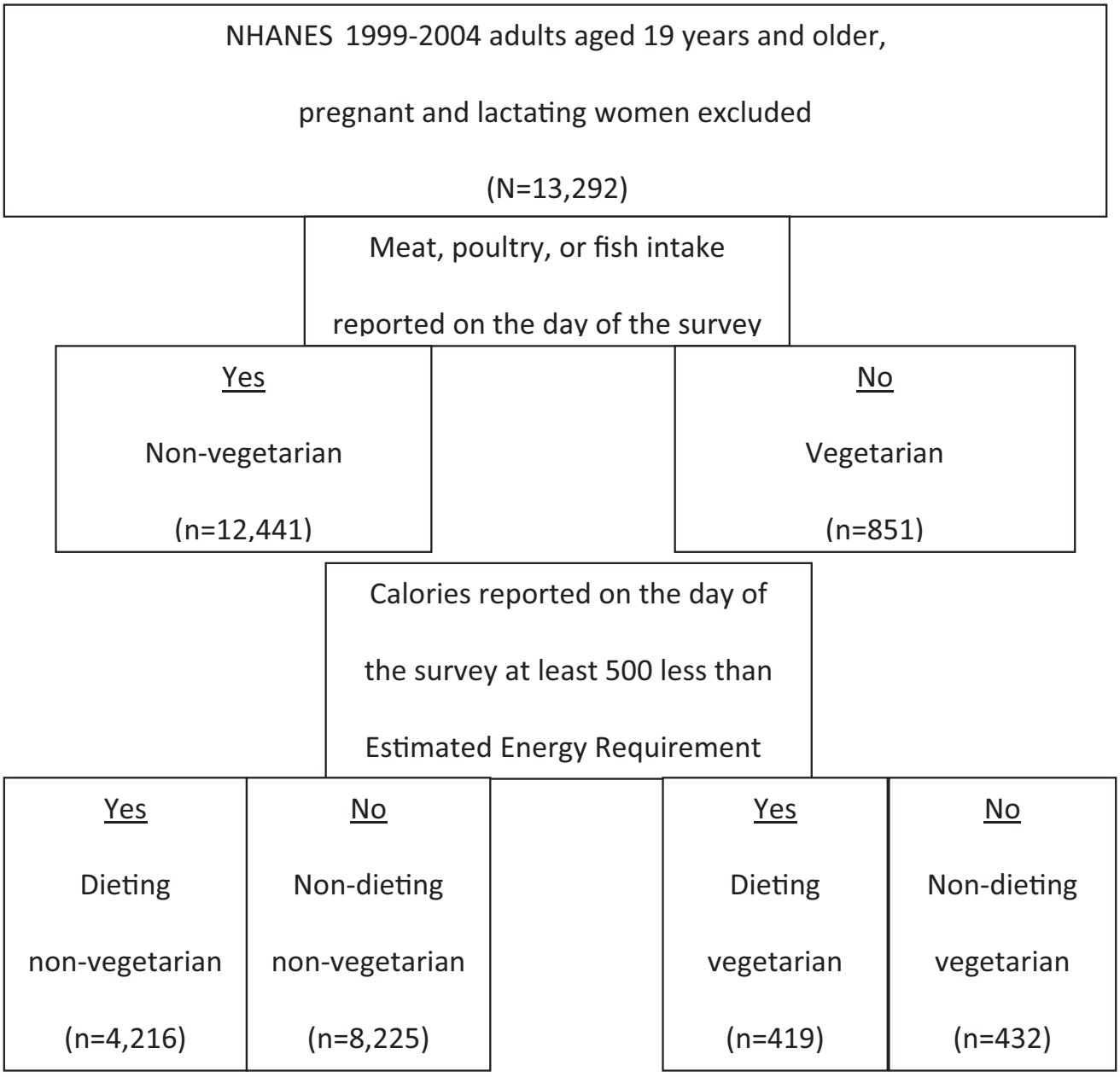

Figure. Schematic diagram used for classifying participants of the National Health and Nutrition Examination Survey (NHANES) 1999-2004, aged 19 years and older, by vegetarian and dieting status.

pattern, and this definition excluded self-defined vegetarians who may actually follow a semi-vegetarian dietary pattern. Previous studies have shown that up to two thirds of self-defined vegetarians reported consuming meat, poultry, or fish on dietary recalls (9,12). Dieters were defined as those who had energy intakes that were at least 500 kcal less than their estimated energy requirements on the day of the survey, a definition that is supported by recommendations from the National Heart, Lung, and Blood Institute for calculating the reduction in energy intake for weight loss of 1 to 2 lb/week (7). The estimated energy requirement was calculated as described by the Institute of Medicine (IOM) (18) using the sedentary activity level (physical activity coefficient 1.0).

