Food patterns and cardiovascular disease risk factors: The Swedish INTERGENE research program

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ABSTRACT

Background: Analyzing the impact of the intake of many foods simultaneously provides additional knowledge about analyses of nutrients and might make it easier to implement recommendations for the public.

Objective: The objective was to examine food patterns in a Swedish population and determine how they are related to metabolic risk factors for cardiovascular disease.

Design: The study is based on data from the INTERGENE population study of women and men aged 25–74 y in western Sweden. Dietary patterns were identified with cluster analysis of 93 food frequencies reported by 3452 participants. Associations with features of the metabolic syndrome, including blood lipids, blood pressure, and anthropometric measures, were analyzed.

Results: Five distinct food patterns were identified, of which one was interpreted as a “healthy” reference pattern. This healthy cluster was distinguished by the more frequent consumption of high-fiber and low-fat foods and lower consumption of products rich in fat and sugar. The other four clusters differed significantly from the reference cluster with respect to prevalence of cardiovascular disease risk factors and the metabolic syndrome. For example, body mass index and waist-to-hip ratio were significantly higher in a cluster characterized by high consumption of energy-dense drinks and white bread and low consumption of fruit and vegetables (P < 0.0001 and P = 0.004, respectively).

Conclusions: It is possible to distinguish food patterns that are related to obesity and obesity-related cardiovascular disease risk factors in contrast with a more healthy pattern conforming with current dietary guidelines. Thus, the results indicate no reason for questioning the current recommendations. Am J Clin Nutr 2008;88:289–97.

INTRODUCTION

Dietary factors are important in the development of obesity and cardiovascular disease (CVD) (1). However, many issues remain unsettled, and we need more knowledge about optimal intake of nutrients and foods and how the intake varies between individuals. One reason for the divergent conclusions in epidemiologic studies is that different dietary factors co-vary and are related to other lifestyle factors. In experimental studies, matters can be simplified by focusing on one or a few components in diet, predominantly nutrients, but in reality dietary intake is more complex because the diet consists of many foods, which in turn consist of many nutrients. Analysis of combinations of foods makes it possible to consider the known and unknown interactions and potential cumulative effects of dietary exposure. Thus, a food pattern may be a stronger predictor of disease risk when many dietary associations exist for the disease, as for CVD (2), and can provide complementary information to analyses of associations with single food components. Furthermore, results from such analyses might be easier to implement in recommendations to the public. Several studies have suggested that certain dietary patterns predict CVD or mortality. The Lyon Diet Heart Study (3) demonstrated that a certain diet reduced risk recurrence after a first myocardial infarction over a period of 4 y. In another randomized intervention study (4), a diet rich in fruit, vegetables, and low-fat dairy foods reduced blood pressure considerably. Still, most evidence for an association between food pattern and CVD comes from observational studies. Common statistical methodologies for assessing dietary patterns are cluster or factor analyses (5). Cluster analysis, in contrast with factor analysis, generally defines nonoverlapping groups of subjects with specific dietary behaviors.

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the lowest intake of saturated fat. In another prospective study that clustered food intake variables, a heart-healthy food pattern was, however, associated with a lower risk of atherosclerosis (8). Furthermore, factor analyses have revealed that a “healthy” pattern is protective against coronary heart disease (9–11) and CVD mortality (12). Thus, CVD morbidity and mortality have been observed to be associated with food patterns in several studies, but a universal protective dietary pattern could not be distinguished.

Previous research from Sweden has revealed significant associations between food patterns, defined using cluster analysis, and components of the metabolic syndrome (13). In that study Wirfält et al defined clusters by percentage of total energy from specific food groups. Because certain foods with a relatively low contribution of energy (eg, vegetables) are likely to be important in healthy food patterns, in the present study we examined food patterns based on intake frequencies rather than on energy. This is consistent with the work of Bailey et al (14), who demonstrated that a cluster analysis using number of servings better identifies a more healthful eating pattern than does an analysis using the percentage of energy from foods groups as the clustering variable. Thus, the aim of the present study was to study dietary patterns associated with CVD risk by clustering the subjects into distinct groups representing different food intake patterns and to examine how these patterns relate to metabolic and anthropometric characteristics. A further aim was to describe the clusters with respect to socioeconomic, lifestyle, and health characteristics.

