American Journal of Epidemiology
Vol. 161, No. 3
Printed in U.S.A.
DOI: 10.1093/aje/kwi039

Dietary Patterns and the Incidence of Type 2 Diabetes

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Received for publication March 26, 2004; accepted for publication July 15, 2004.

Major dietary patterns were studied for the ability to predict type 2 diabetes mellitus in a cohort of 4,304 Finnish men and women aged 40–69 years and free of diabetes at baseline in 1967–1972. Factor analysis was used to identify dietary patterns from dietary data that were collected using a 1-year dietary history interview. A total of 383 incident cases of type 2 diabetes occurred during a 23-year follow-up. Two major dietary patterns were identified. The pattern labeled "prudent" was characterized by higher consumption of fruits and vegetables, and the pattern labeled "conservative" was characterized by consumption of butter, potatoes, and whole milk. The relative risks (adjusted for nondietary confounders) between the extreme quartiles of the pattern scores were 0.72 (95% confidence interval: 0.53, 0.97; $p_{trend} = 0.03$) for the prudent pattern and 1.49 (95% confidence interval: 1.11, 2.00; $p_{trend} = 0.01$) for the conservative pattern. Thus, the prudent dietary pattern score was associated with a reduced risk and the conservative pattern score was associated with an increased risk of type 2 diabetes. In light of these results, it appears conceivable that the risk of developing type 2 diabetes can be reduced by changing dietary patterns.

diabetes mellitus, type 2; diet; food habits; prospective studies

Abbreviation: CI, confidence interval.

The main interest in the link between dietary factors and risk of type 2 diabetes has been focused on individual nutrients or food items (1). However, this approach is apparently confounded by the effect of dietary patterns (2). Instead of isolated nutrients, people eat meals mixing different foods, giving several nutrients a chance to interact. These interactions between nutrients may potentially confound dietary studies. Multicollinearity between nutrients has also made it extremely difficult to separate the effect of individual nutrients in observational dietary studies. The effect of the overall diet beyond that of single foods and nutrients can be studied with dietary pattern analyses.

Analysis of food consumption patterns has become a common tool for studying the associations between diet and health. Three main approaches have been used to define dietary patterns: factor analysis, cluster analysis, and dietary indices (3). Factor analysis and cluster analysis are the predominant a posteriori methods. Both are used in identifying the major dietary patterns independently of their relevance to disease, whereas the a priori approach is used to describe the ideal diet for disease prevention based on available evidence of the disease.

A pattern characterized by higher intake of fruits and vegetables (prudent pattern) and a pattern characterized by higher intake of foods typical of Western diets (Western pattern) were similarly observed in previous a posteriori analyses (4–11).

Despite the growing interest in the relations between dietary patterns and disease, data on the ability of dietary patterns to predict the occurrence of type 2 diabetes are still sparse. A Western dietary pattern predicted an increased and a prudent pattern predicted a reduced risk of type 2 diabetes in a large prospective study of male health professionals (12). Prospective studies among women are still lacking. We studied whether the patterns observed in a large cohort of

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TABLE 1. Food grouping used in dietary pattern analyses, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up

Food group	Food items
Processed meat	Processed meats, salted meat, sausages, bacon
Red meat	Beef, pork, lamb, game, offal
Poultry	Chicken
Fish, canned or frozen	Canned tuna, canned sardines, and dried or frozen fish
Fish, salted or smoked	Smoked or salted sea and lake fish
Fish, unprocessed	Other than smoked or salted fish, shellfish
Eggs	Eggs
Butter	Butter
Margarine and oil	Margarines and oils
Whole milk	Whole milk
Regular dairy products	Cheese, cream, ice cream, yogurt
Reduced-fat dairy products	Skim or low-fat milk, low-fat cheese
Fruit	Pineapples, citrus fruit, peaches, grapes and raisins, bananas, plums, pears, cherries, and fruit juice
Berries	Cranberries, gooseberries, strawberries, black currants, red currants, lingonberries, cloudberries, raspberries
Yellow and red vegetables	Carrots, tomatoes, tomato sauce, paprika, mixed vegetables, and vegetable juice
Green vegetables	Cucumbers, lettuce, spinach, parsley, cultivated leeks, onions, celery
Vegetables, other	Rutabagas, artichokes, swedes, radishes, celery root, cauliflowers, kohlrabies, pickled vegetables, and mushrooms
Peas and nuts	Peanuts, hazelnuts, almonds, peas, beans, and soy flour
Potatoes	Potatoes
Rye	Rye bread, rye crisp, rye flour
Wheat	Wheat flour, white bread, buns, pasta, grits
Grain other than rye or wheat	Rice, rolled oats, barley groats, millet grains, buckwheat groats, and flour
Jams and sugar-rich condiments	Sweetened jams, marmalade, sugar, honey, cocoa

Finnish men and women had a predictive value for type 2 diabetes risk.