This study was deemed exempt by the Human Subjects Review committee at Eastern Michigan University.

Statistical Analysis

Data preparation was performed using SAS software (version 9.13 for Windows, 2003, SAS Institute Inc, Cary, NC). Analysis of variance was conducted to compare BMIs, 1-day nutrient intakes, MyPyramid equivalents, and HEI scores for vegetarians, nonvegetarians, and dieters. Because three

Table 1. Sample characteristics for participants of National Health and Nutrition Examination Survey 1999-2004, aged 19 years and older, by vegetarian and dieting status

	All (N=13,292)				Dieters (n=4,635)				Nondieters (n=8,657)			
	Vegetarian		Nonvegetarian		Vegetarian		Nonvegetarian		Vegetarian		Nonvegetarian	
Characteristic	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
	851	6	12,441	94	419	9	4,216	91	432	5	8,225	95
Sex												
Male	362	43	6,385	51	201	48	2,282	54	161	37	4,103	50
Female	489	57	6,056	49	218	52	1,934	46	271	63	4,122	50
Ethnicity												
Non-Hispanic white	443	52	6,170	50	188	45	1,890	45	255	59	4,280	52
Non-Hispanic black	102	12	2,600	21	72	17	1,110	26	30	7	1,490	18
Mexican American	222	26	2,803	22	116	28	926	22	106	25	1,877	23
Other race	34	4	323	3	12	3	110	3	22	5	213	3
Other Hispanic	50	6	545	4	31	7	180	4	19	4	365	4
	← *mean±standard deviation* →											
Body mass index[a]**	26.76±0.25		28.14±0.10		29.80±0.39		31.43±0.23		25.22±0.31		26.71±0.09	

[a]Adjusted for energy, sex, and ethnicity.
**$P<0.01$ within vegetarian and nonvegetarian comparisons.

2-year cycles of continuous NHANES data were combined, a 6-year weight variable was created as described in the Analytic and Reporting Guidelines (19). All analyses were weighted using the NHANES examination sample weights and adjusted for the complex sample design of NHANES using the SUDAAN version 10.0 statistical package (2008, Research Triangle Institute, Research Triangle Park, NC). Means and standard errors were reported, and standard errors were estimated using the Taylor linearization technique of SUDAAN. Statistical significance was set at $P<0.01$, providing a conservative approach for cross-sectional analyses of population studies that reduces the chance of detecting an effect when one is not present. Energy intake was adjusted for sex and ethnicity. Nutrients, MyPyramid equivalents, and BMIs were adjusted for sex, ethnicity, and energy intake.

RESULTS

Participants

Within the eligible sample of 13,292 adults aged 19 years and older, there were 6,747 male and 6,545 female participants, and the sample was predominately (51%) non-Hispanic white (Table 1). The 851 participants who did not report eating meat, poultry, or fish on the day of the survey were classified as vegetarian, representing 6% of the sample. The remaining 12,441 were classified as nonvegetarian. Of the 851 vegetarians, 419 were classified as dieters, and of the 12,441 nonvegetarians, 4,216 were dieters. Mean BMI was lower for each of the vegetarian groups compared to the nonvegetarian groups.

Comparison of All Vegetarians and Nonvegetarians

Fiber intake was 24% higher for vegetarians than for nonvegetarians, and calcium intake was 17% higher for vegetarians. Vegetarians also had higher intakes of magnesium; iron; vitamins A, C, and E; thiamin; riboflavin; and folate (Table 2). Niacin, vitamin B-12, and zinc intakes were lower for vegetarians. Protein intake was lower for the vegetarians, as was total fat, saturated fat, and cholesterol. Intakes of sodium were lower for the vegetarians than for the nonvegetarians (3,027±36 mg vs 3,494±16 mg, respectively); however, both groups were above the 2,300 mg limit for sodium recommended by the Dietary Guidelines for Americans (8) and the DRI tolerable upper intake level (20).