SUBJECTS AND METHODS

Population

INTERGENE is a population based research program that assessed the INTERplay between GENETic susceptibility and environmental factors for the risk of chronic diseases in western Sweden. The survey started in April 2001 and continued until December 2004. The study population consisted of randomly selected women and men aged 25–74 y and living in the Västra Götaland Region at the time of sampling. For practical reasons, data were collected at screening locations placed in the most densely populated areas; hence, a few small communities were excluded from the sampling. Altogether, the sample consisted of 8625 eligible subjects. Of the invited cohort, 3610 responded: 1908 women (44%) and 1702 men (39%). The mean age of the women was 51.2 y and of the men was 51.6 y. For the purpose of this study, pregnant women (n = 16) were excluded. The participant characteristics and the study procedure are described in detail in an earlier report (15) and on the Internet at http://www.sahlgrenska.gu.se/intergene/. The study was approved by the local ethical committee.

Data collection

The invitees were asked to abstain from eating during the 4 h before the clinical examination. Body height and weight were measured to the nearest 1 cm and 0.1 kg, respectively, while the subjects were wearing light clothing and no shoes. Waist circumference was measured at a level midway between the lower rib margin and iliac crest, and hip circumference was measured as the maximum perimeter over the buttocks. Blood pressure was measured twice in each person, after a 2-min rest, with a validated (16) automatic device (Omron 711 Automatic IS; Omron Healthcare Inc, Vernon Hills, IL) while the subjects were in a supine position. Blood samples were collected after 4-hour fasting, for immediate serum lipid (total cholesterol, HDL cholesterol, and triglycerides) and glucose analysis. Serum total cholesterol and triglyceride concentrations were determined with enzymatic assays. Serum HDL-cholesterol concentrations were measured after dextran sulfate-magnesium precipitation of apolipoprotein B-containing lipoproteins. Serum glucose was analyzed with a hexokinase method (Roche Hitachi 917 and Roche ModularP, Roche, Basel, Switzerland). All samples were identified with bar codes. Nine subjects who had not fasted according to instructions were excluded from the glucose and triglyceride analyses.

The metabolic syndrome was defined by National Cholesterol Education Program, Adult Treatment Panel III (17), ie, the presence of ≥3 of the following 5 components: waist circumference ≥88 cm in women and ≥102 cm in men, serum triglycerides ≥1.7 mmol/L, HDL cholesterol <1.03 mmol/L in men and <1.29 mmol/L in women, blood pressure of 130 mm Hg systolic and/or 85 mm Hg diastolic, fasting plasma glucose ≥6.1 mmol/L.

Usual dietary intake was assessed with a modified version of a validated self-administered food-frequency questionnaire (FFQ) developed at the Karolinska Institute (18–20). It comprised a list of 92 frequency questions, of which 72 had a choice of 8 frequencies ranging from “0 times a month” to “3+ per day.” For 20 foods commonly consumed (various milks, coffee, tea, soft drinks, sugar, cheese, and bread), open questions about servings (eg, slices of bread) per day or week were included. Validity of the FFQ-based food intake estimates assessed as the correlation between the FFQ and food records varied between 0.4 (white bread) and 0.9 (sugar); a mean correlation for 20 of the most commonly consumed food items was 0.6. Additional items covered supplement use; choice of fat for cooking, for dressing, and on sandwiches; meal patterns; and portion sizes of cooked food.

The questionnaire also included information about health, socioeconomic, and lifestyle factors. Physical activity during leisure time was categorized into 4 levels with a validated (21) questionnaire that has been in use in Göteborg since the 1960s (22). In addition questions about activity level during working time as well as time spent at household work, biking and walking, sedentary activities, and exercise were included. On the basis of these items and on the intensity levels of different activities (ratio of work metabolic rate to resting metabolic rate) (23), individual physical activity levels (PALs) were estimated.

Statistical analysis

The hypothesis tested was that there is a healthy food pattern in the population and that this pattern is associated with a better risk factor profile. We used cluster analysis to derive food intake patterns. The K-means nonhierarchical method with Euclidean distance was used to categorize individuals in FASTCLUS (SAS package 9.1; SAS Institute Inc, Chicago, IL.). Servings or frequencies per week were used as input variables. Subjects with >8 missing food frequency values or with no reported use of common foods reported were excluded. In individuals with fewer missing values, missing data were considered as “no consumption” of the actual food.

Unstandardized variables were used to give more frequently consumed foods more influence on cluster formation. To maximize variation, men and women were analyzed together. Because cluster analysis is sensitive to extreme values, the scale of
serving per week (ie, the 20 foods with open answers for frequencies) was truncated to the same endpoint as the scale with 8 categories (ie, ≥21 servings/wk). To identify the optimal number of clusters, several runs with varying numbers of clusters were conducted starting with 2 clusters. Each set of clusters was examined to find a solution that was reasonably sized and that included one cluster considered to be healthy. A cluster solution with 5 big clusters included a clear “healthy cluster,” whereas the analysis with fewer or more potential clusters included ≥2 clusters that could be interpreted as healthier in some aspects. Therefore, the solution with 5 clusters was selected. Forty individuals were excluded because they belonged to small additional identified clusters. The dietary clusters were interpreted and named on the basis of their high or low intakes of some food groups relative to the population mean intake and to the relative ranking of mean intake of all food items included in the cluster analysis. The clusters were validated by performing a cluster analysis, with a cluster solution with 5 clusters, in a random sample of 50% of the participants. The clusters were similar to those emerging in the original analysis, except for the small cluster (“sweet”), which was principally characterized by high consumption of fruit and vegetables and not sugar.

