# Patterns of food consumption and risk factors for cardiovascular disease in the general Dutch population[1–3]

*Rob M van Dam, Linda Grievink, Marga C Ocké, and Edith JM Feskens*

**ABSTRACT**
**Background:** Few studies have examined food consumption patterns in relation to biological risk factors for cardiovascular disease.
**Objective:** The objective of the study was to describe food consumption patterns in the general Dutch population and their association with cardiovascular risk factors.
**Design:** We performed a cross-sectional study of 19 750 randomly selected men and women aged 20–65 y from 3 Dutch municipalities. Food consumption patterns were identified with the use of factor analysis of data from a validated food-frequency questionnaire.
**Results:** Three food consumption patterns were identified: the "cosmopolitan" pattern (greater intakes of fried vegetables, salad, rice, chicken, fish, and wine), the "traditional" pattern (greater intakes of red meat and potatoes and lesser intakes of low-fat dairy and fruit), and the "refined-foods" pattern (greater intakes of French fries, high-sugar beverages, and white bread and lesser intakes of whole-grain bread and boiled vegetables). Higher scores for the traditional pattern were associated with older age, and higher scores for the refined-foods pattern were associated with younger age, but both were associated with lower educational level, cigarette smoking, less physical activity, and higher body mass index. Independent of other lifestyle factors and body mass index, the cosmopolitan-pattern score was significantly associated with lower blood pressure and higher HDL-cholesterol concentrations, and the traditional-pattern score was associated with higher blood pressure and higher concentrations of HDL cholesterol, total cholesterol, and glucose. The refined-foods-pattern score was associated with higher total cholesterol concentrations and lower intakes of micronutrients.
**Conclusion:** In this Dutch population, food consumption patterns were independently associated with blood pressure and plasma glucose and cholesterol concentrations. *Am J Clin Nutr* 2003;77:1156–63.

**KEY WORDS** Dietary patterns, factor analysis, plasma cholesterol, blood pressure, plasma glucose, population-based study, cardiovascular disease, Netherlands

## INTRODUCTION

Results from the Dietary Approaches to Stop Hypertension trial (1) and the Lyon Diet Heart study (2) indicated that interventions to change dietary patterns can be highly effective in reducing cardiovascular disease (CVD) risk. However, the intervention diets in those trials were very different from common dietary patterns in Western populations (3). Information on CVD risk associated with existing food consumption patterns in the general population may help in prioritizing public health efforts. Furthermore, insight into patterns of food use may contribute to successful implementation of dietary changes. People choose foods and combinations of foods rather than isolated nutrients, and practical dietary advice to the public in terms of foods is preferred (4). Dietary changes may be more readily achieved if recommended foods are compatible with existing patterns of food consumption.

Factor analysis emerged as a useful method for the identification of dietary patterns on the basis of a correlation matrix of food intakes. Several studies successfully used this technique to identify interpretable patterns of food consumption (5–14). However, factor analysis of food consumption was used in only a few (mainly Anglo-Saxon) countries, and it is not clear whether meaningful and comparable patterns can be identified by factor analysis in other populations. Furthermore, data on food consumption patterns in relation to CVD risk factors are sparse (6, 10, 14), particularly with regard to blood pressure and plasma glucose (10). We examined food consumption patterns and their association with sociodemographic and lifestyle variables, nutrient intakes, and biological risk factors for CVD in a large sample of the general Dutch population.

## SUBJECTS AND METHODS

### Study population

The Monitoring Project on Risk Factors and Chronic Diseases in the Netherlands (MORGEN Study) was a cross-sectional study of men and women aged 20–65 y, who were examined between

[1] From the Department of Chronic Diseases Epidemiology (RMvD, MCO, and EJMF) and the Laboratory of Exposure Assessment and Environmental Epidemiology (LG), National Institute for Public Health and the Environment, Bilthoven, Netherlands.

[2] Supported by research grant 2000.210 from the Netherlands Heart Foundation (RMvD). The Monitoring Project on Risk Factors and Chronic Diseases in the Netherlands (MORGEN) Study was supported by the Ministry of Health, Welfare and Sport of the Netherlands, the National Institute of Public Health and the Environment, and the Europe Against Cancer Program of the European Union.

[3] Reprints not available. Address correspondence to RM van Dam, Department of Nutrition and Health, Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands. E-mail: rob.van.dam@falw.vu.nl.

Received November 8, 2001.
Accepted for publication April 11, 2002.

1993 and 1997 (15). The study included questionnaires and a physical examination at a Municipal Health Service site. The Medical-Ethical Committee of the TNO Nutrition and Food Research Institute (Zeist, Netherlands) approved the protocol of the MORGEN Study.

Participants were a random sample (stratified by sex and 5-y age groups) from the civil registries of Amsterdam (in the western part of the Netherlands) and Maastricht (in the southern part). In Doetinchem (in the eastern part), the study cohort consisted of persons who had participated in a previous monitoring project (1987–1991) (16) and of a new random sample of persons aged 20–25 y to cover the whole age range. The response rate was 33% in Amsterdam, 45% in Maastricht, and 68% in Doetinchem, for a total of 22 769 participants.

We excluded from the current analysis participants who reported diabetes mellitus ($n$ = 300), myocardial infarction ($n$ = 275), stroke ($n$ = 196), or use of a special diet for medical or other reasons ($n$ = 2078), because these conditions may affect the reporting of the usual diet. We also excluded participants who were pregnant during the study ($n$ = 142), those for whom information on potential confounders was missing ($n$ = 450), and those with > 14 missing answers or large inconsistencies (eg, between the reported frequency of warm meals and the frequency of foods typically eaten with warm meals) on the dietary questionnaire ($n$ = 94). After these exclusions, the study sample comprised 19 750 persons (9321 men and 10 429 women). Participants taking antihypertensive medication ($n$ = 690) were excluded from analyses of blood pressure, and those taking cholesterol-lowering medication ($n$ = 97) were excluded from analyses of total and HDL cholesterol.