Table 3 shows that vegetarians consumed more total grain, fruit, soy, total dairy products and milk, and less discretionary fat than nonvegetarians. In addition, they consumed twice as much whole grain and legumes as nonvegetarians. There was no difference in total vegetable intake between the vegetarians and nonvegetarians; however, there was a difference in distribution of vegetable type between the groups. The vegetarians ate more dark-green vegetables, whereas the nonvegetarians ate more potatoes. Diet quality as measured by the HEI total score was not different for all vegetarians compared to all nonvegetarians (Table 4).

Comparison of Dieting Vegetarians and Nonvegetarians

Fiber intake was significantly higher for dieting vegetarians than for dieting nonvegetarians, as was calcium (Table 2). Intakes of vitamins A, C, and E, folate, magnesium, and iron were also higher for dieting vegetarians, but the differences for these nutrients were not significant. Potassium intake was lower for the dieting vegetarians than for the dieting nonvegetarians; however, neither group met the 4,700-mg adequate intake level for adults. Protein, cholesterol and total fat intakes were lower for the dieting vegetarians, and although saturated fat was also lower, the difference was not significant. Mean sodium intake was lower for the dieting vegetarians (2,957±56 mg) than for the dieting nonvegetarians (3,432±33 mg); however, both groups were above the recommended 2,300 mg limit for sodium.

Table 2. Adjusted mean nutrient intakes for vegetarian and nonvegetarians aged 19 years and older, based on information provided in National Health and Nutrition Examination Survey 1999-2004

Nutrient[a]	All (N=13,292)		Dieters (n=4,635)		Nondieters (n=8,657)	
	Vegetarian (n=851)	Nonvegetarian (n=12,441)	Vegetarian (n=419)	Nonvegetarian (n=4,216)	Vegetarian (n=432)	Nonvegetarian (n=8,225)
	← *mean intake±standard error* →					
Energy (kcal)	1,877±42	2,241±11**	1,179±29	1396±10**	2,440±36	2,623±11**
Protein (g)	63.4±0.7	83.6±0.4**	64.4±0.9	83.1±0.7**	62.5±1.3	83.9±0.6**
Carbohydrate (g)	312±3	270±1**	293±3	266±2**	326±5	271±1**
Fiber (g)	20.3±0.6	15.4±0.2**	16.0±0.6	14.3±0.3**	23.4±0.8	15.8±0.2**
Total fat (g)	75.5±1.0	83.6±0.4**	78.4±1.1	82.7±0.9**	73.1±1.6	83.9±0.5**
Saturated fat (g)	24.9±0.4	27.4±0.2**	26.4±0.6	27.6±0.3	23.7±0.6	27.3±0.2**
Cholesterol (mg)	208±7	295±3**	200±7	291±5**	213±12	296±4**
Vitamin A (μg RAE[b])	718±28	603±10**	600±44	570±19	801±33	619±11**
Vitamin C (mg)	112±6.5	91±1.6**	91±6.1	81±2.6	127±7.9	96±1.7**
Vitamin E (mg AT[c])	8.3±0.3	7.0±0.1**	7.5±0.5	6.6±0.2	8.8±0.3	7.2±0.1**
Thiamin (mg)	1.7±0.0	1.6±0.0**	1.6±0.1	1.6±0.0	1.8±0.0	1.7±0.0**
Riboflavin (mg)	2.3±0.0	2.1±0.0**	2.1±0.1	2.1±0.0	2.4±0.1	2.2±0.0
Niacin (mg)	19.2±0.4	23.9±0.2**	19.5±0.6	23.4±0.3**	18.7±0.6	24.1±0.2**
Vitamin B-6 (mg)	1.8±0.1	1.9±0.0	1.7±0.1	1.8±0.0	1.9±0.1	1.9±0.0
Folate (μg DFE[d])	663±18	536±6**	572±27	519±10	730±28	545±7**
Vitamin B-12 (μg)	3.8±0.2	5.3±0.1**	3.9±0.2	5.2±0.2**	3.8±0.3	5.3±0.1**
Calcium (mg)	1,020±22	846±7**	932±40	837±14**	1,086±35	850±8**
Magnesium (mg)	322±5	281±2**	283±7	268±3	349±6	286±2**
Iron (mg)	16.9±0.4	15.5±0.1**	15.4±0.6	14.8±0.2	17.9±0.5	15.9±0.1**
Zinc (mg)	10.1±0.2	12.1±0.1**	9.9±0.3	11.8±0.2**	10.2±0.3	12.3±0.1**
Sodium (mg)	3,027±36	3,494±16**	2,957±56	3,432±33**	3,067±56	3,522±20**
Potassium (mg)	2,770±42	2,745±18	2,445±63	2,591±28**	2,983±57	2,817±22**