The “healthy” cluster was considered as a reference cluster against which the other clusters were compared regarding metabolic risk factors. Differences from the reference cluster were assessed by using general linear models for risk factors and logistic regressions for the metabolic syndrome. All of the models were adjusted for age, sex, smoking, and PAL in a first step and these variables plus education in a second step. These analyses were performed with and without participants with self-reported diagnoses associated with the metabolic syndrome to avoid bias due to medication use or to changes in diet associated with diagnoses. Women and men were analyzed separately if sex interactions were present. The statistical analyses were performed by using Statistical Analysis Software 9.1 (SAS Institute Inc, Cary, NC).

RESULTS

Dietary patterns

Five distinct dietary patterns were identified by cluster analysis; “healthy”, “sweet”, “coffee”, “traditional” and “fast energy”. The characteristic food intake pattern of each cluster is illustrated in Figure 1 in comparison with the average intake of selected food groups in the 5 clusters together, ie, the bold ring refers to the population mean and the gray figure refers to the relative consumption in the specific cluster in relation to the average intake of each food group. The most common food items in each cluster are shown in Table 1. The “healthy” cluster was characterized by more frequent consumption of high-fiber cereals, fruit and vegetables, low-fat milk products, tea, and fish and less frequent consumption of products rich in fat and sugar, white bread, coffee, beer and spirits. The “sweet” cluster differed from the other clusters by more frequent consumption of sugar, soft drinks, white bread, tea, and sweets and snacks. The “coffee” cluster resembled the whole population even though it was distinguished by frequent consumption of coffee and alcoholic drinks. Distinctive for the “traditional cluster” was consumption of medium-fat milk, offal, boiled coffee, and potatoes and low consumption of low-fat products and alcoholic drinks. Characteristics of the “fast energy” cluster were a frequent consumption of soft drinks, white bread, fast food, full-fat milk, cheese, beer, spirits, sweets and snacks and infrequent consumption of fruit, vegetables, high-fiber products, and low-fat dairy products.

Even though the clusters were distinguished by specific food patterns, some foods were commonly reported in all clusters, as shown in Table 1. Fat cheese, coffee, and bread were generally frequently consumed in the study population. On average, these foods were consumed daily in all clusters, even if the number of servings differed considerably and the choice of bread and coffee...
TABLE 1
Average consumption frequency per week of the most commonly consumed food items (>3 times/portion per week on average), by cluster, on a sliding scale1

