

Food Patterns and Components of the Metabolic Syndrome in Men and Women: A Cross-sectional Study within the Malmö Diet and Cancer Cohort

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This study examined the relations between food patterns and five components of the metabolic syndrome in a sample of Swedish men ($n = 2,040$) and women ($n = 2,959$) aged 45–68 years who joined the Malmö Diet and Cancer study from November 1991 to February 1994. Baseline examinations included an interview-administered diet history, a self-administered questionnaire, blood pressure and anthropologic measurements, and blood samples donated after an overnight fast. Cluster analysis identified six food patterns for which 43 food group variables were used. Logistic regression analysis was used to examine the risk of each component (hyperinsulinemia, hyperglycemia, hypertension, dyslipidemia, and central obesity) and food patterns, controlling for potential confounders. The study demonstrated relations, independent of specific nutrients, between food patterns and hyperglycemia and central obesity in men and hyperinsulinemia in women. Food patterns dominated by fiber bread provided favorable effects, while food patterns high in refined bread or in cheese, cake, and alcoholic beverages contributed adverse effects. In women, food patterns dominated by milk-fat-based spread showed protective relations with hyperinsulinemia. Relations between risk factors and food patterns may partly depend on gender differences in metabolism or food consumption and on variations in confounders across food patterns. *Am J Epidemiol* 2001;154:1150–9.

body constitution; cardiovascular diseases; epidemiologic studies; food; food habits; insulin resistance; nutrition; risk factors

The *metabolic syndrome* is defined as a pattern of metabolic disturbances including central obesity, hyperinsulinemia, insulin resistance and hyperglycemia, hypertension, and elevated blood lipids (1, 2). Variations worldwide have prompted researchers to formulate hypotheses for the natural development of the syndrome. For instance, stress-induced cortisol has been hypothesized to stimulate the visceral accumulation of body fat (1). Others propose that persons who have a history of fetal or infant malnutrition are susceptible to metabolic disturbances related to overfeeding, physical inactivity, and obesity in adult life (“thrifty phenotype”) (3, 4). It is also possible that insulin resistance is common today because it provided survival and reproductive advantages to our ancestors genetically adapted to a carnivorous diet (“thrifty genotype”) (4). Insulin resistance

would not have resulted in a compensatory hyperinsulinemia in persons consuming diets high in protein and low in carbohydrates (“hunter-gatherer diet”). The introduction of agriculture caused a progressive and rapid replacement of protein with carbohydrate in human diets worldwide. Insulin resistance and hyperinsulinemia may be most common today in populations in which this dietary transition occurred comparatively late (4).

A whole array of dietary factors, such as high intakes of saturated fatty acids (5–8) and low intakes of $\omega 3$ fatty acids (9, 10) and various plant foods components (11–17), are reported to contribute to the development of cardiovascular disease. In addition, smoking, physical inactivity, and high alcohol consumption have been associated with increased risk of central obesity (1, 18–20) and other metabolic disturbances (21, 22). Because the relations between diet and disease are so complex, it has been suggested that pattern analysis (e.g., cluster (23, 24) and factor (25, 26) analysis) may enhance interpretation and translation of study outcomes into dietary guidelines (27, 28). However, it is not yet clear whether food pattern analysis contributes information beyond that obtained by traditional multivariate analysis.

The metabolic syndrome has been examined mostly in clinical settings. To enable the syndrome to be examined in epidemiologic studies, a working group associated with the World Health Organization suggested an operational definition in 1998 (29). Recently, the European Group for the study of Insulin Resistance (EGIR) defined cutoffs and for-

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Abbreviations: EGIR, European Group for the study of Insulin Resistance; HDL, high density lipoprotein; LDL, low density lipoprotein; LFHF, low fat and high fiber; MFD, many foods and drinks; NIDDM, non-insulin-dependent diabetes mellitus.

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mulated similar guidelines (30). This paper uses the EGIR guidelines to define five components of the metabolic syndrome and examines their relations with food patterns (i.e., patterns of food energy sources defined by cluster analysis) in a group of nondiabetic men and women aged 46–68 years. Specifically, the risk of each component associated with the emerging food patterns was evaluated, and other lifestyle factors such as smoking and alcohol habits, three types of self-reported physical activities, and intake of specific nutrients were considered simultaneously.