### Dietary and other questionnaires

We used the participants' responses to a self-administered food-frequency questionnaire to assess the habitual consumption of 178 food items during the previous year (17). For 79 main food items, frequency of consumption could be indicated as never or in times per day, week, month, or year. For 28 food items, questions referred to portion sizes shown in color photographs. For other foods, a commonly used unit or portion size was specified. The questionnaire also included questions on consumption of sub-items (eg, brown rice, white rice, and fried rice), use of additives (eg, sugar), use of supplements, special diets, and brand names of fats used on bread and for cooking. Nutrient intake was calculated by multiplying the frequency of use of each food by the portion size and by the nutrient content per gram. Values for nutrient contents of foods were obtained from the 1996 Dutch food composition table (18), supplemented with information from other sources for *trans* fatty acids (19) and folate (20).

The relative validity of the food-frequency questionnaire was assessed among 121 men and women, by comparison with the average of 12 monthly 24-h recalls (17, 21). The median Spearman's correlation coefficient (ρ) for food groups was 0.61 for men and 0.51 for women (17). For nutrient intakes among men and women, respectively, Pearson's correlation coefficients ($r$) (energy-adjusted and corrected for intraindividual variation in 24-h recalls) were 0.71 and 0.67 for protein, 0.61 and 0.63 for fat, 0.74 and 0.76 for carbohydrates, 0.85 and 0.87 for alcohol, 0.61 and 0.74 for fiber, 0.43 and 0.71 for vitamin C, and 0.58 and 0.41 for vitamin E (21). The correlation between questionnaire-assessed protein intake and 24-h urinary nitrogen excretion (corrected for intraindividual variation in excretion) was 0.56 for men and 0.69 for women (21).

We used the participants' responses to a self-administered questionnaire to assess the presence of known diabetes, history of myocardial infarction and stroke, medication use, parental history of diabetes, parental history of myocardial infarction before age 60 y, educational level, physical activity of at least moderate intensity (22, 23), alcohol consumption, and cigarette smoking.

### Physical examinations

Physical examinations were conducted by trained paramedics according to a standardized protocol. Weight (to the nearest 100 g on calibrated scales) and height (to the nearest 0.5 cm) were measured while the participants were wearing only light indoor clothing and no shoes. We calculated the body mass index (BMI) as weight (kg) divided by height (m) squared. Systolic blood pressure was measured twice on the left arm with a random-zero sphygmomanometer while each participant was in sitting position. The mean value of the 2 measurements was used. Nonfasting venous blood samples were collected, and glucose and cholesterol concentrations were determined in the Lipid Reference Laboratory of the Academic Dijkzigt Hospital in Rotterdam. Plasma glucose concentrations were measured by using the hexokinase method. Total cholesterol concentrations were measured enzymatically using the CHOD-PAP mono-test kit (Boehringer Mannheim, Mannheim, Germany; 24). HDL-cholesterol concentrations were determined by the same method after VLDL and LDL were precipitated from the specimen with phosphotungstic acid and magnesium chloride (25).

### Statistical analysis

To identify dietary patterns, we applied factor analysis to data from the food-frequency questionnaire. First, food items that were similar in nutrient profile and culinary use were combined (eg, lean pork and lean beef were combined into lean red meat), which resulted in 46 food groups. Intake of these food groups was adjusted for total energy intake with the use of the residual method (26) to obtain factors uncorrelated with total energy intake.

Second, we applied the principal components procedure for factor analysis of SAS software (27) to the 46 food groups. The resulting factors are linear combinations of the included variables that explain as much of the variation in the original variables as possible. Varimax rotation was applied to obtain orthogonal (uncorrelated) factors. Use of common factor analyses or oblique rotation (resulting in correlated factors) yielded similar factors. We chose to present results from principal component analysis because this is the simplest type of factor analysis and it was used in most previous reports on dietary patterns. To determine the number of factors to retain we used the Scree plot, a plot of the eigenvalues of derived factors. The eigenvalues of the factors dropped substantially after the second (from 2.69 to 2.00) and the third (from 2.00 to 1.74) factor and remained more similar after the fourth factor (1.66 for the fifth and 1.57 for the sixth factor), which suggests that retaining 2 or 3 factors would be optimal. We decided to retain 3 factors because this approach yielded factors that were more interpretable and similar in subgroups by sex and municipality.

Finally, dietary pattern scores were calculated by summing the standardized intake of foods, weighted by the factor loadings of the foods. These scores rank individuals according to the degree to which they conformed with each food consumption pattern. Thus, each participant had a score for all 3 identified food consumption patterns.