<table>
<thead>
<tr>
<th>Healthy (n = 946)</th>
<th>Sweet (n = 145)</th>
<th>Coffee (n = 1404)</th>
<th>Traditional (n = 455)</th>
<th>Fast energy (n = 462)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-meal bread,</td>
<td>Sugar, 31.2 ± 29.8</td>
<td>Filtered coffee,2</td>
<td>Fat cheese, 17.9 ± 16.6</td>
<td>Fat cheese, 21.7 ± 18.9</td>
</tr>
<tr>
<td>16.1 ± 11.1</td>
<td></td>
<td>25.5 ± 11.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat cheese, 14.5 ± 15.4</td>
<td>Tea, 21.0 ± 17.5</td>
<td>Fat cheese, 15.0 ± 14.5</td>
<td>Whole-meal bread, 16.5 ± 12.8</td>
<td>White bread, 21.3 ± 14.4</td>
</tr>
<tr>
<td>10.4 ± 11.2</td>
<td>White bread, 17.6 ± 11.3</td>
<td>Whole-meal bread, 10.4 ± 9.1</td>
<td>Filtered coffee,2 10.7 ± 13.3</td>
<td>Filtered coffee, 17.4 ± 15.8</td>
</tr>
<tr>
<td>Tea, 9.8 ± 11.0</td>
<td>Fat cheese, 14.5 ± 15.4</td>
<td>White bread, 7.6 ± 8.8</td>
<td>Medium-fat milk, 7.7 ± 8.2</td>
<td>Soft drink, 11.2 ± 13.8</td>
</tr>
<tr>
<td>Crisp bread, 9.0 ± 8.7</td>
<td>Soft drinks, 9.4 ± 14.4</td>
<td>Crisp bread, 7.3 ± 8.0</td>
<td>Filtered coffee,2 5.7 ± 9.5</td>
<td>Sugar, 9.0 ± 20.4</td>
</tr>
<tr>
<td>Low-fat milk, 5.7 ± 8.1</td>
<td>Whole-meal bread, 7.2 ± 7.1</td>
<td>Sugar, 5.6 ± 16.2</td>
<td>Crisp bread, 5.5 ± 7.4</td>
<td>Whole-meal bread, 5.1 ± 7.6</td>
</tr>
<tr>
<td>Apple, 4.5 ± 4.1</td>
<td>Crisp bread, 5.9 ± 8.0</td>
<td>Apple, 3.6 ± 3.6</td>
<td>Sugar, 5.1 ± 12.3</td>
<td>Boiled coffee, 4.2 ± 10.9</td>
</tr>
<tr>
<td>Sugar, 4.5 ± 11.4</td>
<td>Filtered coffee,2 5.9 ± 9.3</td>
<td>Tomato, 3.5 ± 2.8</td>
<td>White bread, 4.8 ± 7.7</td>
<td>Delicatessen, 3.4 ± 3.5</td>
</tr>
<tr>
<td>Low-fat cheese, 4.0 ± 10.1</td>
<td>Tomato, 4.7 ± 3.9</td>
<td>Boiled potato, 3.4 ± 2.6</td>
<td>Delicatessen, 4.0 ± 4.4</td>
<td>Medium-fat milk, 3.4 ± 6.7</td>
</tr>
<tr>
<td>Boiled coffee,2 4.0 ± 9.0</td>
<td>Lettuce, 3.7 ± 3.4</td>
<td>Medium-fat milk, 3.3 ± 6.2</td>
<td>Boiled potato, 3.9 ± 3.0</td>
<td>Crisp bread, 3.4 ± 6.9</td>
</tr>
<tr>
<td>Tomato, 4.0 ± 3.0</td>
<td>Apple, 3.6 ± 3.4</td>
<td>Lettuce, 3.0 ± 2.5</td>
<td>Tomato, 3.4 ± 2.8</td>
<td>Full-fat milk, 3.0 ± 7.8</td>
</tr>
<tr>
<td>Low-fat yogurt,4 3.8 ± 5.6</td>
<td>Banana, 3.5 ± 3.9</td>
<td></td>
<td>Apple, 3.3 ± 3.2</td>
<td></td>
</tr>
<tr>
<td>Boiled potato, 3.5 ± 3.5</td>
<td>Medium-fat milk, 3.5 ± 6.7</td>
<td></td>
<td>Soft drinks, 3.2 ± 7.1</td>
<td></td>
</tr>
<tr>
<td>Orange, 3.4 ± 3.5</td>
<td>Onion, 3.4 ± 3.2</td>
<td></td>
<td>Banana, 3.0 ± 2.7</td>
<td></td>
</tr>
<tr>
<td>Banana, 3.3 ± 3.0</td>
<td>Boiled potato, 3.3 ± 3.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals, 3.3 ± 3.4</td>
<td>Mixed vegetables, 3.3 ± 3.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White bread, 3.2 ± 6.0</td>
<td>Orange, 3.2 ± 3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce, 3.2 ± 2.6</td>
<td>Delicatessen, 3.1 ± 3.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots, 3.1 ± 2.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 All values are ñ ± SD.
2 Filtered coffee includes instant coffee, and boiled coffee includes espresso and unfiltered coffee.
3 Yogurt or other cultured milk.

Dietary patterns in relation to cardiovascular disease risk factors

The association between dietary cluster and metabolic syndrome were analyzed in all participants and in the “healthy” participants, ie, those with no self-reported diagnoses associated with the metabolic syndrome. Results are presented separately for women and men because interactions between cluster and sex were significant. Compared with the reference cluster, the risk of metabolic syndrome was higher for women and men in the “fast energy” cluster, after adjustment for age, PAL, and smoking (Table 3). The “fast energy” cluster had a higher risk of all the components in the syndrome, although not significantly so. Having a “sweet” food pattern was associated with elevated plasma glucose and, in men, with low HDL cholesterol and elevated serum triglycerides.

The “healthy” reference cluster was compared with the other clusters with respect to selected metabolic risk factors. Mean values in the “healthy” cluster and significant differences from this cluster are shown in Table 4. The participants in the “healthy” cluster had a significantly lower body mass index (BMI) and waist-to-hip ratio (WHR) than did the other participants, ie, the other clusters combined. When each cluster was compared with the reference, the “traditional” and “fast energy” clusters had a significantly higher BMI and WHR than did the “healthy” cluster. Compared with the reference, blood pressure also tended to be higher in the “fast energy” cluster. Furthermore, serum triglycerides were higher in the “fast energy” cluster, and serum HDL concentrations were lower in the “traditional” and “fast energy” clusters than in the “healthy” cluster when all participants were included in the analyses. Some of these associations were not significant after adjustment for BMI and WHR.