MATERIALS AND METHODS

Population

In the Malmö Diet and Cancer study, a population-based prospective cohort ($n = 28,098$) study in the third largest city in Sweden, baseline examinations were conducted from March 1991 to October 1996 (31). Men aged 46–73 years and women aged 45–73 years were invited to participate in the study. Approximately 40 percent of the background population joined either spontaneously or after receiving a mailed invitation. Compared with the background population, the cohort includes slightly more persons with higher educational levels and white-collar workers in higher-level positions as well as slightly fewer current smokers and persons of non-Swedish origin. The “cardiovascular subcohort” is a random sample (i.e., 50 percent) of those who joined from November 1991 to February 1994 and underwent additional measurements to assess carotid arteriosclerosis by ultrasound ($n = 6,103$) and to donate blood after fasting ($n = 5,533$). A total of 5,135 persons participated in dietary and fasting blood data collection. Of this number, 136 persons were excluded because of either current use of diabetes mellitus medication or a previous diabetes mellitus diagnosis. The remaining 2,040 men and 2,959 women (i.e., including those with a fasting blood sugar level of ≥ 5.6 mmol/liter but without a diabetes mellitus diagnosis) constituted the study population reported on in this paper.

Data collection

Participants visited the study center on three occasions. During the first visit, trained project staff provided groups of participants with detailed instructions about the data collection procedure, distributed the study questionnaires, and conducted anthropometric measurements. At the second visit, trained diet interviewers conducted the diet history interview and checked the correctness of questionnaires completed at home. Fasting blood was donated during a third visit.

Dietary data

Diet history data were obtained for the Malmö Diet and Cancer study by combining a 7-day menu book (“current” diet information) and a diet history questionnaire (“usual” diet information). The reference period for the questionnaire was the preceding year. A total of 13 diet interviewers conducted interviews, carefully checking that the information

obtained from the two sources did not overlap. An interactive computer software program (Kostsvar; AIVO AB, Stockholm, Sweden), which facilitated standardized data entry and homogeneity across interviewers, was used. The Malmö Diet and Cancer food and nutrient database, specifically developed for this study, originates from PC KOST, version 2/93 of the Swedish National Food Administration. The validation study, which included 241 Malmö residents (126 men and 115 women) aged 50–69 years, examined the concurrent validity of the diet history method with weighed food records (18 days) collected during 1 year as the reference (32, 33). The validation correlations were generally higher than those found by using comparable dietary methods in other populations (34). The energy-adjusted validation correlation coefficients for foods were on average 0.59 for men and 0.64 for women; for both genders, the coefficient for low-fat milk was highest (0.92), and the one for rice and pasta was lowest (0.24). For total fat, the energy-adjusted correlations were 0.64 for men and 0.69 for women. The respective values for dietary fiber, β -carotene, and ascorbic acid were 0.74, 0.48, and 0.64 for men and 0.69, 0.70, and 0.71 for women (33).

A categorical variable delineating the four seasons (winter, spring, summer, autumn) was created from the date of the dietary interview. Both season of data collection and diet interviewer were controlled for in the multivariate analyses. Current use of dietary supplements was recorded in the menu book. In this study, a dichotomous variable delineates current supplement users from nonusers.

A previous paper described construction of food patterns by using cluster analysis of subjects ($n = 5,375$) in the cardiovascular Malmö Diet and Cancer cohort for whom dietary data were complete (35). In short, all available dietary information was converted from grams of the specific foods consumed to the percentage of total energy contributed by these foods and was aggregated into 43 food group variables. Six clusters seemed most appropriately to capture the food patterns in this sample. The labels attached to these food patterns indicate the major sources of food energy: “many foods and drinks” (MFD), “fiber bread,” “low fat and high fiber” (LFHF), “white bread,” “milk fat,” and “sweets and cakes.” The dietary composition of these six food pattern clusters is presented in table 1: total energy (MJ), total fat (g), percentage of total energy from fat, ratio of polyunsaturated and saturated fatty acids, ratio of $\omega 3$ to $\omega 6$ fatty acids, alcohol (g), vitamin E (mg), ascorbic acid (mg), β -carotene (mg), folic acid (μg), fiber (g), magnesium (mg), zinc (mg), calcium (mg), and iron (mg). As reported previously, persons in the fiber bread and LFHF clusters were more likely and those in the MFD, milk-fat, and sweets and cakes food clusters less likely to report a past food habit change, when compared with those in all other clusters. The mean ratio of total energy intake to basal metabolic rate, computed from the equations recommended by the World Health Organization (36), was low (i.e., 1.34) for the LFHF food pattern, indicating a higher prevalence of low-energy reporters (37). Obesity was common in the LFHF food pattern, especially among women. In the current study, the six food pattern clusters constituted the main independent variable.