MATERIALS AND METHODS

The Finnish Mobile Clinic Health Examination Survey carried out health examinations in various regions of Finland during 1966–1972. Selection and characteristics of the population examined were described previously (13–15). A dietary history interview of 10,054 citizens, 15 years of age or more, was included in the study in 1967 (16). The study population comprised 4,344 men and women, after including only individuals 40–69 years of age who were free of diabetes. After exclusion of those who reported a daily energy intake of less than 800 kcal or more than 6,000 kcal or those who were pregnant, the final study population comprised 4,304 persons.

A questionnaire yielded information on occupational group, current pregnancy, babies born with birth weight over 4,500 g, family history of diabetes, previous and current illnesses, consumption of medicines, and health-related habits, such as smoking (15). Occupation was grouped into nine categories according to the Nordic Standard Classification of Occupations (17). Body weight and height were measured, and body mass index was calculated (kg/m^2). Casual blood pressure was measured with the auscultatory method. Four hypertension categories were formed based on systolic blood pressure, diastolic blood pressure, and antihypertensive medication (15). Persons with systolic blood pressure of 170 mmHg or more and diastolic blood pressure of 100 mmHg or more and persons using antihypertensive medication were considered definitely hypertensive. Persons with systolic blood pressure of 160 mmHg or more and diastolic blood pressure of 95 mmHg or more but not defined as hypertensive were considered to have mild hypertension, and those with systolic blood pressure of less than 140 mmHg and diastolic blood pressure of less than 90 mmHg were considered normotensive. All persons with intermediate values were considered to have borderline hypertension. The serum cholesterol concentration was determined with an autoanalyzer modification of the Liebermann-Burchard reaction (18). Known cases of diabetes were identified by information given by the participants. A glucose tolerance test was carried out to diagnose new diabetes at baseline, using diagnostic criteria of the World Health Organization (19). Previously known or new persons with diabetes at baseline were excluded from the analyses.

Total habitual food consumption during the previous year was estimated using a dietary history interview (16). Trained interviewers used a questionnaire listing over 100 food items and mixed dishes common to the Finnish diet. Consumption of foods was estimated per day, week, month, or year according to the choice of the respondent. Individual consumption of food items was converted to grams per day. The food items were grouped into 23 food groups based on nutrient profile and culinary use of the item (table 1). Short- and long-term reproducibility of the food consumption data has been reported previously (20). The intraclass correlation coefficients for short-term repeatability were 0.63 for vegetables, 0.55 for fruits and berries, 0.68 for milk products, and 0.72 for meat products. The corresponding long-term repeatability coefficients for 4–7 years were 0.47 for vegetables, 0.39 for fruits and berries, 0.54 for milk products, and 0.47 for meat products.

To identify dietary patterns, we applied the principal component method with Varimax rotation in the factor analysis and used SAS software for the analyses (21, 22). We labeled two factors with eigenvalues of greater than 2.5 as the "prudent" pattern and the "conservative" pattern and discarded other factors with eigenvalues of less than 1.5 on the basis of the results of a scree test and interpretability of the factors (23). The factor-loading matrix for these two retained dietary patterns is shown in table 2. The factor score for each pattern was computed by summing the observed variables multiplied with their factor loadings. These scores were used to rank participants according to the degree to which they conformed to each dietary pattern.

During a 23-year follow-up, a total of 164 male and 219 female incident cases were identified from a nationwide registry of patients receiving drug reimbursement, which is maintained by the Social Insurance Institution (14). Participants in the present study were linked to this register by unique Social Security codes assigned to each Finnish citizen.

Nutrient intakes as well as dietary pattern scores were adjusted for total energy (12) using the residual method described by Willett and Stampfer (24). Relative risks of type 2 diabetes with 95 percent confidence intervals between quartiles of scores were calculated using Cox's model (25). Potential confounding and effect-modifying factors were entered into the model. Tests for trends based on the likelihood ratio test, including variables as continuous variables in the model, were carried out.