Background characteristics of the clusters

The distribution of demographic, lifestyle, and health characteristics by dietary pattern is shown in Table 2. Individuals in the “healthy” cluster were older and the proportion of women was higher than in the other clusters. The reference pattern (“healthy” pattern) was characterized by subjects with a higher education and a more settled financial position, by a lower proportion of smokers, and a higher proportion of subjects who reported regular physical exercise, dietary supplement use, regular consumption of breakfast, and recent changes in diet. The proportion of self-reported CVD diagnoses and treatments was higher in the “healthy” cluster than in the other clusters. The associations between cluster and previous diagnoses were not independent of age.
FOOD PATTERNS AND CARDIOVASCULAR DISEASE RISK

TABLE 2
Background characteristics by cluster

|                          | Healthy, reference (n = 946) | Sweet (n = 145) | Coffee (n = 404) | Traditional (n = 455) | Fast energy (n = 462) | Total (n = 3412) | P
|--------------------------|-----------------------------|----------------|------------------|----------------------|---------------------|-----------------|---
| **Demographic characteristics** |                             |                |                  |                      |                     |                 | ---
| Age (y)²                 | 53.2 ± 13.0                 | 49.0 ± 13.1    | 51.5 ± 12.2      | 51.1 ± 14.5          | 46.2 ± 13.1         | 51.4 ± 13.1     | <0.0001
| P                        |                             |                |                  |                      |                     |                 | ---
| Sex (% female)           | 62.3                        | 44.1           | 53.0             | 53.4                 | 34.6                | 52.8            | <0.0001
| P                        | <0.0001                    | <0.0001        | 0.006            | <0.0001              | 0.08                |                 | ---
| Married or cohabiting (%)| 75.0                        | 76.3           | 78.3             | 73.6                 | 73.6                | 76.1            | 0.3
| P                        | 0.5                         |                 |                  |                      |                     |                 | ---
| ≥1 child in household (%)| 37.0                        | 51.5           | 46.6             | 45.3                 | 49.3                | 44.3            | <0.0001
|                               |                             |                |                  |                      |                     |                 | 0.008
| Socioeconomic status      |                             |                |                  |                      |                     |                 | ---
| University education (%)  | 37.9                        | 31.0           | 30.8             | 29.5                 | 19.5                | 31.0            | <0.0001
| P                        |                             | <0.0001        |                 |                      |                     |                 | ---
| Small economic buffer (%) | 8.2                         | 11.8           | 10.0             | 12.9                 | 16.6                | 11.3            | 0.0038
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Economic imbalance (%)    | 9.8                         | 16.7           | 8.4              | 11.0                 | 16.4                | 10.6            | 0.39
| P                        |                             |                 |                  |                      |                     |                 | 1.0
| Dietary behavior          |                             |                |                  |                      |                     |                 | ---
| Cooked food ≥ twice a day (%) | 32.6                       | 36.8           | 33.4             | 34.8                 | 21.4                | 31.9            | 0.6
| P                        |                             |                 |                  |                      |                     |                 | 0.3
| Sandwiches per week²      | 28.3 ± 16.2                 | 30.7 ± 17.1    | 25.3 ± 15.2      | 26.8 ± 16.5          | 29.8 ± 17.9         | 27.2 ± 16.3     | 0.8
| P                        |                             |                 |                  |                      |                     |                 | 0.3
| No breakfast (%)          | 6.1                         | 12.4           | 10.0             | 11.0                 | 15.8                | 10.0            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Liquid fat used in cooking (%) | 83.8                      | 86.1           | 79.8             | 76.2                 | 76.1                | 80.2            | 0.001
| P                        |                             |                 |                  |                      |                     |                 | 0.002
| No fat used on sandwich (%) | 25.8                      | 13.1           | 17.7             | 14.6                 | 8.2                 | 18.0            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Large amount of fat used on sandwich (%) | 5.1                      | 11.0           | 10.9             | 13.0                 | 22.3                | 11.1            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Regular dietary supplement use (%) | 27.1                    | 17.0           | 20.3             | 20.3                 | 12.7                | 21.0            | <0.0001
|                             |                             |                 |                  |                      |                     |                 | <0.0001
| Frequent consumption of raw vegetables (%) | 72.1                    | 67.9           | 70.5             | 63.7                 | 59.5                | 68.4            | 0.005
| P                        |                             |                 |                  |                      |                     |                 | 0.002
| Dietary changes in past 5 y (%) | 52.0                      | 36.1           | 41.5             | 35.2                 | 27.9                | 41.2            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Dietary changes in past 1 y (%) | 39.9                      | 31.0           | 30.6             | 32.4                 | 27.0                | 32.8            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| **Other health behaviors** |                             |                |                  |                      |                     |                 | ---
| Current smoker (%)        | 10.5                        | 22.4           | 20.2             | 14.8                 | 27.6                | 17.9            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| Alcohol consumption (g)²  | 7.6 ± 7.7                   | 7.2 ± 6.7      | 9.2 ± 8.5        | 6.6 ± 7.8            | 8.8 ± 10.3          | 8.2 ± 8.4       | 0.8
| P                        |                             |                 |                  |                      |                     |                 | 0.01
| Regular physical exercise (%) | 32.1                      | 23.4           | 27.0             | 24.4                 | 20.0                | 27.0            | <0.0001
| P                        |                             |                 |                  |                      |                     |                 | <0.0001
| **Self-reported health**  |                             |                |                  |                      |                     |                 | ---
| Poor perceived health (%) | 23.8                        | 30.6           | 20.8             | 27.9                 | 29.4                | 24.2            | 0.7
| P                        |                             |                 |                  |                      |                     |                 | 0.1
| Diabetes (%)              | 5.0                         | 2.1            | 2.6              | 5.7                  | 2.0                 | 3.6             | 0.007
| P                        |                             |                 |                  |                      |                     |                 | 0.9
| Hypertension (%)          | 18.6                        | 15.2           | 16.0             | 18.0                 | 11.5                | 16.3            | 0.03
| P                        |                             |                 |                  |                      |                     |                 | 0.7
| Hypercholesterolemia (%)  | 12.7                        | 9.0            | 12.3             | 10.8                 | 8.7                 | 11.6            | 0.2
| P                        |                             |                 |                  |                      |                     |                 | 0.8
| History of prior heart attack (%) | 3.4                       | 2.1            | 1.6              | 2.4                  | 2.2                 | 2.3             | 0.009
| P                        |                             |                 |                  |                      |                     |                 | 0.04
| Use of antihypertensive medication (%) | 21.0                      | 13.8           | 15.6             | 17.3                 | 9.2                 | 15.6            | 0.0006
| P                        |                             |                 |                  |                      |                     |                 | 0.1
| Use of serum lipid-lowering medication (%) | 9.6                       | 5.2            | 7.1              | 9.8                  | 5.2                 | 7.8             | 0.03