**TABLE 1**
Factor-loading matrix for the food consumption patterns identified among participants in the MORGEN Study, 1993–1997[1]

| | Mean intake | Cosmopolitan pattern | Traditional pattern | Refined-foods pattern |
|---|---|---|---|---|
| | *g/d* | | | |
| Vegetable oils | 3.8 | 0.67 | — | — |
| Garlic | 0.2 | 0.67 | — | — |
| Fried vegetables | 10.9 | 0.56 | — | — |
| White rice | 19.7 | 0.50 | — | — |
| Salad vegetables | 34.0 | 0.50 | — | — |
| Brown rice | 6.3 | 0.40 | −0.21 | — |
| Chicken | 13.0 | 0.37 | 0.19 | — |
| Fish | 9.8 | 0.33 | — | — |
| Wine | 45.0 | 0.32 | — | −0.16 |
| Pasta | 35.3 | 0.32 | — | — |
| Warm sauces | 17.9 | 0.32 | — | 0.23 |
| Organ meat | 1.1 | 0.24 | 0.20 | — |
| Water | 342.1 | 0.20 | — | — |
| Added sugar | 31.0 | −0.25 | — | — |
| Added fat | | | | |
| <0.35 SFA/g fat | 11.5 | −0.30 | — | −0.18 |
| ≥0.35 g SFA/g fat | 12.5 | — | 0.35 | — |
| Red meat | | | | |
| >0.05 g fat/g | 44.4 | — | 0.58 | — |
| ≤0.05 g fat/g | 21.1 | — | 0.47 | — |
| Processed meat | 41.2 | — | 0.49 | — |
| Potatoes | 93.4 | −0.33 | 0.41 | −0.20 |
| Coffee | 564.8 | −0.17 | 0.34 | −0.19 |
| Beer | 156.5 | — | 0.32 | — |
| Eggs | 17.2 | — | 0.25 | — |
| Spirits | 7.9 | — | 0.17 | — |
| Soup | 76.3 | — | — | — |
| Nuts | 10.6 | — | −0.21 | — |
| Dairy | | | | |
| >0.02 g fat/g | 130.2 | −0.21 | −0.25 | −0.20 |
| ≤0.02 g fat/g | 252.4 | — | −0.41 | −0.17 |
| Juice | 82.8 | — | −0.28 | — |
| Fruit | 165.2 | — | −0.31 | −0.23 |
| Pastries | 26.8 | −0.17 | −0.33 | — |
| Tea | 250.7 | — | −0.34 | — |
| Breakfast cereals | 4.2 | — | −0.40 | — |
| Soy products | 2.2 | 0.21 | −0.47 | — |
| French fries | 29.9 | — | 0.22 | 0.54 |
| High-sugar beverages | 118.9 | — | — | 0.54 |
| Mayonnaise | 6.4 | 0.15 | — | 0.42 |
| Salty snacks | 13.6 | — | — | 0.42 |
| White bread | 44.4 | — | 0.17 | 0.40 |
| Low-sugar beverages | 35.5 | — | — | 0.34 |
| Candy | 14.2 | — | —0.25 | 0.31 |
| Pizza | 12.8 | 0.22 | —0.23 | 0.27 |
| Legumes | 9.5 | — | — | —0.17 |
| Cheese | 35.5 | — | —0.17 | —0.25 |
| Boiled vegetables | 76.1 | — | 0.17 | —0.34 |
| Whole-grain bread | 113.6 | — | — | —0.52 |

[1] Factor loadings between −0.15 and 0.15 are not shown for simplicity. The patterns were identified by principal component analysis with the use of energy-adjusted food intake. SFAs, saturated fatty acids; MORGEN, Monitoring Project on Risk Factors and Chronic Diseases in the Netherlands.

We used Pearson's correlation coefficients for correlations with nutrient intakes and linear regression analysis for associations with biological risk factors. We calculated adjusted means and prevalences according to quintiles of dietary pattern scores by using analysis of covariance. *P* values for trend were calculated with quintiles of dietary pattern scores modeled as continuous variables. All *P* values were two-sided.

## RESULTS

### Food consumption patterns

The factor loadings of foods for the 3 identified dietary patterns are shown in **Table 1**. The factor loading of a food increases as the contribution to the corresponding dietary pattern score increases. The factor that we labeled the "cosmopolitan"

**TABLE 2**
Pearson's correlation coefficients (*r*) for dietary pattern scores and nutrient intakes among participants in the MORGEN Study, 1993–1997[1]

| | Cosmopolitan pattern | Traditional pattern | Refined-foods pattern |
|---|---|---|---|
| Total fat (% of energy intake) | −0.03 | 0.27 | 0.06 |
| Saturated fat (% of energy intake) | −0.24 | 0.16 | −0.08 |
| Monounsaturated fat (% of energy intake) | 0.03 | 0.35 | 0.25 |
| Polyunsaturated fat (% of energy intake) | 0.21 | 0.06 | −0.04 |
| *trans* Fat (% of energy intake) | −0.14 | 0.24 | 0.43 |
| Protein (% of energy intake) | 0.04 | 0.06 | −0.28 |
| Carbohydrate (% of energy intake) | −0.18 | −0.45 | 0.16 |
| Alcohol (drinks/d) | 0.24 | 0.28 | −0.13 |
| Cholesterol (g/d) | 0.07 | 0.49 | −0.08 |
| Fiber (g/d) | −0.05 | −0.05 | −0.48 |
| Magnesium (g/d) | 0.05 | −0.09 | −0.45 |
| Calcium (g/d) | −0.05 | −0.41 | −0.35 |
| Vitamin B-6 (g/d) | 0.05 | 0.29 | −0.19 |
| Folate (g/d) | 0.26 | 0.20 | −0.31 |
| Vitamin C (g/d) | 0.23 | −0.32 | −0.17 |
| Vitamin E (g/d) | 0.22 | 0.06 | −0.05 |

[1] The food consumption patterns were derived from energy-adjusted food intake, and dietary pattern scores were uncorrelated with total energy intake. MORGEN, Monitoring Project on Risk Factors and Chronic Diseases in the Netherlands. All correlations significant at $P < 0.0001$.

pattern was characterized by greater consumption of vegetable oils, garlic, fried vegetables, salad vegetables, rice, pasta, chicken, fish, and wine and lesser consumption of potatoes. The "traditional" pattern was characterized by greater consumption of red meat, potatoes, highly saturated added fat, coffee, and beer and lesser consumption of soy products, low-fat dairy, breakfast cereals, tea, and fruit. The "refined-foods" pattern was characterized by greater consumption of French fries, high-sugar beverages, mayonnaise, salty snacks, white bread, and candy and lesser consumption of whole-grain bread and boiled vegetables. The 3 patterns overall explained 18.4% (7.0, 6.4, and 5.1%, respectively) of the variations in food intake.