RESULTS

The factor we labeled as the prudent dietary pattern was characterized by consumption of fruits and vegetables, whereas the factor labeled as the conservative dietary pattern was characterized by consumption of butter, potatoes, and whole milk (table 2). Baseline characteristics of the study sample according to categories of dietary pattern scores are presented in table 3. Persons having higher prudent dietary pattern scores were less likely to be men or smokers, whereas persons with higher conservative dietary pattern scores were more likely to be men or current smokers. Higher intakes of polyunsaturated fat, vitamin E, and beta-carotene were associated with higher prudent pattern scores and lower conservative pattern scores. The prudent pattern was inversely associated with intake of saturated fat. Of the food items, processed meat and canned or frozen fish, poultry, margarine and oil, regular and reduced-fat dairy products, fruits and berries, and vegetables were directly associated with prudent pattern scores but not with conservative pattern scores. Higher conservative pattern scores were directly associated and prudent pattern scores inversely associated with higher intakes of butter and potatoes.

TABLE 2. Factor-loading matrix for the major dietary patterns identified, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up

Foods or food groups	Correlation coefficient	
	Prudent pattern	Conservative pattern
Butter	—*	0.68
Potatoes	—	0.66
Whole milk	–0.30	0.59
Red meat	0.32	0.56
Jams and sugar-rich condiments	—	0.49
Rye	—	0.45
Processed meat	—	0.43
Grain other than rye or wheat	—	0.43
Wheat	—	0.39
Peas and nuts	0.23	0.30
Fish, salted or smoked	—	0.31
Fish, unprocessed	—	0.31
Yellow and red vegetables	0.64	—
Green vegetables	0.63	—
Fruit	0.62	—
Vegetables, other†	0.57	—
Poultry	0.35	—
Eggs	0.34	0.32
Regular dairy products	0.26	—
Berries	0.28	—
Margarine and oil	0.26	—
Reduced-fat dairy products	0.26	—
Fish, canned or frozen	0.22	—

* —, loadings with absolute values of less than 0.20.
† Vegetables other than green, yellow, or red.

During the 23-year follow-up, higher prudent pattern scores predicted a lower risk of type 2 diabetes while, in contrast, higher conservative pattern scores predicted an increased diabetes risk (table 4). When the highest and lowest quartiles of the prudent pattern scores were compared, the relative risk of type 2 diabetes was 0.72 (95 percent confidence interval (CI): 0.53, 0.97; $p_{trend} = 0.03$), after adjustment for age, sex, body mass index, energy intake, smoking, family history of diabetes, geographic area, serum cholesterol, and hypertension. The corresponding value between extreme categories of conservative pattern scores was 1.49 (95 percent CI: 1.11, 2.00; $p_{trend} = 0.01$).

To study the potential interaction between dietary patterns, we cross-tabulated the pattern scores and compared the rela-

TABLE 3. Mean values and baseline characteristics according to quartile of energy-adjusted dietary pattern scores, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up