1 P values indicate differences between the reference cluster and all other clusters combined. The calculations were performed by using general linear models and logistic regressions. The last column reflects adjustments for age and sex.
2 All values are ± SD.
3 P values indicate differences from the reference cluster. The calculations were performed by using general linear models and logistic regressions.
4 Unable to raise SEK 14 000 (€1500) within 1 wk.
5 Difficulty paying bills, rent, and food during the past year.
6 Reflects the 2 last categories in the scale: excellent, good, moderate, and poor.

When subjects with a previous diagnosis were excluded, the same trend as for all participants was observed, even if the other associations became significant for the blood lipids. The analyses in Table 4 showed similar results when additionally adjusted for education.

DISCUSSION

We identified 5 unique dietary patterns, of which 1 was associated with a better CVD risk factor profile. Variations in healthy clusters were observed in previous studies, and some showed similarities with the present study (24–30), although based on different clustering methods of various dietary data in various populations. Thus, it seems that dietary recommendations that encompass several dimensions of a health-promoting diet (eg, consumption of vegetables, fruit, and fish and low-fat and highfiber products) are adopted by some persons. Other characteristics of a healthy pattern, which also have been identified in previous research, are the consumption of dietary supplements (24, 28, 31) and the regular consumption of breakfast (32). In addition to identifying divergent food patterns, the results also indicate some general Swedish food patterns. Bread, cheese, coffee, and milk were frequently consumed food groups in all clusters, which indicated that it might be useful to include information on alternatives to these foods in dietary guidelines.

Persons in the “healthy” diet cluster had a higher socioeconomic status, smoked less, and exercised more than did the population as a whole, which indicates a generally healthy lifestyle. On the other hand, they reported more CVD diagnoses and treatments. These diagnoses and treatments were significantly associated with recent
dietary changes (data not shown). Medical treatment might improve the risk factor profile, and dietary advice may result in reporting healthier food choices as a matter of what is desired and as a reflection of actual changes. Indeed, some previous studies have observed that a healthier eating pattern is associated with consuming a medically prescribed diet (6, 33), reporting changed food habits (34, 35), or having a diagnosis of cancer, arthritis, heart disease (6), or diabetes (36). Thus, the results indicate that a healthy food pattern is associated with a better risk factor profile, although recognized risk is probably an important reason for adopting these dietary behaviors, despite the fact that half of those in this cluster had made dietary changes during the past 5 years indicating that they recently consumed a less healthy diet.