TABLE 1. Dietary composition of each food pattern (major energy-contributing food groups and mean energy and nutrient intakes) in a sample (n = 4,999) from the Malmö Diet and Cancer cohort, Sweden*

	Many foods and drinks (n = 1,399)	Fiber bread (n = 460)	Low-fat and high-fiber foods (n = 755)	White bread (n = 713)	Milk fat (n = 638)	Sweets and cakes (n = 1,034)
% of total energy intake from food groups†						
18.0–15.1				White bread		Sweets
15.0–12.1		Fiber bread			“Bregott” spread	
12.0–9.1		Fat meat	Fruits, low-fat milk			
9.0–6.1	Cheese, fat meat			Fat meat, sweets, low-fat spread, low-fat meat	Sweets, white bread, fat meat	Fat meat
6.0–3.1	Cake, fruits, white bread, sweets, low-fat meat, boiled potato, medium-fat spread, low-fat milk, regular milk, low-fat spread, fiber bread	Sweets, fruits, low-fat meats, low-fat spread, cheese, boiled potato, low-fat milk, cake, vegetables	Low-fat meat, fat meat, sweets, vegetables, boiled potato, cake, fiber bread, white bread, fiber crisp-bread, low-fat spread, cereals, cheese	Cheese, fruits, boiled potato, cake, low-fat milk, regular milk, medium-fat spread	Cheese, regular milk, low-fat meat, cake, fruits, boiled potato, fiber bread	White bread, fruits, cake, cheese, low-fat meat, regular milk, low-fat milk, low-fat spread, boiled potato, fiber bread
Geometric means of total energy‡ and nutrient§ intakes (unit)						
Energy (MJ)	9.7	9.6	8.05	10.4	10.9	10.2
Fat (g)	100.5	99.6	88.5	88.1	99.8	91.3
Fat (% energy)	40.9	35.4	33.5	38.3	45.0	37.5
P/S ratio¶	0.39	0.46	0.46	0.46	0.27	0.39
ω3/ω6 ratio#	0.20	0.21	0.22	0.18	0.26	0.20
Alcohol** (g)	10.8	5.8	5.2	6.0	9.2	5.5
Vitamin E (mg)	11.0	10.4	9.73	11.3	9.84	10.6
Ascorbic acid (mg)	102.0	102.0	129.0	82.8	88.9	96.5
β-Carotene (mg)	3.02	3.67	4.56	2.35	2.54	2.82
Folic acid (μg)	244.0	292.0	265.0	258.0	244.0	244.0
Fiber (g)	19.6	26.6	22.6	20.9	19.2	20.4
Magnesium (mg)	356.0	391.0	362.0	377.0	362.0	363.0
Zinc (mg)	11.7	12.3	10.6	12.7	12.3	11.5
Calcium (mg)	1,134.0	1,089.0	1,148.0	1,108.0	1,114.0	1,151.0
Iron (mg)	15.2	17.6	13.2	19.6	16.4	16.0

* Data collected from November 1991 to February 1994.

† Food groups contributing less than 3.1% of total energy are not shown.

‡ Adjusted for age and gender.

§ Adjusted for age, gender, and energy intake.

¶ Ratio of polyunsaturated to saturated fatty acids.

Ratio of ω3 to ω6 fatty acids.

** Alcohol values are medians.

Indicators of the metabolic syndrome

EGIR recently identified components of the metabolic syndrome suitable for evaluating the syndrome in prospective studies (30). The proposed guidelines are intended for

use among nondiabetics only and include five components (insulin resistance, hyperglycemia, hypertension, dyslipidemia, and central obesity).

Blood pressure and anthropometric measurements. Blood pressure (mmHg) was measured once after subjects

rested for 10 minutes. *Hypertension* was defined as having a systolic blood pressure of more than or equal to 140 mmHg, having a diastolic blood pressure of more than or equal to 90 mmHg, or having been treated for hypertension. Waist and hip circumferences (cm) were measured with participants wearing light indoor clothing and no shoes. *Central obesity* was defined as having a waist circumference of more than or equal to 94 cm in men and more than or equal to 80 cm in women.

Laboratory analyses. After subjects fasted overnight, blood samples were drawn to determine serum lipids, serum insulin, and whole blood glucose levels. Samples were analyzed by using standard methods at the Department of Clinical Chemistry, Malmö University Hospital, which has a recurrent, standardized (continuous calibration and validation) system in place. Insulin levels (mIU/liter) were measured by radioimmunoassay (detection limit, 3 mIU/liter; intra- and interassay coefficients of variation, 5 and 8 percent, respectively). Blood glucose (mmol/liter) was determined by using a routine hexokinase method. Triglycerides (mmol/liter) and total cholesterol (mmol/liter) were determined on a DAX 48 automatic analyzer with use of reagents and calibrators from the supplier of the instrument (Bayer AB, Gothenburg, Sweden). High density lipoprotein (HDL) cholesterol (mmol/liter) was determined by using the same procedure as that used for total cholesterol but after precipitation of low density lipoprotein (LDL) cholesterol and very low density lipoprotein cholesterol with dextran sulphate. LDL cholesterol (mmol/liter) was calculated from the values for triglycerides, total cholesterol, and HDL cholesterol according to the Friedewald formula: $LDL\ cholesterol = total\ cholesterol - HDL\ cholesterol - (triglycerides/2.2)$ (38).