Variable	Prudent dietary pattern quartile				Conservative dietary pattern quartile			
	1 (lowest)	2	3	4 (highest)	1 (lowest)	2	3	4 (highest)
Sex, %*	66.4	53.5	46.4	46.1	44.2	49.9	55.5	62.7
Age, years	52.8 (8.2)†	52.7 (8.1)	51.4 (7.9)	50.7 (7.7)	51.3 (7.9)	52.0 (8.2)	51.9 (7.9)	52.4 (8.1)
Family history of diabetes, %‡	19.1	18.5	20.1	22.1	19.5	20.7	19.3	20.2
Current smokers, %	39.3	31.0	28.9	30.9	25.7	27.8	36.7	39.9
Hypertension, %§	13.5	17.6	18.0	17.4	19.0	16.9	15.8	14.8
Serum cholesterol, mmol/liter	6.9 (1.4)	7.0 (1.5)	7.1 (1.4)	7.1 (1.4)	7.0 (1.4)	7.0 (1.4)	7.0 (1.4)	7.1 (1.5)
Body mass index, kg/m^2	26.0 (4.0)	26.5 (4.0)	26.7 (4.0)	26.8 (4.0)	26.6 (4.1)	26.5 (3.9)	26.5 (4.0)	26.3 (4.0)
Energy-adjusted nutrient intakes, g/day								
Energy¶	2,596 (810)	2,386 (799)	2,448 (831)	2,545 (944)	2,533 (612)	2,418 (660)	2,450 (819)	2,573 (1,187)
Carbohydrates	299 (55.6)	288 (55.4)	284 (55.2)	277 (56.2)	285 (59.6)	287 (56.2)	287 (53.8)	288 (55.0)
Proteins	87.3 (17.6)	87.7 (19.7)	90.4 (20.5)	98.5 (23.9)	86.1 (19.0)	88.1 (18.5)	91.5 (19.6)	98.1 (24.5)
Saturated fats	67.2 (16.4)	61.7 (15.7)	57.0 (14.9)	53.5 (14.7)	56.3 (15.7)	59.5 (15.4)	61.4 (16.7)	62.2 (16.6)
Monounsaturated fats	34.3 (8.2)	33.7 (8.7)	32.8 (8.8)	33.9 (9.3)	32.3 (8.1)	33.1 (8.5)	34.0 (8.6)	35.3 (9.5)
Polyunsaturated fats	6.3 (1.8)	6.7 (2.6)	7.3 (3.4)	9.2 (5.4)	8.0 (5.3)	7.0 (3.1)	7.1 (2.9)	7.3 (2.9)
trans-Fatty acids	2.2 (0.63)	2.2 (0.82)	2.1 (1.04)	2.4 (1.5)	2.5 (1.4)	2.2 (0.92)	2.2 (0.88)	2.0 (0.77)
Vitamin E#	5.7 (1.1)	6.2 (1.6)	6.9 (2.0)	8.5 (3.4)	7.4 (3.4)	6.5 (1.9)	6.5 (1.9)	6.9 (2.0)
Vitamin C#	48.9 (15.4)	60.3 (19.2)	76.9 (23.2)	108 (46.2)	81.6 (43.7)	70.7 (33.3)	68.8 (31.3)	72.8 (33.9)
Beta-carotene**	872 (691)	1,261 (1,053)	1,917 (1,660)	3,290 (3,156)	2,307 (2,854)	1,708 (1,698)	1,638 (1,696)	1,687 (1,866)
Folic acid**	200 (42.1)	205 (46.6)	222 (43.7)	261 (56.8)	223 (54.2)	217 (48.7)	221 (53.5)	226 (56.3)
Fiber	26.2 (8.8)	26.6 (8.4)	27.9 (8.4)	29.3 (8.8)	26.6 (8.8)	27.3 (8.4)	27.5 (8.4)	28.7 (9.0)
Food intakes, g/day								
Processed meat and red meat	103 (68.6)	118 (75.6)	136 (90.7)	170 (113)	122 (74.0)	122 (72.6)	127 (78.9)	156 (127)
Processed meat	42.4 (43.6)	47.9 (48.1)	52.9 (53.2)	65.5 (64.2)	53.4 (49.4)	50.7 (47.6)	49.4 (46.3)	55.2 (67.9)
Red meat	60.3 (46.2)	70.1 (50.8)	82.8 (61.6)	104.6 (74.1)	68.4 (44.5)	71.7 (46.5)	77.4 (52.6)	100 (87.0)
Fish, all	26.7 (30.3)	30.7 (33.5)	39.3 (41.6)	50.5 (60.2)	25.9 (24.2)	27.7 (24.4)	34.5 (31.8)	59.2 (69.5)
Fish, smoked or salted	11.0 (17.9)	14.1 (24.4)	16.6 (25.8)	21.1 (36.8)	10.0 (13.6)	11.5 (15.2)	14.5 (18.1)	26.7 (45.5)

Table continues

tive risks across the categories. We noted that the association between a conservative pattern score and risk of type 2 diabetes was higher than that among persons with a lower prudent pattern score (figure 1). On the other hand, a higher prudent pattern score did not predict reduced diabetes risk among persons with low conservative pattern scores. However, the interaction term was not significant ($p_{interaction}$ = 0.38).

In additional analyses, we included occupational group in the model to study whether sociodemographic factors could explain the associations found between the prudent pattern and diabetes risk. The relative risk of 0.73 (95 percent CI: 0.53, 1.01; p_{trend} = 0.05) indicated no notable effect on the results. We also included dietary fiber, vitamin E, vitamin C, beta-carotene, and folic acid individually in the model. The relative risks were 0.76 (95 percent CI: 0.55, 1.04; p_{trend} = 0.07), 0.85 (95 percent CI: 0.61, 1.20; p_{trend} = 0.30), 0.76 (95 percent CI: 0.52, 1.11; p_{trend} = 0.13), 0.75 (95 percent CI: 0.54, 1.05; p_{trend} = 0.08), and 0.79 (95 percent CI: 0.55, 1.13; p_{trend} = 0.17), respectively. In the final model containing fiber, vitamin E, vitamin C, beta-carotene, and folic acid in the same model, the relative risk for type 2 diabetes was 0.93 (95 percent CI: 0.61, 1.42; p_{trend} = 0.63).