To examine the stability of the derived food consumption patterns, we conducted factor analyses within subgroups by municipality and sex. Essentially the same 3 patterns were identified in each subgroup. In groups by municipality, Pearson's correlation coefficients with pattern scores derived for the entire study population ranged from 0.88 to 0.99. In groups by sex, these correlations were ≥0.96 for all pattern scores.

### Correlations with nutrient intakes

Higher cosmopolitan-pattern scores were significantly associated with a lower intake of saturated fat and higher intakes of polyunsaturated fat, alcohol, folate, vitamin C, and vitamin E (**Table 2**). The traditional-pattern score was associated with higher intakes of fat and cholesterol and lower intakes of carbohydrates, calcium, and vitamin C. Although correlations between pattern scores and nutrient intakes were generally similar for the men and the women, sex differences were observed for the correlation of the traditional-pattern score with intakes of alcohol (men: $r = 0.31$; women: $r = 0.14$), vitamin B-6 (men: $r = 0.26$; women: $r = 0.09$), and folate (men: $r = 0.17$; women: $r = 0.03$). The lower correlation of the traditional-pattern score with beer consumption in the women (men: $r = 0.33$; women: $r = 0.10$) probably contributed to these sex differences. The refined-foods-pattern score was associated with higher intakes of *trans* fatty acids and lower intakes of protein, fiber, vitamins, and minerals.

### Sociodemographic characteristics, lifestyle, and time trends

The men had a higher mean traditional-pattern score than did the women [age-adjusted difference 0.48 (95% CI: 0.45, 0.51); one unit of the scores is 1 SD]. Differences between the men and the women were small for the other dietary pattern scores [scores for the women were 0.05 (95% CI: 0.02, 0.08) higher for the cosmopolitan pattern and 0.12 (95% CI: 0.09, 0.14) higher for the refined-foods pattern].

The means and percentages of demographic and lifestyle characteristics by quintiles of dietary pattern scores are shown in **Table 3**. Higher cosmopolitan-pattern scores were associated with a higher educational level, more leisure physical activity, light cigarette smoking (<10 cigarettes/d), and supplement use. The traditional-pattern score was associated with older age (≥50 y), and the refined-foods-pattern score was associated with younger age (<30 y), but both were associated with a lower educational level, less leisure physical activity, less supplement use, heavy cigarette smoking (≥10 cigarettes/d), and higher BMI.

The traditional-pattern score decreased between 1993 and 1997 [$\beta = -0.19$ (95% CI: −0.23, −0.14) per 5 y, adjusted for age, sex, municipality, and educational level]. In contrast, the scores for the cosmopolitan pattern [$\beta = 0.24$ (95% CI: 0.20, 0.29)] and the refined-foods pattern [$\beta = 0.26$ (95% CI: 0.22, 0.31)] increased significantly ($P < 0.0001$).

### Biological risk factors of cardiovascular disease

Regression coefficients for the association between dietary pattern scores and biological risk factors are shown in **Table 4**. Dietary pattern scores were expressed as the difference between the medians of the lowest and highest quintiles. Higher traditional-pattern scores were associated with a higher systolic blood pressure and higher total cholesterol and glucose concentrations. These associations were attenuated after adjustment for other risk factors (physical activity, smoking, educational level, family history of diabetes and myocardial infarction, BMI), but they remained significant, except for total cholesterol in the women. After multivariate adjustment, the traditional-pattern score was

**TABLE 3**
Demographic and lifestyle characteristics by quintile of dietary pattern scores among participants in the MORGEN Study, 1993–1997[1]