In this study, insulin resistance was examined as *hyperinsulinemia* and was defined as being in the upper quartile of the fasting insulin distribution. *Hyperglycemia* was defined as fasting blood glucose of more than or equal to 5.6 mmol/liter (which corresponds to plasma glucose of more than or equal to 6.1 mmol/liter). *Dyslipidemia* was defined as having an HDL cholesterol level of less than 1.00 mmol/liter, having a triglycerides level of more than 2.00 mmol/liter, or having been treated for dyslipidemia.

Other variables

Information on age and gender was obtained through the personal identification number. (In Sweden, each person is assigned a 10-digit number at birth; six digits indicate the date of birth and one identifies sex/gender.) Body composition was estimated by using single-frequency bioimpedance methodology, with participants in the supine position. Estimates of body fat percentage were included as a covariate in the multivariate analysis.

A standardized questionnaire collected information on socioeconomic, demographic, and lifestyle factors and on medical and health history. Past diet change was based on the following questionnaire item: "Have you, because of ill health or other reasons, substantially changed your food habits?" with yes and no response categories. Alcohol habits, defined by a four-category variable, were assessed from both the 7-day menu book and the lifestyle question-

naire. Zero consumers were those participants whose menu book reported zero consumption and whose questionnaire indicated no alcohol consumption during the previous 30 days or previous year. The remainder of subjects were categorized according to an assumption of biologic risk (39). Per-day cutoff limits for alcohol were, for men, <20 g (low), 20–40 g (medium), and >40 g (high); and, for women, <15 g (low), 15–30 g (medium), and >30 g (high). In this study, smoking status was defined by using a three-category variable: current smoker, former smoker, and never smoker. Leisure-time physical activity was assessed by a list of activities in the questionnaire (18 items), developed from the Minnesota Leisure Time Physical Activity instrument (40, 41). Participants reported how many minutes per week, during each of the four seasons, they spent on a specific activity. A physical activity score was obtained by multiplying the number of minutes for each activity by an activity-specific factor, and a four-category variable was defined by the participants' quartile ranking. A four-category questionnaire item defined physical activity at work as very light, moderately light, strenuous, or very strenuous. One questionnaire item requested information on the number of hours participants spent on household activities each week. Based on the quartile ranking of participants, a four-category household physical activity variable was created.

Statistical analysis

Chi-square analysis examined the distributions of gender, zero consumers of alcohol, supplement users, smoking, physical activity habits, and five components of the metabolic syndrome across the six food pattern clusters. Logistic regression analysis first examined the risk of each metabolic syndrome component in relation to each food pattern with all other food patterns as the reference, controlling for age, total energy, body fat percentage, diet interviewer, past diet change, and season of data collection. This design was prompted by statistical power considerations and was chosen because the risk variation between reference clusters was expected to be small. Models were also formulated that included smoking status, alcohol habits, leisure-time physical activity, household work, and physical activity at work. Lastly, the independent effects of food patterns were evaluated by including total fat, total fiber, ratio of polyunsaturated to saturated fatty acids, ratio of $\omega 3$ to $\omega 6$ fatty acids, magnesium, folic acid, vitamin E, and β -carotene in the models, adjusting for the potential confounders of the first model and lifestyle factors. Continuous variables were log-transformed prior to analysis to normalize the distribution of data. For all analyses, the SPSS statistical computer package (version 9.0; SPSS Inc., Chicago, Illinois) was used.

RESULTS

More women belonged to the LFHF food pattern cluster (table 2), while the fiber bread and white bread food pattern clusters had higher proportions of men. Zero consumption of alcohol was more common in those with the fiber bread,

TABLE 2. Distribution of gender and selected lifestyle characteristics across food-pattern clusters in a sample (*n* = 4,999) from the Malmö Diet and Cancer cohort, Sweden*