To shed light on the possible modifying effect of potential interacting variables, we also analyzed categories pertaining to age, sex, body mass index, and smoking (table 5). Although no significant interactions were found, we noted that the prudent pattern scores were associated with a lower risk of type 2 diabetes among older persons, women, persons with higher body mass index, and nonsmokers. Among these subgroups, higher conservative pattern scores predicted an increased risk of type 2 diabetes.

DISCUSSION

In the present study, we identified two major dietary patterns in a large cohort of Finns. The prudent dietary pattern, which was rich in fruits and vegetables, was associated with a reduced risk of type 2 diabetes. In contrast, the conservative pattern, which was rich in butter, potatoes, red meat, and whole milk, was associated with a higher risk of type 2 diabetes. The findings appeared to be more

TABLE 3. Continued

Variable	Prudent dietary pattern quartile				Conservative dietary pattern quartile			
	1 (lowest)	2	3	4 (highest)	1 (lowest)	2	3	4 (highest)
Fish, canned or frozen	0.24 (1.5)	0.55 (2.4)	1.0 (3.5)	2.4 (7.7)	1.5 (5.5)	1.2 (4.6)	0.93 (4.3)	0.67 (3.6)
Fish, unprocessed	11.4 (19.6)	12.5 (18.1)	17.8 (27.1)	23.2 (36.7)	11.4 (15.3)	11.5 (14.4)	15.0 (20.5)	27.1 (43.1)
Poultry	0.28 (1.9)	0.66 (2.5)	1.8 (5.3)	7.5 (17.4)	4.3 (14.5)	2.2 (7.4)	2.0 (6.6)	1.9 (7.9)
Eggs	21.3 (20.3)	26.4 (24.9)	32.8 (27.3)	41.4 (35.4)	29.2 (23.6)	27.9 (22.5)	29.2 (25.1)	35.5 (39.0)
Butter	56.2 (31.5)	45.9 (25.8)	44.2 (27.9)	38.1 (26.0)	37.5 (21.8)	44.4 (23.5)	49.2 (2.7)	53.4 (35.1)
Margarine and oil	3.5 (5.0)	5.0 (8.4)	6.7 (10.4)	11.5 (17.0)	11.6 (16.6)	6.1 (9.2)	4.9 (8.1)	4.1 (8.3)
Milk products	1,000 (455)	848 (428)	815 (397)	790 (432)	879 (409)	851 (371)	884 (428)	840 (522)
Whole milk	892 (447)	659 (410)	571 (378)	444 (364)	597 (418)	648 (384)	674 (430)	647 (491)
Regular dairy products	106 (151)	187 (208)	237 (234)	288 (297)	228 (238)	194 (214)	206 (244)	190 (253)
Reduced-fat dairy products	0.96 (14.6)	2.1 (29.1)	7.4 (61.4)	58.3 (186)	52.9 (185)	8.7 (58.1)	4.3 (39.4)	3.0 (29.8)
Fruit and berries	40.5 (40.6)	78.6 (60.1)	124 (85.6)	209 (151)	165 (147)	113 (101)	86.9 (82.8)	85.6 (89.2)
Fruit	30.5 (38.0)	65.2 (57.5)	106 (82.2)	185 (143)	149 (141)	98.2 (93.6)	71.7 (76.8)	67.9 (80.4)
Berries	9.9 (11.3)	13.4 (15.2)	17.5 (19.7)	23.9 (29.8)	16.7 (19.3)	15.1 (18.4)	15.2 (19.7)	17.7 (25.3)
Vegetables, all	33.7 (26.5)	65.4 (34.7)	103 (43.3)	180 (85.4)	118 (89.2)	91.3 (66.1)	87.7 (68.2)	86.0 (73.9)
Vegetables, yellow and red	19.9 (20.0)	38.7 (29.4)	60.5 (38.0)	103 (66.5)	72.4 (64.3)	53.4 (44.5)	49.2 (46.3)	46.7 (47.6)
Vegetables, green	11.5 (12.0)	22.0 (17.2)	34.8 (22.7)	57.6 (39.9)	34.3 (30.0)	29.6 (27.6)	30.5 (30.4)	31.5 (33.8)
Peas and nuts	4.3 (4.7)	5.6 (5.5)	6.3 (6.5)	7.9 (10.2)	4.9 (4.9)	5.5 (5.4)	6.0 (5.5)	7.7 (10.9)
Vegetables, other	2.3 (3.7)	4.8 (6.0)	8.1 (9.2)	20.2 (23.1)	11.2 (18.7)	8.2 (13.2)	8.0 (12.4)	7.8 (13.3)
Potatoes	252 (137)	215 (117)	217 (120)	198 (124)	161 (76.2)	195 (92.9)	235 (109)	293 (167)
Grains	301 (137)	264 (119)	266 (117)	258 (140)	280 (123)	272 (120)	270 (123)	267 (152)
Rye	124 (106)	126 (94.8)	133 (93.5)	135 (110)	121 (96.0)	129 (94.1)	129 (97.5)	139 (115)
Wheat	153 (118)	117 (87.8)	111 (76.9)	102 (75.3)	141 (99.1)	123 (85.4)	118 (92.3)	101 (91.7)
Grain other than rye or wheat	24.3 (20.1)	21.4 (18.0)	21.4 (17.5)	20.9 (21.0)	17.7 (12.6)	20.7 (15.1)	22.6 (16.7)	27.0 (27.8)
Jams and sugar-rich condiments	57.4 (34.6)	54.1 (33.2)	55.3 (36.4)	52.0 (40.3)	52.3 (30.4)	53.8 (31.4)	55.1 (35.1)	57.6 (45.9)