[a]Energy intake adjusted for sex and ethnicity; all other nutrients adjusted for energy, sex, and ethnicity.
[b]RAE=retinol activity equivalent.
[c]α-Tocopherol.
[d]DFE=dietary folate equivalents.
**$P<0.01$ within vegetarian and nonvegetarian comparisons.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

The dieting vegetarians consumed more total grain, whole grain, legumes, nuts, cheese, and added sugar than did the dieting nonvegetarians (Table 3). Soy intake for the dieting vegetarians was 0.29±0.1 oz equivalents vs 0.04±0.01 oz equivalents for the dieting nonvegetarians ($P=0.013$). There were no differences between these two groups for intakes of fruit, vegetables, egg, total dairy, milk, and discretionary fats and oils. The total HEI score was higher for dieting nonvegetarians than for dieting vegetarians (Table 4).

Comparison of Nondieting Vegetarians and Nonvegetarians

When dieters were separated from the two groups, the differences in food and nutrient intakes between vegetarians and nonvegetarians was magnified (Table 2). Pairwise comparisons (data not shown) showed that there were fewer differences in nutrient intakes between dieters and nondieters among nonvegetarians than among vegetarians, and the differences among vegetarians were greater than among nonvegetarians. The HEI score for nondieting vegetarians was higher than for the nonvegetarians, with vegetarians having a greater number of significantly better scores for individual components than the nonvegetarians (Table 4).

DISCUSSION

The data presented in this study show that the lacto-ovo vegetarian dietary pattern is more nutrient dense than that of the nonvegetarians. Kilocalorie for kilocalorie, the vegetarians had higher intakes of fiber, vitamins A, C, and E, thiamin, riboflavin, folate, calcium, magnesium, iron, and potassium than nonvegetarians. Along with higher fiber intakes, the lower total fat, saturated fat, and cholesterol intakes for vegetarians in this study are consistent with current dietary guidelines, and this was also seen in two analyses of Continuing Survey of Food Intakes by Individuals 1994-1996 data (1,9).

Adjusted mean intakes for all vegetarians in the present study suggest that they did not have an increased risk for lower nutrient intakes when compared to all nonvegetarians. Indeed, the vegetarians had higher mean intakes of many nutrients than did nonvegetarians. Fiber, vitamins A, C, and E, calcium, magnesium, and potassium have been identified as nutrients of concern for the general population (13), and the vegetarians in our study had higher mean intakes of all of these nutrients than nonvegetarians. The higher mean calcium intake of the vegetarians was not surprising because this was a lacto-ovo vegetarian dietary pattern, and the vegetarians had

Table 3. Adjusted mean food group intakes for vegetarians, nonvegetarians, and dieters aged 19 years and older participating in the National Health and Nutrition Examination Survey 1999-2004