	Frequency (%)							<i>p</i> value
	Many foods and drinks	Fiber bread	Low-fat and high-fiber foods	White bread	Milk fat	Sweets and cakes	Total	
Gender								
Women	884 (63)	220 (48)	607 (80)	304 (43)	333 (52)	611 (59)	2,959 (59)	0.0001
Men	515 (37)	240 (52)	148 (20)	409 (57)	305 (48)	423 (41)	2,040 (41)	
Smoking status†								
Current	366 (26)	87 (19)	146 (19)	207 (29)	245 (38)	300 (29)	1,351 (27)	0.0001
Former	476 (34)	181 (39)	265 (35)	265 (37)	181 (28)	293 (28)	1,661 (33)	
Never	556 (40)	192 (42)	344 (46)	241 (34)	212 (33)	440 (43)	1,985 (40)	
Alcohol consumption								
Zero-alcohol consumers	84 (6)	61 (13)	89 (12)	104 (15)	52 (8)	138 (13)	528 (11)	0.0001
Alcohol consumers	1,314 (94)	397 (87)	661 (88)	606 (85)	586 (92)	893 (87)	4,456 (89)	
Leisure-time physical activity‡								
Quartile 1	334 (24)	104 (23)	148 (20)	217 (31)	168 (26)	274 (27)	1,245 (25)	0.0001§
Quartile 4	348 (25)	115 (25)	222 (30)	173 (25)	134 (21)	245 (24)	1,237 (25)	
Physical activity at work‡								
Low	676 (49)	182 (40)	308 (42)	289 (41)	285 (45)	435 (43)	2,175 (44)	0.0001§
High	23 (1.7)	21 (5)	2 (0.3)	28 (4)	18 (3)	25 (2)	117 (2)	
Household work‡								
Quartile 1	328 (24)	131 (30)	124 (17)	224 (33)	202 (33)	276 (28)	1,285 (27)	0.0001§
Quartile 4	274 (20)	78 (18)	219 (30)	146 (21)	95 (16)	214 (22)	1,026 (21)	

* Data collected from September 1991 to March 1994.

† Because of rounding, the Milk-fat percentages do not total 100.

‡ Only the prevalences of persons in the lowest and highest exposure categories within each cluster are shown.

§ Although only the prevalences of persons in specific clusters and exposure categories are shown, the *p* values refer to tests across all clusters and categories.

white bread, and sweets and cakes patterns. Current smoking was found more often with the milk-fat pattern (table 2), never smoking with the LFHF pattern, and former smoking with the fiber bread and white bread patterns. High leisure-time physical activity was more common with the LFHF pattern but less common with the white bread pattern. Persons with the fiber bread and white bread patterns were more physically active at work, but those with the MFD pattern were less active. Household activities were found more often among persons with the LFHF food pattern but less often with the white bread and milk-fat food patterns. The use of dietary supplements did not differ across food pattern clusters (data not shown).

When the distribution of the five metabolic syndrome components was examined across food patterns, no relations were found for hypertension or for hyperglycemia in women and for hyperinsulinemia in men (table 3). When each food pattern was examined with all others as the reference, no relations were observed with the sweets and cakes and LFHF patterns (table 4). For women, the white bread food pattern was associated with a higher risk of hyperinsulinemia and the milk-fat pattern with a lower risk of hyperinsulinemia. The white bread pattern was associated with a higher risk of dyslipidemia in both men and women. For men, the most striking findings were a higher risk of hyperglycemia with the MFD pattern and a lower risk of central obesity with the fiber bread food pattern. For men, the MFD pattern was also associated with a higher

risk of central obesity and the fiber bread food pattern with a lower risk of dyslipidemia.

When other lifestyle factors were included in the analysis (model I, table 5), a borderline association was found for the fiber bread food patterns and dyslipidemia in men, but the relation with the white bread pattern was no longer significant (data not shown). To evaluate the independent effects of food patterns, additional nutrient variables were included in the analysis (models II and III, table 5). The positive relation between the MFD pattern and hyperglycemia and the negative relation between the fiber bread pattern and central obesity remained significant for men. For women, the positive relation between the white bread pattern and hyperinsulinemia remained significant. The negative relation between the milk-fat pattern and hyperinsulinemia in women was stronger when additional nutrient variables were added to the model. The association between the white bread food pattern and dyslipidemia in women was independent of total fat and fiber but was no longer significant when the other nutrient variables were included in analysis. Inclusion of supplement use in the analysis did not change these relations.

DISCUSSION

In this study, four food patterns defined by cluster analysis showed independent relations with four components of the metabolic syndrome. A strong, positive relation was observed for men between hyperglycemia and food patterns,

TABLE 3. Distribution of five “metabolic syndrome” components, by food patterns and gender, in a sample (n = 4,999) from the Malmö Diet and Cancer cohort, Sweden*