* Proportion of men.
† Numbers in parentheses, standard deviation.
‡ Proportion of persons having first-degree relatives with diabetes.
§ Proportion of persons with mild or definite hypertension.
¶ kcal/day, not adjusted for energy.
# mg/day.
** μg/day.

pronounced among older persons, women, nonsmokers, and individuals with a relatively high body mass index, although none of the interaction terms was significant.

The findings corroborate the previously reported results of the Health Professionals Follow-up Study (12). In that study, the Western dietary pattern (rich in processed meats, high-fat dairy products, french fries, and refined grains) was associated with an increased risk of type 2 diabetes, whereas the prudent dietary pattern (rich in vegetables, fruits, fish, poultry, and whole grains) was associated with a reduced risk. In a British cross-sectional study, a dietary pattern characterized by a high consumption of fruits and vegetables and a low consumption of processed meat and fried foods was inversely associated with type 2 diabetes risk (26). A pattern characterized by higher intakes of french fries, chocolate, cake, canned meat, and canned fruit was associated with a higher prevalence of type 2 diabetes in a Canadian cross-sectional study (27). A pattern identified by cluster analysis, including higher intakes of cheese, fatty meat, and cake, was associated with a higher risk of hyperglycemia among men in the European Prospective Investigation into Cancer–Malmö Study (28). The Western dietary pattern was reported to be associated with plasma insulin level and C-peptide level, biomarkers of developing type 2 diabetes (29). An a priori-formed pattern score based on the intake of cereal fiber, polyunsaturated fat, *trans*-fatty acids, and postprandial glycemic load was related to development of diabetes risk during a 16-year follow-up in the Nurses' Health Study (30). A few dietary interventions have demonstrated a considerably lower risk of diabetes among the intervention group prescribed a healthy diet and exercise (31–33).

In contrast to the study of individual nutrients or foods, dietary pattern analysis also considers the overall diet, reflecting more closely the real world. Complicated interactions among nutrients that occur together in common foods can be accounted for here. Our finding on the relation between the dietary pattern reflecting vegetable and fruit intake and diabetes risk is in line with results of previous studies, which have shown an inverse association between consumption of fruits and vegetables and the risk of type 2 diabetes (34–36), although controversial results have also been shown (37). The preventive effects of fruits and vegeta-

TABLE 4. Relative risks* of type 2 diabetes among quartiles of dietary pattern scores, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up

