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Dietary patterns and mortality in Danish men and women: a prospective observational study

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The analysis of dietary patterns emerged recently as a possible approach to examining diet–disease relation. We analysed the risk of all-cause and cardiovascular mortality associated with dietary patterns in men and women, while taking a number of potential confounding variables into account. Data were from a prospective cohort study with follow-up of total and cause-specific mortality. A random sample of 3698 men and 3618 women aged 30–70 years and living in Copenhagen County, Denmark, were followed from 1982 to 1998 (median 15 years). Three dietary patterns were identified from a twenty-eight item food frequency questionnaire, collected at baseline: (1) a predefined healthy food index, which reflected daily intakes of fruits, vegetables and wholemeal bread, (2) a prudent and (3) a Western dietary pattern derived by principal component analysis. The prudent pattern was positively associated with frequent intake of wholemeal bread, fruits and vegetables, whereas the Western was characterized by frequent intakes of meat products, potatoes, white bread, butter and lard. Among participants with complete information on all variables, 398 men and 231 women died during follow-up. The healthy food index was associated with reduced all-cause mortality in both men and women, but the relations were attenuated after adjustment for smoking, physical activity, educational level, BMI, and alcohol intake. The prudent pattern was inversely associated with all-cause and cardiovascular mortality after controlling for confounding variables. The Western pattern was not significantly associated with mortality. This study partly supports the assumption that overall dietary patterns can predict mortality, and that the dietary pattern associated with the lowest risk is the one which is in accordance with the current recommendations for a prudent diet.

Dietary pattern: Follow-up study: Factor analysis: Mortality

In most nutritional literature, diet is described in terms of single nutrients or food items. Today a diet high in fat and low in antioxidants is considered to have a detrimental influence on the development of chronic diseases, which are still the leading causes of death in many Westernised societies (Willett, 1998). However, given the complexity of human diets, high correlations between intakes of various nutrients or food items, and the many nutrient-to-nutrient biochemical interactions, the effects of consumption level of a single nutrient or food on a specific health outcome, may be spurious (Willett, 1998). The overall pattern of a diet may have a greater effect on health than any single component. Furthermore, epidemiological analyses based on nutrients are generally not directly related to dietary recommendations, since individuals ultimately determine nutrient intake largely by their choice of different foods.

A major problem in studying dietary patterns is finding a method to define patterns. Data from food frequency questionnaires (FFQ), which are commonly used in epidemiological studies to estimate individual consumption of certain foods, do not directly lend themselves to define dietary patterns. Some investigators have examined the association of food indices created '*a priori*' on the basis of current food recommendations (healthy eating indices), with disease outcomes (Kant, 1996; Huijbregts *et al.* 1997), but such composite scores reflect a particular eating pattern, and do not overcome the problems with multi-collinearity of various dietary variables. Consequently,

Abbreviation: FFQ, Food frequency questionnaire.

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dietary patterns studied by so called '*a posteriori*' data-reduction techniques have elicited considerable interest (Gex-Fabry *et al.* 1988; Prevost *et al.* 1997; Beaudry *et al.* 1998; Slattery *et al.* 1998; Hu *et al.* 1999; Kumagai *et al.* 1999). However, to our knowledge this technique has only been used to examine dietary associations with mortality in one prospective study, and here the sample size was limited to less than 1000 participants (Kumagai *et al.* 1999).

In the present prospective population study we examined whether food intake patterns, defined both *a priori* on basis of current food recommendations and *a posterori* by factor analysis, determine subsequent mortality in middle-aged men and women.

Methods

Subjects

The study is based on data from the Danish World Health Organization-MONICA surveys, previously described in detail (Gerdes *et al.* 2000). Briefly, random equal-sized samples of 30-, 40-, 50-, and 60-year-old men and women living in the south-western part of Copenhagen County were drawn from the National Central Person Registry and invited to participate in surveys conducted in 1982–4 (DAN-MONICA I), 1987 (DAN-MONICA II), and 1991–2 (DAN-MONICA III). The MONICA III survey also included men and women aged 70 years. The response rates were 79 %, 75 %, and 73 % respectively, and the total population comprised 3698 men (1940 + 748 + 1010) and 3618 women (1845 + 756 + 1017) (Table 1).