	All (N=13,292)		Dieters (n=4,635)		Nondieters (n=8,657)	
Food group	**Vegetarian (n=851)**	**Nonvegetarian (n=12,441)**	**Vegetarian (n=419)**	**Nonvegetarian (n=4,216)**	**Vegetarian (n=432)**	**Nonvegetarian (n=8,225)**
	← *mean[a] intake± standard error* →					
Total grain (oz)	7.84±0.14	6.72±0.05**	7.17±0.19	6.52±0.09**	8.3±0.18	6.82±0.05**
Non-whole grain	6.64±0.14	6.11±0.05**	6.35±0.18	6.01±0.08	6.84±0.18	6.16±0.05**
Whole grain	1.2±0.07	0.61±0.02**	0.82±0.09	0.51±0.03**	1.46±0.09	0.66±0.02**
Fruit (c)	1.32±0.08	0.99±0.03**	0.9±0.1	0.84±0.04	1.61±0.1	1.06±0.03**
Vegetables (c)	1.58±0.08	1.62±0.02	1.41±0.1	1.52±0.03	1.68±0.08	1.67±0.02
Dark-green vegetables	0.15±0.02	0.11±0.01**	0.11±0.02	0.1±0.01	0.18±0.02	0.11±0.01**
Orange vegetables	0.08±0.01	0.08±0	0.05±0.01	0.06±0	0.1±0.02	0.09±0
Potatoes	0.25±0.02	0.41±0.01**	0.3±0.04	0.39±0.01	0.21±0.02	0.42±0.01**
Meat, poultry, fish (oz)	0.82±0.08	5.12±0.05**	1.83±0.11	5.14±0.08**	0.06±0.09	5.11±0.07**
Eggs (oz)	0.5±0.04	0.47±0.01	0.41±0.06	0.45±0.02	0.57±0.05	0.47±0.01
Legumes (c)	0.22±0.03	0.11±0**	0.17±0.02	0.11±0.01**	0.27±0.04	0.11±0.01**
Soy (oz)	0.33±0.06	0.05±0**	0.29±0.1	0.04±0.01	0.36±0.07	0.05±0.01**
Nuts (oz)	0.89±0.09	0.54±0.02**	0.74±0.08	0.54±0.06**	1.01±0.14	0.54±0.03**
Total dairy (c)	1.98±0.07	1.52±0.02**	1.82±0.13	1.57±0.04	2.12±0.12	1.5±0.03**
Milk	1.15±0.07	0.87±0.02**	0.93±0.09	0.83±0.03	1.32±0.1	0.88±0.02**
Cheese	0.79±0.04	0.62±0.01**	0.86±0.06	0.71±0.03**	0.75±0.06	0.58±0.01
Added sugar (tsp)	24.11±0.82	22.1±0.38	26.1±1	23.13±0.58**	22.82±1.27	21.62±0.41
Discretionary fat (g)	44.88±0.91	48.12±0.34**	47.73±1.05	48.37±0.57	42.77±1.3	48.01±0.34**
Discretionary oil (g)	18.77±0.74	17.93±0.25	18.62±0.83	17.37±0.51	18.76±1.24	18.19±0.29

[a]Adjusted for energy, sex, and ethnicity.
**$P<0.01$ within vegetarian and nonvegetarian comparisons.

Table 4. Healthy Eating Index scores for vegetarians, nonvegetarians, and dieters aged 19 years and older, National Health and Nutriton Examination Survey 1999-2004

		All (N=13,292)		Dieters (n=4,635)		Nondieters (n=8,657)	
Component	**Maximum score**	**Vegetarian (n=851)**	**Nonvegetarian (n=12,441)**	**Vegetarian (n=419)**	**Nonvegetarian (n=4,216)**	**Vegetarian (n=432)**	**Nonvegetarian (n=8,225)**
		← *score± standard error* →					
Total fruit	5	2.44±0.11	2.11±0.05**	1.81±0.13	1.84±0.06	2.87±0.12	2.24±0.05**
Whole fruit	5	2.16±0.13	1.87±0.05	1.48±0.15	1.6±0.07	2.62±0.15	2±0.05**
Total vegetable	5	2.74±0.1	3.04±0.03**	2.43±0.16	2.92±0.05**	2.95±0.09	3.1±0.03
Dark-green and orange vegetables	5	1.22±0.09	1.18±0.03	0.87±0.11	1.04±0.05	1.46±0.12	1.24±0.04
Total grain	5	4.28±0.06	4.15±0.02	3.97±0.11	4.05±0.03	4.5±0.06	4.2±0.02**
Whole grain	5	1.55±0.09	0.92±0.02**	1.15±0.13	0.82±0.04**	1.83±0.1	0.97±0.03**
Milk products and soy beverages	10	5.66±0.16	4.68±0.06**	5.16±0.28	4.66±0.08	6.04±0.21	4.69±0.07**
Meat and beans	10	3.66±0.2	8.46±0.04**	2.91±0.28	8.45±0.06**	4.24±0.24	8.47±0.05**
Oils	10	5.15±0.17	5.33±0.05	4.87±0.26	5.1±0.09	5.32±0.06	5.44±0.06
Saturated fat	10	6.79±0.14	5.89±0.06**	6.64±0.21	5.86±0.08**	6.89±0.18	5.91±0.06**
Sodium	10	5.57±0.12	4.11±0.05**	5.84±0.24	3.99±0.09**	5.34±0.16	4.16±0.06**
Solid fat, alcohol, and added sugar	20	8.62±0.32	8.37±0.14	7.56±0.48	8.6±0.23	9.48±0.37	8.26±0.14**
Total score	100	50.5±0.88	50.1±0.33	47.3±1.27	51±0.47**	53±0.91	49.7±0.34**