According to a review by Giugliano et al (37), many diets high in refined starch, sugar, and saturated and trans fat and low in n-3 fatty acids and natural antioxidants and fiber from fruit, vegetables, and whole grains cause the inflammation associated with the metabolic syndrome by affecting the immune system. In the present study, the “fast energy” food pattern was associated with the metabolic syndrome and characterized by a frequent

**Table 3**

Prevalences (age adjusted) and odds ratios (ORs) and 95% CIs for the metabolic syndrome and the components of the metabolic syndrome by cluster and stratified by sex.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>No. of subjects (n)</th>
<th>Women</th>
<th></th>
<th></th>
<th></th>
<th>Men</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Sweet</td>
<td>Coffee</td>
<td>Traditional</td>
<td>Fast energy</td>
<td>Healthy</td>
<td>Sweet</td>
<td>Coffee</td>
<td>Traditional</td>
</tr>
<tr>
<td>Metabolic syndrome (%)</td>
<td>1142</td>
<td>9.1</td>
<td>10.6</td>
<td>7.0</td>
<td>13.9</td>
<td>19.9</td>
<td>1099</td>
<td>1</td>
<td>1.1 (0.4, 3.4)</td>
</tr>
<tr>
<td>Central obesity (%)</td>
<td>1291</td>
<td>23.6</td>
<td>20.4</td>
<td>21.0</td>
<td>27.7</td>
<td>31.3</td>
<td>1241</td>
<td>1</td>
<td>0.7 (0.3, 1.6)</td>
</tr>
<tr>
<td>Elevated BP (%)</td>
<td>1350</td>
<td>39.7</td>
<td>39.9</td>
<td>41.6</td>
<td>45.3</td>
<td>50.5</td>
<td>1300</td>
<td>1</td>
<td>1.0 (0.5, 2.1)</td>
</tr>
<tr>
<td>Low HDL concentration (%)</td>
<td>1213</td>
<td>21.7</td>
<td>28.4</td>
<td>14.9</td>
<td>26.0</td>
<td>33.4</td>
<td>1217</td>
<td>1</td>
<td>1.1 (0.5, 2.4)</td>
</tr>
<tr>
<td>Elevated plasma glucose (%)</td>
<td>1212</td>
<td>0.8</td>
<td>4.9</td>
<td>1.9</td>
<td>3.0</td>
<td>2.8</td>
<td>1167</td>
<td>1</td>
<td>15.1 (2.2, 103.7)</td>
</tr>
<tr>
<td>Elevated TG concentration (%)</td>
<td>1211</td>
<td>13.2</td>
<td>20.9</td>
<td>9.4</td>
<td>18.6</td>
<td>21.5</td>
<td>1168</td>
<td>1</td>
<td>1.7 (0.7, 3.8)</td>
</tr>
</tbody>
</table>

† Odds ratio and 95% CIs were adjusted for age, smoking, and physical activity level in logistic regressions. All overall P values for the models were < 0.01. TG, triglyceride; BP, blood pressure.

2 Excludes participants with self-reported diabetes, prior myocardial infarction, hypertension, hypercholesterolemia, and use of lipid-lowering or antihypertensive medication.

3 Defined by the National Cholesterol Education Program Adult Treatment Panel III as ≥3 of the following: central obesity (waist circumference ≥88 cm in women and ≥102 cm in men), elevated serum TG (≥1.7 mmol/L), low HDL cholesterol (<1.03 mmol/L in men and <1.29 mmol/L in women), elevated BP (130 mm Hg systolic or 85 mm Hg diastolic), elevated fasting plasma glucose (≥6.1 mmol/L).

4 Significant (P < 0.05) when all participants in the analyses were included.

5 Not significant (P > 0.05) when all participants were included in the analyses.

6 Interactions between sex and cluster were significant (P < 0.05) for the analysis of TGs in participants with no cardiovascular disease diagnosis or treatment.
consumption of full-fat milk products and foods rich in refined carbohydrates, and a low consumption of fruit, vegetables, nuts, and whole grains. This cluster was also associated with high consumption of soft drinks which support the association between metabolic syndrome and soft drink consumption observed in a previous study (38).