| | Quintile of cosmopolitan-pattern score | | | | | Quintile of traditional-pattern score | | | | | Quintile of refined-foods-pattern score | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Age (%) | | | | | | | | | | | | | | | |
| ≥50 y | 37 | 31 | 27 | 24 | 21[2] | 18 | 26 | 29 | 31 | 36[2] | 47 | 36 | 28 | 20 | 10[2] |
| 30–50 y | 47 | 52 | 55 | 58 | 60[2] | 55 | 53 | 54 | 55 | 54 | 46 | 56 | 59 | 60 | 51[2] |
| <30 y | 16 | 17 | 18 | 18 | 19[3] | 27 | 21 | 17 | 14 | 10[2] | 6 | 8 | 13 | 21 | 40[2] |
| Education (%)[4] | | | | | | | | | | | | | | | |
| High | 11 | 16 | 24 | 32 | 40[2] | 41 | 29 | 23 | 19 | 12[2] | 32 | 29 | 28 | 21 | 13[2] |
| Medium | 25 | 28 | 29 | 30 | 27[3] | 29 | 31 | 29 | 27 | 24[2] | 28 | 28 | 28 | 28 | 27 |
| Low | 64 | 55 | 47 | 37 | 33[2] | 31 | 41 | 48 | 54 | 65[2] | 40 | 43 | 44 | 51 | 59[2] |
| BMI ($kg/m^2$) | 24.8 | 25.0 | 24.9 | 24.7 | 24.7[3] | 23.9 | 24.5 | 24.9 | 25.2 | 25.6[2] | 24.0 | 24.5 | 24.8 | 25.2 | 25.6[2] |
| Physical activity (h/wk)[5] | 4.3 | 4.4 | 4.6 | 4.9 | 5.0[2] | 5.8 | 5.0 | 4.5 | 4.2 | 3.7[2] | 5.5 | 5.0 | 4.7 | 4.3 | 3.8[2] |
| Cigarette smoking (%) | | | | | | | | | | | | | | | |
| Never | 39 | 37 | 34 | 32 | 30[2] | 44 | 39 | 36 | 30 | 23[2] | 37 | 35 | 35 | 33 | 33[2] |
| Current, <10/d | 8 | 8 | 10 | 11 | 14[2] | 11 | 11 | 10 | 11 | 8[2] | 11 | 11 | 11 | 10 | 9[3] |
| Current, ≥10/d | 28 | 26 | 25 | 26 | 27 | 14 | 19 | 24 | 31 | 46[2] | 22 | 24 | 24 | 29 | 33[2] |
| Alcohol intake (%) | | | | | | | | | | | | | | | |
| Men | | | | | | | | | | | | | | | |
| Abstainer | 37 | 26 | 20 | 18 | 21[2] | 32 | 27 | 26 | 19 | 17[2] | 22 | 22 | 22 | 25 | 31[2] |
| >3 drinks/d | 9 | 15 | 19 | 24 | 30[2] | 9 | 12 | 16 | 24 | 36[2] | 21 | 20 | 20 | 19 | 18 |
| Women | | | | | | | | | | | | | | | |
| Abstainer | 75 | 57 | 46 | 35 | 33[2] | 48 | 49 | 51 | 48 | 48 | 42 | 43 | 47 | 53 | 60[2] |
| >1 drink/d | 5 | 16 | 24 | 34 | 43[2] | 21 | 22 | 22 | 25 | 31[2] | 31 | 27 | 25 | 21 | 18[2] |
| Use of supplements (%) | 22 | 26 | 29 | 34 | 37[2] | 39 | 33 | 29 | 26 | 22[2] | 33 | 30 | 30 | 29 | 26[2] |

[1] $n$ = 9321 M, 10 429 F. Values were adjusted for age (y). Quintiles were derived for men and women separately, so the percentage of men and women is evenly distributed over the quintiles.
[2] $P$ for trend <0.0001.
[3] $P$ for trend <0.01.
[4] Low, junior high school or less; medium, high school; high, vocational college or university.
[5] Leisure physical activity of at least moderate intensity (≥4.5 metabolic equivalents).

also associated with higher HDL-cholesterol concentrations. After further adjustment for alcohol consumption (0, <1, 1–3, >3 drinks/d), the traditional-pattern score remained positively associated with systolic blood pressure [men: $\beta$ = 0.65 (95% CI: −0.09, 1.39); women: $\beta$ = 1.25 (95% CI: 0.41, 2.09)] and HDL-cholesterol concentrations [men: $\beta$ = 0.03 (95% CI: 0.02, 0.05); women: $\beta$ = 0.02 (95% CI: 0.00, 0.04)].

The cosmopolitan-pattern score was associated with higher HDL cholesterol and lower systolic blood pressure. In addition, the pattern score was associated with lower total cholesterol in the women and with higher plasma glucose concentrations in the men. Results were essentially the same for basic and multivariate models. Further adjustment for alcohol consumption weakened the positive association with HDL cholesterol [men: $\beta$ = 0.04 (95% CI: 0.03, 0.06); women: $\beta$ = 0.00 (95% CI: −0.02, 0.02)] but strengthened the inverse association with systolic blood pressure [men: $\beta$ = −1.44 (95% CI: −2.12, −0.75); women: $\beta$ = −1.92 (95% CI: −2.69, −1.16)].

The refined-foods pattern score was associated with higher total cholesterol, higher plasma glucose, higher systolic blood pressure (in the women), and lower HDL cholesterol. After adjustment for other risk factors including BMI, associations with higher total cholesterol concentrations remained (Table 4).

## DISCUSSION

In this sample of 19 750 men and women from the general Dutch population, we identified 3 major food consumption patterns, which we called the cosmopolitan pattern, the traditional pattern, and the refined-foods pattern. The cosmopolitan-pattern score was associated with a higher educational level and more leisure physical activity. The traditional-pattern score was associated with older age, and the refined-foods-pattern score was associated with younger age, but both were associated with a lower educational level, less leisure physical activity, heavy cigarette smoking, and a higher BMI. Independent of other lifestyle factors and BMI, the cosmopolitan-pattern score was associated with lower blood pressure and higher HDL cholesterol, and the traditional-pattern score was associated with higher blood pressure and higher total cholesterol, HDL-cholesterol, and glucose concentrations. The refined-foods-pattern score was associated with higher total cholesterol concentrations and lower intakes of micronutrients.

The strengths of our study included the extensive information on diet and lifestyle, the large size of the study population, and the sampling from the general population. However, the response rate in this study was rather low (45%), particularly for men, younger persons, and inhabitants of Amsterdam (28). Nevertheless, we identified similar dietary patterns in subgroups (by sex and municipality) with higher and lower response rates, which suggests that the lower response rates in subgroups did not substantially affect the identified dietary patterns. Comparison of responders and incomplete responders (eg, only questionnaire response or nonresponse to telephone survey) did not show marked differences for low educational level (46% compared with 49%, respectively), cigarette smoking (36% compared with 37%, respectively), or sport participation (47% compared with 43%, respectively) (28).