**$P<0.01$ within vegetarian and nonvegetarian comparisons.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

higher total dairy consumption than the nonvegetarians. As such, consumption of dairy products may have been the primary source of calcium, but the vegetarians also had higher intakes of alternative sources of calcium, including dark-green vegetables, nuts, legumes, and soy.

As observed in previous studies (1,2,9,10,12,21), protein intake was lower for vegetarians than for nonvegetarians. The low HEI score for meat and bean intake for the vegetarians compared to the score for the nonvegetarians suggests substandard intake of protein for the vegetarians; however, the adjusted mean intake of protein by the vegetarians was not lower than recommended amounts for adults (18). Perhaps an alternative HEI is needed to more accurately assess diet quality for vegetarians with respect to protein sources. Plant protein sources (soy, nuts, and legumes) were higher in the vegetarian diet than the nonvegetarian diet, and it has been suggested that protein requirements are higher for vegetarians due to the lower digestibility of plant proteins. However, according to the Food and Nutrition Board of the IOM, this has not been supported by available evidence (18). Nevertheless, approximately one more ounce equivalent of beans, tofu, nuts, seeds or eggs per 1,000 calories would improve the vegetarians' score to be comparable to that of nonvegetarians for this component of the HEI. Furthermore, the addition of 1.5- to 2-oz equivalents per 1,000 kcal would improve the vegetarians' score to the maximum 10 points. One ounce equivalent of beans or tofu is ½ cup, one egg equals 1 oz equivalent, and 1 oz of nuts and seeds equals 1 oz equivalent in the meat and bean category.

Other nutrients often thought to be of concern for vegetarians are iron, vitamin B-12, and zinc. Intake of vitamin B-12 by lacto-ovo vegetarians is generally not below recommendations, and this was the case in our study as well as in previous work (9,10,12). Population-based studies (9,10) have shown higher intakes of iron for vegetarians compared to nonvegetarians, and similar results were seen in our analysis. However, absorption of iron can be compromised by other constituents of a vegetarian diet, so the IOM has recommended that vegetarians increase iron intake by 80% of the DRI (22). A common practice used by vegetarians to enhance absorption of iron is to consume vitamin C–containing fruits and vegetables, and the nondieting vegetarians in our study had mean intakes of more than 3 c of fruit and vegetables per day.

Energy balance has been shown to be a major determinant of weight loss (23-25), and American Dietetic Association evidence analysis supports a reduction of 500 to 1,000 kcal/day as the basis of dietary recommendations for weight management (24). Population-based studies have shown that vegetarians have energy intakes that are as much as 464 kcal lower than nonvegetarians (1,2,10). This, taken with data showing that, on average, BMIs for vegetarians are 1.4 lower than nonvegetarians (1-4), suggests that a vegetarian diet could be considered a version of a low-energy weight management diet. Our study also supports this assumption, showing that all vegetarians consumed 363 fewer kilocalories than do all nonvegetarians, and the mean BMI for all vegetarians was 1.4 lower than the mean for all nonvegetarians.