Variable	Quartile of energy-adjusted pattern score							p_{trend}
	1 (lowest) (referent)	2		3		4 (highest)		
		Relative risk	95% confidence interval	Relative risk	95% confidence interval	Relative risk	95% confidence interval	
Prudent pattern score†								
Model A	1	0.85	0.65, 1.13	0.76	0.58, 1.01	0.70	0.52, 0.93	0.01
Model B	1	0.89	0.67, 1.19	0.80	0.60, 1.08	0.72	0.53, 0.98	0.03
Model C	1	0.88	0.66, 1.17	0.79	0.59, 1.06	0.72	0.53, 0.97	0.03
Conservative pattern score‡								
Model A	1	1.30	0.97, 1.75	1.35	1.00, 1.81	1.44	1.07, 1.94	0.02
Model B	1	1.21	0.90, 1.63	1.33	1.00, 1.78	1.40	1.04, 1.87	0.02
Model C	1	1.29	0.96, 1.74	1.33	0.99, 1.79	1.49	1.11, 2.00	0.01

* Model A was adjusted for age, sex, body mass index, and energy intake; model B was further adjusted for smoking, family history of diabetes, and geographic area; model C was further adjusted for serum cholesterol and hypertension.

† Cases of diabetes mellitus, type 2, by quartile: quartile 1 (n = 105); quartile 2 (n = 96); quartile 3 (n = 96); quartile 4 (n = 86).

‡ Cases of diabetes mellitus, type 2, by quartile: quartile 1 (n = 82); quartile 2 (n = 96); quartile 3 (n = 102); quartile 4 (n = 103).

bles have been hypothesized to be mediated by antioxidants, and results of some follow-up studies have supported this hypothesis (35, 38–40). Magnesium has been related to reduced diabetes development since hypomagnesemia may impair insulin secretion and promote insulin resistance. Folic acid also has a potential reducing effect on the development of disease linked to metabolic syndrome and type 2 diabetes through a lower concentration of serum homocysteine (41). In the present study, adjustment for vitamin E, vitamin C, beta-carotene, or folic acid attenuated the association.

Dietary fiber has also been hypothesized to prevent development of type 2 diabetes by reducing postprandial insulin demand. We tested whether dietary fiber could have explained the finding and found that inclusion of fiber in the model did not notably alter the result. The fact that fiber, mainly derived from grain products (42), was included in the conservative pattern apparently biased the result for the conservative pattern. This underlines that the pattern analysis approach cannot be specific about the particular nutrients responsible for the observed association between

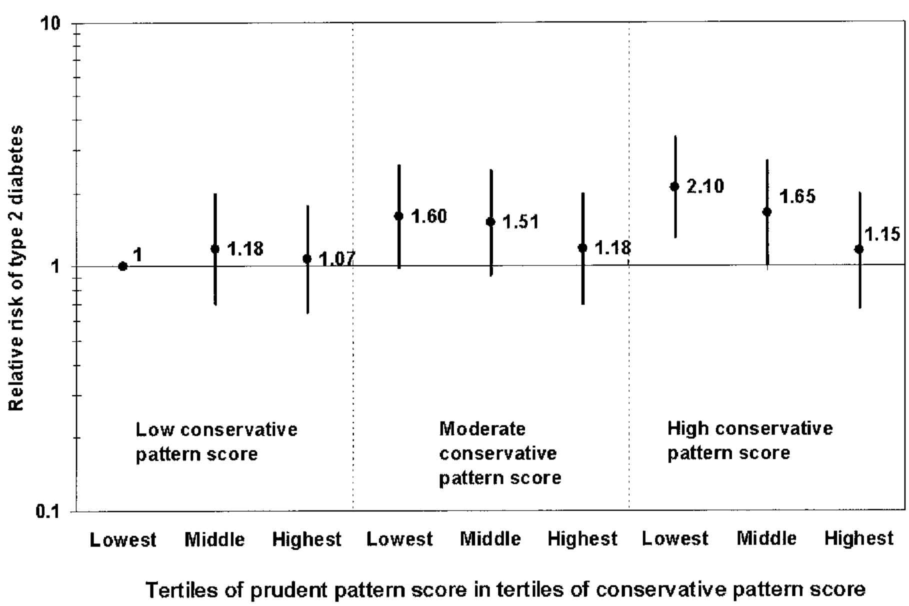

FIGURE 1. Relative risk (adjusted for age, sex, body mass index, energy, smoking, family history of diabetes, geographic area, serum cholesterol, and hypertension) for type 2 diabetes, according to combinations of dietary pattern scores, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up.