	Frequency (%)†							Chi-square p value‡
	Many foods and drinks	Fiber bread	Low-fat and high-fiber foods	White bread	Milk fat	Sweets and cakes	Total	
Central obesity								
Women	291 (33)	63 (29)	232 (38)	110 (36)	93 (28)	179 (29)	968 (33)	0.002
Men	253 (49)	77 (32)	73 (49)	180 (44)	121 (40)	171 (40)	875 (43)	0.0001
Hyperinsulinemia								
Women	220 (25)	50 (23)	164 (27)	99 (33)	60 (18)	138 (23)	731 (25)	0.001
Men	190 (37)	73 (30)	49 (33)	152 (37)	109 (36)	139 (33)	712 (35)	0.413
Hyperglycemia								
Women	94 (11)	27 (12)	64 (11)	28 (9)	24 (7)	54 (9)	291 (10)	0.320
Men	137 (27)	36 (15)	27 (18)	74 (18)	50 (16)	68 (16)	392 (19)	0.0001
Hypertension								
Women	521 (59)	136 (62)	381 (63)	191 (63)	183 (55)	357 (58)	1,769 (60)	0.170
Men	363 (71)	161 (67)	103 (70)	273 (67)	212 (70)	285 (67)	1,397 (69)	0.818
Dyslipidemia								
Women	114 (13)	32 (15)	100 (17)	59 (19)	32 (10)	86 (14)	423 (14)	0.006
Men	169 (33)	70 (29)	57 (39)	164 (40)	94 (31)	148 (35)	702 (34)	0.031

* Data collected from November 1991 to February 1994.

† The prevalence of each condition within a specific cluster is shown (omitting those without) separately for women and men.

‡ The p values refer to tests performed, separately for women and men, for each condition and across all clusters.

with food energy distributed over several foods (cheese, cake, and alcoholic beverages ranked comparatively high and vegetables and fiber bread low). In addition, central obesity was less likely to occur in men whose food patterns were dominated by fiber-rich bread. Hyperinsulinemia was more likely in women whose food patterns were dominated by refined bread and less likely for food patterns dominated by milk-fat-based dietary fats.

For men, a borderline negative association was observed between dyslipidemia and food patterns dominated by fiber-rich bread. For women, the positive association found between food patterns dominated by refined bread and dys-

lipidemia was not independent of specific nutrient variables. No relations were observed between food patterns and hypertension. In this study, blood pressure was measured only once, which could suggest low precision in the hypertension estimate, causing attenuated relations.

Although the protective association with the fiber bread food pattern supports previous reports of the benefits of whole grain foods (13–17), the higher intakes of several micronutrients imply that the favorable effects of this pattern could be quite complex. The MFD pattern (with high intakes of alcohol and fat and low intakes of folic acid, fiber, and magnesium) and the white bread pattern (with a low

TABLE 4. Risk associated with selected components of the metabolic syndrome given a specific food pattern,* analyzed separately for women and men, in a sample (n = 4,999) from the Malmö Diet and Cancer cohort, Sweden†,‡

	Many foods and drinks		Fiber bread		Low-fat and high-fiber foods		White bread		Milk fat		Sweets and cakes	
	OR§	95% CI§	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Dyslipidemia												
Women	0.85	0.67, 1.09	1.06	0.71, 1.59	1.01	0.77, 1.31	1.54	1.12, 2.11	0.70	0.47, 1.03	1.08	0.82, 1.41
Men	0.87	0.70, 1.08	0.72	0.53, 0.99	1.06	0.73, 1.53	1.37	1.08, 1.73	0.88	0.67, 1.16	1.12	0.88, 1.41
Hyperinsulinemia												
Women	0.99	0.81, 1.22	0.97	0.68, 1.40	1.01	0.80, 1.28	1.47	1.10, 1.95	0.66	0.48, 0.91	0.99	0.79, 1.26
Men	1.08	0.86, 1.35	0.83	0.61, 1.15	0.91	0.61, 1.35	1.14	0.89, 1.45	1.05	0.79, 1.40	0.90	0.70, 1.16
Hyperglycemia												
Women	1.17	0.89, 1.53	1.37	0.88, 2.12	0.92	0.67, 1.25	0.85	0.56, 1.30	0.74	0.47, 1.15	0.99	0.72, 1.36
Men	1.79	1.40, 2.29	0.74	0.51, 1.09	0.88	0.56, 1.39	0.88	0.65, 1.17	0.82	0.58, 1.15	0.78	0.58, 1.06
Central obesity												
Women	0.96	0.76, 1.21	0.79	0.52, 1.20	1.05	0.81, 1.37	1.03	0.73, 1.45	0.90	0.63, 1.28	1.15	0.89, 1.50
Men	1.32	1.04, 1.68	0.58	0.41, 0.81	1.41	0.94, 2.12	1.01	0.78, 1.31	0.90	0.66, 1.22	0.94	0.73, 1.22

* Adjusted for age, total energy, body fat percentage, past diet change, diet interviewer, and season of data collection.

† Data collected from November 1991 to February 1994.

‡ Reference group, persons in all other food-pattern groups.

§ OR, odds ratio; CI, confidence interval.