To observe the effect of a 500-kcal deficit on nutrient density, subjects who had energy intakes that were at least 500 kcal less than their estimated energy requirements were separated from the vegetarian and nonvegetarian groups and identified as dieters. Although food and nutrient intake patterns were similar across all three comparisons, there were fewer significant differences between the two dieting groups. This suggests that the vegetarian dietary pattern affected nutrient density more than did energy intake. When "dieting," the vegetarians still had higher intakes of vitamins A, C, and E, folate, magnesium, and iron, although the differences were no longer significant. To the contrary, diet quality as measured by the HEI was significantly lower for the dieting vegetarians compared to the dieting nonvegetarians. The dieting vegetarians scored better only for the whole-grain, saturated fat, and sodium components of the HEI. It may be that many of the vegetarians who were identified as dieters were new to this eating pattern, and needed assistance in making nutrient-dense food choices. This could also explain the high BMI for the dieting vegetarians. Long-term vegetarians (more than 5 years) are more likely to have lower BMIs than those who are relatively new to this dietary pattern (26).

Although our study did not examine the relationship between BMI and vegetarian eating patterns, the data showed that BMIs were lower for vegetarians across the range of energy intakes. Previous population-based studies have shown that lower mean BMIs for vegetarians compared to nonvegetarians are associated with characteristics of the vegetarian diet at typical rather than reduced energy intakes (2,4). Given this, in addition to the observed decrease in diet quality for the dieting vegetarians, it is suggested that practitioners should recommend vegetarian diets for weight management without further reductions in energy intake.

Strengths of this study include the large sample size, based on recent, nationally representative data of adults in the United States, which allows for statistically reliable estimates of dietary intakes. One limitation of this study was the analysis of only 1-day food intake, and because of this, the data cannot be used to assess adequacy of the diets. Further analysis of current data is needed to determine usual dietary intakes and nutritional adequacy of vegetarian diets. A second limitation of this study was the definition used for the vegetarian group. It is often difficult to characterize the nutrient content of vegetarian diets due to some ambiguity in the definition of "vegetarian." Dietary patterns of self-defined vegetarians may range from those who eat reduced amounts of red meat, to those who only eat chicken or fish, to those who exclude all animal foods (9,12). The definition of vegetarians used in this study—those who did not eat meat, poultry, or fish on the day of the survey—is supported by the energy intake and BMI differences which are consistent with previous analyses comparing vegetarians with nonvegetarians (1-4,9,10). In addition, food group intake data showing higher consumption of legumes and soy agree with work by Haddad and Tanzman (9), which reported higher intakes of these foods by self-defined vegetarians who did not eat meat.

CONCLUSIONS

This research contributes toward a better understanding of dietary intake quality for vegetarians, nonvegetarians, and dieters. Further, it supports previous work (9,10,12) showing that the nutrient intake pattern for a vegetarian diet is

consistent with current dietary guidelines. Because our study analyzes only 1 day of food intake, these data cannot be used to assess dietary adequacy; rather, they can only be used to compare nutrient intakes and diet quality for vegetarians, nonvegetarians, and dieters. Whereas further research is needed to characterize dietary intakes of self-defined vegetarians who consume no meat, poultry, or fish, our study suggests that a vegetarian diet is more nutrient dense than a nonvegetarian diet, and that nutrients of concern were similar for both groups. Although vegetarians in this study had higher intakes of vitamins E and A, calcium, magnesium, and fiber than nonvegetarians, improvements are necessary for both vegetarians and nonvegetarians. It may be necessary for vegetarians to be more aware of zinc intake, and food and nutrition practitioners should assist vegetarians, particularly those who are new to this eating pattern, in planning menus that incorporate good sources of zinc, such as legumes, seeds, and fortified foods. A modified food guide pyramid for lacto-vegetarians and vegans (27) and a food guide for North American vegetarians (28) have been developed, with specific recommendations for optimizing intake of zinc and also vitamin B-12, iron, calcium, and vitamin D. There may be a critical point at which decreasing the energy level of a vegetarian diet would result in poor diet quality and nutrient intakes below recommendations; however, this eating pattern may be a way to maintain a nutrient dense diet while decreasing energy intake enough to maintain a healthy weight.

STATEMENT OF POTENTIAL CONFLICT OF INTEREST: Bonnie Farmer, MS, RD, is a member of the Vegetarian Nutrition Dietetics Practice Group of the American Dietetic Association.

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