Although conclusions are inconsistent (39) in studies examining the association between food patterns and anthropometric measures, several studies have found food cluster differences in central or general obesity or anthropometric measures. In studies in which a more healthy cluster can be identified, BMI or WHR tended to be low (although not always the lowest) compared with clusters with less healthy food patterns (6, 14, 25, 26, 28, 29, 33, 36, 40). Even so, many reported associations were not significant, and inverse associations were found in some studies (27, 30, 41). Prospective studies have found a healthy food pattern to be protective against overweight (34) and to prevent increases in BMI and waist circumference (24). In the present study, both BMI and WHR were significantly lower in the “healthy” food cluster than in 2 of the other clusters, which might support the current dietary recommendations for a healthy weight.

In the Framingham Study (25), a “heart healthy” cluster had a lower average systolic blood pressure than did the “empty calorie” and “wine and moderate eating” clusters, but in most studies no significant associations were observed for blood pressure or hypertension (13, 30, 36). The present study found lower blood
pressure levels in the healthy cluster than in the “fast energy” cluster. A lower body weight, a lower alcohol consumption, and a higher consumption of fruit and vegetables might contribute to this.

Some studies using cluster analysis have observed associations between food pattern and serum lipids (13, 25, 30, 33, 36, 42, 43). In general, a pattern characterized by high alcohol consumption has been shown to be associated with high serum HDL cholesterol (25, 33, 43, 44). In the present study, mean serum HDL cholesterol as well as alcohol consumption was highest in the “coffee” cluster. Mean HDL cholesterol was also significantly higher in the “healthy” cluster than in the “traditional” and “fast energy” clusters, probably as a result of the higher weight in the 2 latter clusters, as indicated by the results. This also seems to be one explanation for the higher average serum triglyceride concentration in “fast energy” cluster than in the “healthy” reference cluster.

A limitation of the present study was that the examinations were not standardized to the morning or fasting overnight. That the blood samples were drawn at different times of the day probably affected the plasma glucose and serum triglycerides values. That the fasting duration was only ≥4 h might also have influenced the results, but probably only to a limited extent (45, 46). Furthermore, overreporting of foods considered to be healthy and underreporting of other foods may selectively misclassify individual to clusters. Such biases might be associated with nutritional knowledge, which in turn might be a result of diagnosed risk factors. The low response rate might also have biased the picture of the food patterns in the population. It is less likely that the associations observed are a result of a selection bias. Non-participation may affect the results if it is associated with CVD risk and eating patterns, eg, if obese individuals with a healthy food pattern are overrepresented among the dropouts.

We decided to base the cluster analysis on servings and frequency of several foods. An important concept in cluster analyses is to explore relations between dietary guidelines to the public and health outcomes, and these guidelines are usually expressed in terms of servings. Cluster and factor analyses are often referred to as empirically derived and, therefore, are not expressed in terms of servings. Cluster and factor analyses are based on highly aggregated food groups that, in turn, are formed by the presence or absence of certain nutrients and components known to be related to the outcome variables. One of the reasons for aggregating foods into a limited number of food groups is to avoid exclusion of subjects due to missing data; however, this might be done at the sacrifice of identification of key food behaviors with implications for health. If these analyses should be data driven and combine information of many aspects of the diet, they must be based on intake of food categories reflecting both cultural and nutrient differences. Probably, much information about cultural and/or nutrient-specific patterns would be lost if, for example, milk products with varying fat content are grouped together or if noncaloric beverages are excluded or grouped into one food category. In the present study, tea consumption was associated with a “healthy” food pattern, soft drinks with a “fast energy” pattern, and boiled coffee with a “traditional” pattern. Potentially, beverages can be used as markers for more or less healthy behaviors, as suggested by Duffey and Popkin (47).

In conclusion, in the present population, the cluster of subjects consuming a “healthy” diet had better anthropometric, blood pressure, and blood lipid values than did the other dietary patterns. The group of people with this healthy pattern were distinguished from the population in general by more frequent consumption of high-fiber cereals, low-fat milk products, fruit, vegetables, tea, and fish and less frequent consumption of products rich in fat and sugar, coffee, beer, and spirits, or in other words a diet corresponding with the current recommendations. However, the fact that the diagnosis of disease or risk seems to be an important motive for conforming to dietary recommendations (or reporting to do so) has to be taken into consideration in future research, because medical treatment and biased reporting might lead to erroneous conclusions regarding the associations between healthy food patterns and health outcomes.

The authors’ responsibilities were as follows—CMB: designed the study, conducted and synthesized the analyses, and wrote the manuscript; NA and GL: provided statistical support and advice; KT, DST, LL, and AR: designed the research program and organized and founded the data collection; DST, LL, and AR: contributed to the study design and manuscript; ES: coordinated the data bank; and AW: developed the FFQ. All authors read and approved the final version of the manuscript. No conflicts of interest were reported.

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