TABLE 5. Risk associated with selected components of the metabolic syndrome in relation to the Many foods and drinks and Fiber bread food patterns for men and the White bread and Milk-fat food patterns for women* in the Malmö Diet and Cancer cohort, Sweden†

	Men					
	Many foods and drinks			Fiber bread		
	OR‡	95% CI‡	<i>p</i> value	OR	95% CI	<i>p</i> value
Model I§						
Central obesity	1.29	1.00, 1.67	0.053	0.56	0.39, 0.80	0.001
Dyslipidemia				0.73	0.53, 1.01	0.058
Hyperglycemia	1.70	1.30, 2.22	0.0001			
Model II¶						
Central obesity	1.24	0.95, 1.61	0.111	0.61	0.42, 0.88	0.009
Dyslipidemia				0.72	0.51, 1.01	0.057
Hyperglycemia	1.68	1.28, 2.20	0.0002			
Model III#						
Central obesity	1.22	0.94, 1.61	0.140	0.61	0.42, 0.89	0.011
Dyslipidemia				0.70	0.50, 1.00	0.047
Hyperglycemia	1.64	1.24, 2.17	0.0006			
	Women					
	White bread			Milk fat		
	OR	95% CI	<i>p</i> value	OR	95% CI	<i>p</i> value
Model I§						
Hyperinsulinemia	1.43	1.07, 1.93	0.017	0.67	0.48, 0.94	0.019
Dyslipidemia	1.50	1.07, 2.09	0.018			
Model II¶						
Hyperinsulinemia	1.39	1.03, 1.87	0.030	0.62	0.44, 0.88	0.008
Dyslipidemia	1.44	1.03, 2.01	0.035			
Model III#						
Hyperinsulinemia	1.39	1.02, 1.89	0.033	0.58	0.40, 0.84	0.004
Dyslipidemia	1.28	0.91, 1.81	0.155			

* All models controlled for age, total energy, body fat percentage, past diet change, diet interviewer, and season of data collection.

† Data collected from November 1991 to February 1994.

‡ OR, odds ratio; CI, confidence interval.

§ Includes alcohol consumption habits, smoking status, leisure-time physical activity, physical activity at work, and household work.

¶ Includes the same variables as model I plus total fat and total fiber.

Includes the same variables as model I plus total fat, total fiber, ratio of polyunsaturated to saturated fatty acids, ratio of ω 3 to ω 6 fatty acids, magnesium, folic acid, vitamin E, and β -carotene.

ratio of ω 3 to ω 6 fatty acids and lower intakes of β -carotene and ascorbic acid) are striking contrasts. The findings from this study are supported by a range of other studies. For instance, positive associations have been reported between alcohol intake and hyperglycemia and other cardiovascular disease risk factors (21, 42). Low intake of minerals such as magnesium and chromium has been linked to hyperglycemia and insulin dysfunction (43–46), and the importance of folic acid (47–49) and dietary antioxidants (11) in the development of cardiovascular disease has been documented. Furthermore, the postprandial glucose and insulin response (i.e., the glycemic index) depends on the type of carbohydrate and physical properties of carbohydrate-rich foods (50, 51). The fiber bread pattern could indicate more frequent consumption of low-glycemic-index foods, such as bread with whole kernels or bread made from sourdough. Research indicates that low-glycemic-index energy-restricted diets, compared with similar high-glycemic-index diets, result in physiologic adaptations, which over time

would favor weight reduction (52). High-glycemic-index diets have been related to increased risk of non-insulin-dependent diabetes mellitus (NIDDM) and coronary heart disease in both men and women (16, 53, 54), while low-glycemic-index diets have been associated with improved lipid profiles and capacity of fibrinolysis in persons with NIDDM (55).

In addition, many reports suggest positive relations of saturated fats with glucose intolerance and insulin resistance (56). Specifically, larger proportions of saturated fatty acids and smaller proportions of ω 3 fatty acids (9) and of long-chain unsaturated fatty acids (6) in the structural lipids of cell membranes have been associated with insulin resistance. This finding indicates a dietary effect, since the fatty-acid profile of diet is reflected in the structural lipids of skeletal muscle. However, in this study, relations were independent of total fat, total fiber, ratio of polyunsaturated to saturated fatty acids, and ratio of ω 3 to ω 6 fatty acids and independent of magnesium, folic acid, vitamin E, and β -carotene, which suggests

that the observed effects may depend on synergism between nutrients, on other food components, or on other (unknown) factors associated with these food patterns. The findings imply that similar effects on health and disease are unlikely with supplements and vitamin-mineral fortification. Dietary and public health guidelines should not only focus on daily nutrient intakes but also incorporate food selection in a broader context.