TABLE 5. Relative risk* for type 2 diabetes between the highest and lowest quartiles of energy-adjusted dietary pattern scores in strata of potential effect-modifying factors, Finnish Mobile Clinic Health Examination Survey, 1966–1972, with 23-year follow-up

	Prudent pattern		Conservative pattern	
	Relative risk	95% confidence interval	Relative risk	95% confidence interval
Age				
Below median†	1.12	0.70, 1.78	1.35	0.86, 2.13
Median or higher	0.51	0.34, 0.77	1.62	1.10, 2.39
$p_{interaction}$		0.08		0.80
Sex				
Men	0.93	0.60, 1.44	1.56	0.96, 2.52
Women	0.56	0.38, 0.85	1.49	1.02, 2.19
$p_{interaction}$		0.25		0.25
Body mass index				
Below median‡	1.00	0.53, 1.88	1.43	0.75, 2.70
Median or higher	0.68	0.48, 0.97	1.44	1.03, 2.01
$p_{interaction}$		0.58		0.39
Smoking				
Current smokers	1.02	0.58, 1.79	2.35	1.17, 4.71
Former and nonsmokers	0.68	0.48, 0.97	1.29	0.92, 1.80
$p_{interaction}$		0.69		0.39

* Adjusted for age, sex, body mass index, energy, smoking, family history of diabetes, geographic area, serum cholesterol, and hypertension.

† Median value for age was 51 years.

‡ Median value for body mass index was 26.12 kg/m^2.

dietary pattern and disease risk. In contrast to previous studies, the intake of whole grain (rye) was related to the conservative pattern in our data. The reason is that grain products, especially rye bread, were commonly eaten with butter. We suggest that this fact has diminished the difference between the two dietary patterns in predicting the risk of type 2 diabetes.

Since food consumption patterns reflect existing preferences and the foods available, it could be expected that the identified patterns differ by population and time. However, two similar major dietary patterns, prudent and Western, have been identified using factor analysis in several populations (5, 6, 9–11). The fact that several studies have resulted in more diverse patterns (7, 43–53) cannot be excluded, however. The major dietary patterns that we observed among 10,054 Finns in 1967–1972 have similarities to those observed in the 1980s and 1990s in the United States, Denmark, and Sweden (6, 9–11, 54). In our analysis, the prudent dietary pattern was characterized by fruits, vegetables, and poultry, which were associated with a prudent or vegetable-rich pattern in these previous studies. The conservative pattern was characterized by butter, potatoes, processed meat, red meat, and whole milk, which previously have also been associated with Western or high-calorie patterns.

Measurement of the dietary data requires an appropriate instrument to capture the food items of interest. In our study, a 1-year dietary history interview applied to the nationwide sample allowed us to identify two major dietary patterns of Finns. Although the dietary history interview is considered a relatively accurate method, certain inaccuracies in the method tend to alter the associations observed between dietary exposure and outcome (55). In the present study, all the interviewers were trained nutrition professionals, and a preformed questionnaire was used to diminish differences among interviewers. The questions were open-ended and offered opportunities to specify the answers. Likewise, food models were used to reduce errors of recall. In general, the short-term repeatability of the dietary history method was favorable, but long-term reliability was rather poor because of changes in food consumption by Finns (16). The poor long-term reliability of dietary data has possibly weakened the associations between diet and diabetes. The conservative dietary pattern score was directly associated with smoking and inversely associated with hypertension. It is possible that some residual confounding has remained after adjustments because of inaccurate measurement of smoking status or blood pressure.

The information on incident diabetes cases was received from a nationwide registry of drug reimbursements. The registry does not include persons with diabetes undergoing dietary therapy only and, therefore, there may have been loss of statistical power. On the other hand, it is probable that in many cases diabetic patients undergoing only dietary therapy later proceed to a phase during which drug therapy is needed. Thus, it is probable that the cases included represent a group of patients with more severe disease of rather long duration. Unfortunately, as an apparent limitation of our study, we had no valid data available on baseline physical activity and intakes of alcoholic and nonalcoholic beverages. Since persons with healthier diets may be physically more active than other persons, the lack of physical activity data in particular may have confounded the results.

In conclusion, the prudent dietary pattern observed in our data predicted a reduced risk, and the conservative dietary pattern, reflecting an ordinary diet among Finns in 1967–1972, predicted an elevated risk of type 2 diabetes in persons free from the disease. In light of the present results, it seems conceivable that the risk of type 2 diabetes can be reduced by shifting from the conservative pattern to the prudent one. Since the patterns can be easily integrated into diets, they may be highly useful in public education.

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