**TABLE 4**

Regression coefficients (± SEs) for the association between dietary pattern scores (for the difference between the medians of the lowest and the highest quintiles) and biological risk factors among participants in the MORGEN Study, 1993–1997[1]

| | Cosmopolitan pattern | | Traditional pattern | | Refined-foods pattern | |
|---|---|---|---|---|---|---|
| | Men | Women | Men | Women | Men | Women |
| Systolic blood pressure (mm Hg) | | | | | | |
| Adjustments | | | | | | |
| Age, municipality, year of examination[2] | −1.00 ± 0.35[3] | −1.87 ± 0.38[4] | 2.84 ± 0.35[4] | 3.40 ± 0.40[4] | 0.68 ± 0.35 | 2.19 ± 0.43[4] |
| Multivariate[5] | −0.48 ± 0.36 | −0.95 ± 0.39[6] | 2.69 ± 0.37[4] | 3.12 ± 0.43[4] | 0.29 ± 0.36 | 1.32 ± 0.44[3] |
| Multivariate with BMI[7] | −0.85 ± 0.35[6] | −1.19 ± 0.38[3] | 1.59 ± 0.36[4] | 1.73 ± 0.43[4] | −0.53 ± 0.35 | 0.04 ± 0.43 |
| Total cholesterol (mmol/L) | | | | | | |
| Adjustments | | | | | | |
| Age, municipality, year of examination[1] | 0.06 ± 0.02[6] | −0.15 ± 0.02[4] | 0.32 ± 0.02[4] | 0.15 ± 0.03[4] | 0.13 ± 0.02[4] | 0.19 ± 0.03[4] |
| Multivariate[5] | 0.07 ± 0.02[3] | −0.12 ± 0.02[4] | 0.29 ± 0.03[4] | 0.07 ± 0.03[3] | 0.09 ± 0.02[4] | 0.15 ± 0.03[4] |
| Multivariate with BMI[7] | 0.05 ± 0.02[6] | −0.13 ± 0.02[4] | 0.23 ± 0.03[4] | 0.04 ± 0.03 | 0.05 ± 0.02[6] | 0.12 ± 0.03[4] |
| HDL cholesterol (mmol/L) | | | | | | |
| Adjustments | | | | | | |
| Age, municipality, year of examination[1] | 0.06 ± 0.01[4] | 0.08 ± 0.01[4] | 0.00 ± 0.01 | −0.06 ± 0.01[4] | −0.06 ± 0.01[4] | −0.10 ± 0.01[4] |
| Multivariate[5] | 0.06 ± 0.01[4] | 0.05 ± 0.01[4] | 0.05 ± 0.01[4] | 0.02 ± 0.01 | −0.04 ± 0.01[4] | −0.05 ± 0.01[4] |
| Multivariate with BMI[7] | 0.07 ± 0.01[4] | 0.05 ± 0.01[4] | 0.08 ± 0.01[4] | 0.06 ± 0.01[4] | −0.02 ± 0.01[6] | −0.02 ± 0.01 |
| Glucose (mmol/L) | | | | | | |
| Adjustments | | | | | | |
| Age, municipality, year of examination[1] | 0.10 ± 0.03[3] | 0.03 ± 0.03 | 0.20 ± 0.03[4] | 0.17 ± 0.03[4] | 0.14 ± 0.03[4] | 0.12 ± 0.03[4] |
| Multivariate[5] | 0.13 ± 0.03[4] | 0.05 ± 0.03 | 0.15 ± 0.03[4] | 0.16 ± 0.03[4] | 0.10 ± 0.03[3] | 0.09 ± 0.03[3] |
| Multivariate with BMI[7] | 0.10 ± 0.03[3] | 0.04 ± 0.03 | 0.08 ± 0.03[6] | 0.10 ± 0.03[3] | 0.05 ± 0.03 | 0.04 ± 0.03 |

[1] Total cholesterol, HDL-cholesterol, and glucose concentrations were measured in nonfasting plasma samples. Persons using antihypertensive medication ($n$ = 690) were excluded from the blood pressure analysis, and persons with cholesterol-lowering medications ($n$ = 97) were excluded from the analyses with total cholesterol and HDL cholesterol as dependent variables. Because of these exclusions and missing values, data for blood pressure refer to 9008 men and 10 048 women, data for total cholesterol refer to 9215 men and 10 333 women, data for HDL cholesterol refer to 9212 men and 10 327 women, and data for glucose refer to 8487 men and 9395 women.

[2] Municipality (Amsterdam, Doetinchem, or Maastricht) and year of examination (1993, 1994, 1995, 1996, or 1997).

[3] $P < 0.01$.

[4] $P < 0.0001$.

[5] Additional adjustment for parental history of diabetes (yes or no), parental history of myocardial infarction before age 60 (yes or no), educational level (junior high school or less, high school, or vocational college or university), total energy intake (kJ/d), leisure physical activity of at least moderate intensity (h/wk), and cigarette smoking [never, past, current (<10 cigarettes/d, 10–19/d, ≥20/d).

[6] $P < 0.05$.

[7] Multivariate model with additional adjustment for BMI (kg/m$^2$).

Another potential limitation is that the use of principal-component analysis requires several arbitrary decisions about the selection of included variables, the number of retained factors, the method of rotation, and the labels of the factors. We conducted sensitivity analyses to examine whether these decisions affected the identified food consumption patterns. The use of other types of factor analysis (eg, common-factor analysis and oblique instead of orthogonal rotation), analyses retaining 4 instead of 3 factors, or analyses within subgroups of the population indicated that the identified patterns were robust. The labeling of the identified patterns was subjective, but it can be judged by the reader from the presented factor loadings (Table 1).