In food-pattern projects, food variables and analysis approaches should be selected so that the emerging patterns make sense from a dietary perspective. As discussed in a previous paper (35), percent-energy variables are in a sense standardized and have a specific meaning, because they express the proportions of dietary components. In cluster analysis, *z*-score transformation is recommended to hinder variables with larger values from overwhelming those with much smaller values (57). However, if *z* scores had been used in this study, the food group variables would have been standardized twice, foods contributing little energy would have been given equal weight to foods contributing much energy, and the original meaning of the percent-energy concept would have been lost. Both cluster and factor analysis approaches are useful when food patterns are constructed without predetermined dietary cutoffs. Factor analysis searches for correlated variables or underlying factors (25, 26). Cluster analysis aggregates persons with similar characteristics, and easily interpretable food patterns emerge (23, 24), especially when percent-energy variables are used. However, the latter approach would not be useful when the underlying hypothesis is focused on micronutrients and components of plant foods. Furthermore, in studies in which the purpose is to test health and disease in relation to a number of dietary variables with distinct cutoffs, an approach involving a diet-quality score may be more suitable (58).

Food choices are often associated with lifestyle (59, 60). One could argue that the negative association between hyperinsulinemia and the milk-fat pattern, together with a tendency not to have changed diets in the past, simply indicates fewer health problems and incentives to adapt healthful lifestyles. However, this study controlled for past diet change and lifestyle, and it examined specific nutrient variables in an attempt to isolate pure food-pattern effects. Therefore, the significant protective relation with the milk-fat pattern suggests that either there is a pattern effect or another factor closely related to these types of food habits is at play. Other observations from the Malmö Diet and Cancer cohort indicate that groups of higher socioeconomic status (especially women) have comparatively better cardiovascular disease risk factor profiles (61). However, inclusion of socioeconomic status in the analytical model (data not shown) did not change the relation. Although milk appears to be insulinotropic (62), inverse relations between milk fat (i.e., pentadecanoic acid C15:0) and metabolic risk factors have been observed (63). It is also plausible that milk-fat consumers have lower exposure over the long term to *trans*-fatty acids (e.g., persons in the milk-fat food pattern group as opposed to those in the white-bread food pattern group). Several reports indicate positive associations between *trans*-fatty acids and risks of coronary heart disease (64, 65) and NIDDM (66).

The dissimilar relations observed for men and women could depend on differences in cell metabolism, because hormones are known to influence receptors for both insulin effects and lipid removal (67). However, the diet-disease relations found in epidemiologic studies are also critically dependent on how well diet is assessed. Actual food choices (68), self-reported preferences for foods (69), and accuracy of dietary assessment may all vary by gender (70, 71). Although it is difficult to fully conceptualize how gender affects assessment (72), studies have indicated that men and women may rate differently on scales measuring social desirability and social approval (73, 74) and that these scores have different relations to self-reported diets.

As reported previously, a higher prevalence of low-energy reporting, a high prevalence of obesity, and past diet change were particularly common in the LFHF cluster (35). A strong relation between obesity and low-energy reporting is common (75–78). This study controlled for these confounders in analysis, which may partly explain why no associations were observed with this cluster and the metabolic syndrome components. The fiber bread and LFHF food patterns both emerged as most dense in micronutrients, but the gender distributions were markedly different between the two patterns, implying that healthful food choices may differ between men and women. However, both men and women in the LFHF cluster seemed to underreport energy, compared with men and women in the fiber bread cluster. It is plausible that diets dominated by fiber-rich bread are less sensitive to energy underreporting. However, a more likely explanation is that obesity was common in persons (mostly women) reporting diets dominated by fruits, low-fat products, and vegetables, while those participants (mostly men) reporting diets high in fiber-rich bread were not obese and (therefore) were less likely to underreport energy. The protective relation between the fiber bread food pattern and central obesity in men may have been more easy to observe not only because the proportion of men with this food pattern was larger but also because the dietary exposure reflected by the food pattern may have been less tinted by confounding factors (i.e., obesity and low-energy reporting). Thus, the findings cannot be interpreted as indicating no causal effects of fiber-rich bread for women.

In conclusion, this study demonstrated relations (not explained by specific nutrients) between food patterns and hyperglycemia and central obesity in men and hyperinsulinemia in women. Dietary patterns dominated by fiber bread (comparatively high in several micronutrients) provide protective effects, while food patterns high in refined bread or in cheese, cake, and alcoholic beverages (with lower intakes of several micronutrients) increase the risk for several components of the metabolic syndrome. In addition, food patterns in which a high proportion of energy is derived from milk-fat-based dietary spreads indicated protective relations with hyperinsulinemia in women. The findings imply that differences between genders in the observed effects of food patterns on health depend not only on gender differences in cell metabolism but also on food selection differences as well as on variation in confounders (such as obesity, underreporting of energy, and other lifestyle factors) across food patterns.

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