Because food consumption patterns reflect existing dietary habits, the identified patterns can be expected to differ by population. However, similarities to food consumption patterns in other countries are evident. In Canadian and United Kingdom populations, a refined-foods–type pattern was identified (8, 9, 11, 12), and a "Western" dietary pattern identified in US populations was characterized by a combination of the foods associated with the traditional and the refined-foods patterns in our study (5–7). The percentage of the variance of the original variables that is explained by factors greatly depends on the number and type of variables included. In studies of food consumption patterns that used comparable methods, the explained variance in our study was similar to that (range: 18–26% for 3 factors) in other studies of food consumption patterns that used comparable methods (5, 9, 10, 12, 13, 29).

The observed associations between dietary pattern scores and biological risk factors in our study were generally in the expected direction. In the Health Professionals Follow-up Study, the Western dietary pattern score was associated with higher C-peptide and insulin concentrations (6) and increased risk of type 2 diabetes (30). Our finding of an association between the traditional-pattern score and plasma glucose is in line with these results, but the positive association between the cosmopolitan-pattern score and plasma glucose in the men was unexpected and requires further study. Associations with plasma glucose were essentially the same in the subgroup of our study population who reported themselves to be fasting (data not shown). Associations of major food consumption patterns with HDL and total cholesterol have been examined in several studies (6, 10, 14). In the Health Professionals Follow-up Study, the Western dietary pattern score was associated with higher HDL-cholesterol concentrations, but the association with total cholesterol was not significant (6). Lack of control for other lifestyle factors such as physical activity complicates interpretation of the findings of other studies (10, 14). Information on food consumption patterns and blood pressure is sparse. In the Bogalusa Heart Study, food consumption patterns were not appreciably associated with blood pressure, but this study included only young (aged 12–24 y) persons and examined 17 eating patterns, instead of a few major dietary patterns (31). Some of our findings for dietary patterns and biological risk factors differed substantially between the men and the women. Such sex differences were also observed in a Swedish population (32) and may reflect differences in physiology, reporting of diet, or the specific types of foods that contributed to high pattern scores.

In the Dietary Approaches to Stop Hypertension trial, a diet rich in fruit, vegetables, and low-fat dairy products and with a lower saturated fat content resulted in a systolic blood pressure that was 5.5 mm Hg lower (1), a total cholesterol that was 0.35 mmol/L lower, and an HDL-cholesterol concentration that was 0.09 mmol/L lower (33). As expected, the associations with total cholesterol and blood pressure were substantially weaker for the dietary patterns in our study, for 2 reasons. First, measurement error in diet and biological risk factors probably attenuated the associations. Second, factor analysis identifies existing food consumption patterns in free-living populations that are unlikely to represent an optimal diet for cardiovascular health. Even so, differences in the risks for CVD between persons with high and low dietary pattern scores may be substantial (7, 29). Dietary patterns can affect the risk of coronary artery disease through multiple pathways, including those not reflected by the associations with traditional risk factors. For example, the lower intakes of vitamins and minerals associated with the refined-foods-pattern score may increase the risk of coronary artery disease (34).

Information on existing food consumption patterns, their change over time, and associated sociodemographic and lifestyle factors can be useful for public health efforts to improve diet. Interventions may be more effective if they are targeted at specific sociodemographic subgroups. In our population, for example, dietary advice to younger people should address undesirable aspects of the refined-foods pattern, whereas the traditional pattern may deserve more attention in older people. Our observation that unfavorable food consumption patterns were associated with low educational level (8–13), less physical activity (5, 6, 10), and cigarette smoking (5, 6, 8, 10, 12, 35) is consistent with results from previous studies. Combining campaigns to improve diet with efforts to increase physical activity and reduce cigarette smoking may be needed to effectively reduce CVD risk.

In conclusion, this Dutch population had identifiable patterns of food consumption that were strongly linked to age, educational level, and other lifestyle factors and that were associated with biological risk factors for CVD. These data suggest that public health efforts targeted at specific population subgroups may be warranted to address undesirable aspects of the traditional and refined-foods patterns and improve cardiovascular health.

We thank the epidemiologists and field workers of the Municipal Health Services of Amsterdam, Doetinchem, and Maastricht for their important contributions to collection of data for this study. The project steering committee consisted of HB Bueno de Mesquita, HA Smit, WMM Verschuren, and JC Seidell (project director). Logistic management was provided by A Jansen and J Steenbrink and data management by A Blokstra, P Steinberger, and A van Kessel.

## REFERENCES

1. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. N Engl J Med 1997;336:1117–24.
2. de Lorgeril M, Salen P, Martin JL, Monjaud I, Delaye J, Mamelle N. Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction: final report of the Lyon Diet Heart Study. Circulation 1999;99:779–85.
3. Blackburn GL. The public health implications of the Dietary Approaches to Stop Hypertension Trial. Am J Clin Nutr 2001;74:1–2.
4. Truswell AS. Practical and realistic approaches to healthier diet modifications. Am J Clin Nutr 1998;67(suppl):583S–90S.
5. Slattery ML, Boucher KM, Caan BJ, Potter JD, Ma KN. Eating patterns and risk of colon cancer. Am J Epidemiol 1998;148:4–16.
6. Fung TT, Rimm EB, Spiegelman D, et al. Association between dietary patterns and plasma biomarkers of obesity and cardiovascular disease risk. Am J Clin Nutr 2001;73:61–7.
7. Fung TT, Willett WC, Stampfer MJ, Manson JE, Hu FB. Dietary patterns and risk of coronary heart disease in women. Arch Intern Med 2001;161:1857–62.
8. Nolan CC, Gray-Donald K, Shatenstein B, O'Loughlin J. Dietary patterns leading to high fat intake. Can J Public Health 1995;86:389–91.
9. Beaudry M, Galibois I, Chaumette P. Dietary patterns in Quebec and their nutritional adequacy. Can J Public Health 1998;89:347–51.
10. Williams DEM, Prevost T, Whichelow MJ, Cox BD, Day NE, Wareham NJ. A cross-sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. Br J Nutr 2000;83:257–66.
11. Barker ME, McClean SI, Thompson KA, Reid NG. Dietary behaviours and sociocultural demographics in Northern Ireland. Br J Nutr 1990;64:319–29.
12. Wichelow MJ, Prevost AT. Dietary patterns and their associations with demographic, lifestyle and health variables in a random sample of British adults. Br J Nutr 1996;76:17–30.
13. Gex-Fabry M, Raymond L, Jeanneret O. Multivariate analysis of dietary patterns in 939 Swiss adults: sociodemographic parameters and alcohol consumption profiles. Int J Epidemiol 1988;17:548–55.
14. Barker ME, McClean SI, Strain JJ, Thompson KA. Dietary behaviour and health in Northern Ireland: an exploration of biochemical and haematological associations. J Epidemiol Community Health 1992;46:151–6.
15. Lean MEJ, Han TS, Seidell JC. Impairment of health and quality of life in people with large waist circumference. Lancet 1998;351:853–6.
16. Verschuren WM, Boerma GJ, Kromhout D. Total and HDL-cholesterol in The Netherlands: 1987–1992. Levels and changes over time in relation to age, gender and educational level. Int J Epidemiol 1994;23:948–56.
17. Ocké MC, Bueno de Mesquita HB, Goddijn HE, et al. The Dutch EPIC food frequency questionnaire. I. Description of the questionnaire, and relative validity and reproducibility for food groups. Int J Epidemiol 1997;26(suppl 1):S37–48.
18. Stichting NEVO. NEVO tabel. Nederlands Voedingsstoffenbestand 1996. (NEVO table. Dutch Nutrient Database 1996). Den Haag: Voorlichtingsbureau voor de Voeding, 1996 (in Dutch).
19. Oomen CM, Ocké MC, Feskens EJM, van Erp-Baart MAJ, Kok FJ, Kromhout D. Association between trans fatty acid intake and 10-year risk of coronary heart disease in the Zutphen Elderly Study: a prospective population based study. Lancet 2001;347:746–51.
20. Konings EJM, Roomans HHS, Dorant E, Goldbohm RA, Saris WHM, van den Brandt PA. Folate intake of the Dutch population according to newly established liquid chromatography data for foods. Am J Clin Nutr 2001;73:765–76.
21. Ocké MC, Bueno de Mesquita HB, Pols MA, Smit HA, van Staveren WA, Kromhout D. The Dutch EPIC food frequency questionnaire. II. Relative validity and reproducibility for nutrients. Int J Epidemiol 1997;26(suppl 1):S49–58.
22. Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 1982;36:936–42.
23. Pols MA, Peeters PH, Ocké MC, Slimani N, Bueno-de-Mesquita HB, Collette HJ. Estimation of reproducibility and relative validity of the questions included in the EPIC Physical Activity Questionnaire. Int J Epidemiol 1997;26(suppl 1):S181–9.
24. Kattermann R, Jaworek D, Möller G. Multicenter study of a new enzymatic method of cholesterol determination. J Clin Chem Clin Biochem 1984;22:245–51.

25. Lopes-Virella MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. Clin Chem 1977;23:882–4.
26. Willett WC, Stampfer MJ. Implications of total energy intake for epidemiological analysis. In: Willett WC, ed. Nutritional epidemiology. 2nd ed. New York: Oxford University Press, 1998:273–301.
27. SAS Institute Inc. SAS/STAT user's guide, version 6, vol 2. 4th ed. Cary, NC: SAS Institute Inc, 1989.
28. Van Loon AJM, Tijhuis M, Picavet HSJ, Surtees PG, Ormel J. Survey non-response in the Netherlands. Effects on prevalence estimates and associations. Ann Epidemiol 2003;13:105–10.
29. Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D, Willett WC. Prospective study of major dietary patterns and risk of coronary heart disease in men. Am J Clin Nutr 2000;72:912–21.
30. van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Dietary patterns and risk for type 2 diabetes mellitus in U.S. men. Ann Intern Med 2002;136:201–9.
31. Nicklas TA, Webber LS, Thompson B, Berenson GS. A multivariate model for assessing eating patterns and their relationship to cardiovascular risk factors: the Bogalusa Heart Study. Am J Clin Nutr 1989;49:1320–7.
32. Wirfält E, Hedblad B, Gullberg B, et al. Food patterns and components of the metabolic syndrome in men and women: a cross-sectional study within the Malmö Diet and Cancer Cohort. Am J Epidemiol 2001;154:1150–9.
33. Obarzanek E, Sacks FM, Vollmer WM, et al. Effects on blood lipids of a blood pressure-lowering diet: the Dietary Approaches to Stop Hypertension (DASH) Trial. Am J Clin Nutr 2001;74:80–9.
34. Rimm EB, Willett WC, Hu FB, et al. Folate and vitamin B6 from diet and supplements in relation to risk of coronary heart disease among women. JAMA 1998;279:359–64.
35. Randall E, Marshall JR, Graham S, Brasure J. High-risk health behaviors associated with various dietary patterns. Nutr Cancer 1991;16:135–51.