Data collection

Data on well-established biological and behavioural cardiovascular risk factors were collected by clinical examinations and questionnaires respectively. Comparable survey methods, which followed the WHO-MONICA protocol, were used in all three surveys. These methods are described in earlier reports (Gerdes *et al.* 2000). Data on the biological variables, smoking, drinking and physical activity were missing from less than 1 % of the participants, whereas 19 % of the participants had missing data for one or more of the variables in the questionnaire on dietary habits. Subjects with incomplete data were more often women, lower educated and from the MONICA II survey. There was no evidence that the occurrence depended on the value of the missing data themselves. Thus, for subjects with five or fewer missing values over all food items, missing values were replaced by the individual's mean, an average over the non-missing items. All analyses were conducted both on the subgroup of 2994 men and 2877 women, with complete information on all variables and on the subjects with five or fewer missing data after replacing the missing dietary data with means (data not shown). These two approaches gave essentially similar results.

Dietary variables

In all three studies, an extensive questionnaire on socio-demographic variables, lifestyle, and health was completed before a general health examination. This questionnaire included a question in which respondents were asked: 'How often do you, on average, eat the following food items?' followed by a list with the twenty-six items specified in Table 2, which gives the exact answer categories. The alternatives used in the frequency scale were as follows: never, once per month or less, twice per month, once per week, 2–3 times per week, once per day, 2–3 times per day, and 4 times or more per day. Participants were also asked about their average daily number of cups of tea or coffee. The FFQ has been compared with a diet history interview as a part of the present study (Osler & Heitmann, 1996). This cross-comparison showed that the mean food intake measured by a diet history interview increased with increasing frequency category of the FFQ, indicating that the FFQ was able to identify levels of food intake correctly.

Data were aggregated, in a predefined healthy food index and in scores defined *a posteriori* using principal component analysis (factor analysis). The predefined food index was calculated on basis of previous indices of overall diet quality, and the current recommendations for a healthy diet (Kant, 1996). We calculated a crude index by giving one point for each of the following four characteristics of the diet: (1) not consuming butter, lard or margarine daily, (2) consuming either raw or boiled vegetables at least once daily, (3) consuming either coarse white or coarse rye bread at least once daily, and (4) consuming fruit at least once daily. Since there were relatively few participants in the last

Table 1. Overview of study participants*

Study	Men (*n*)	Women (*n*)	Deaths		Person-years	
			Men (*n*)	Women (*n*)	Men	Women
MONICA I	1940	1845	333	185	27 282	37 341
MONICA II	748	756	76	40	8496	8861
MONICA III	1010	1017	94	69	7017	7187
Total	3698	3618	503	294	42 795	53 389
Participants with complete data						
MONICA I	1853	1760	308	172	26 641	26 132
MONICA II	318	305	23	11	3668	3616
MONICA III	823	813	67	48	5785	5794
Total	2994	2878	398	231	36 094	35 542

* For details of the surveys, see Gerdes *et al.* (2000).

Table 2. Principal components and horizontal-rotated factor loadings for dietary variables in Danish men and women aged 30–70 years*

	Prudent diet component	Western diet component
White bread	−0·38	0·51†
Wholemeal bread	0·61†	
White ryebread	−0·46	0·38
Wholemeal ryebread	0·56†	
Porridge, groats	0·30	
Pasta	0·35	
Rice	0·41	
Potatoes		0·28
Vegetables, raw	0·53†	
Vegetables, boiled	0·39	
Fruit	0·51†	
Juice	0·36	0·21
Jam, honey	0·33	0·32
Cakes, cookies	0·36	0·43
Candy, chocolate	0·31	0·44
Ice cream, soft drinks		0·43
Milk, yoghurt	0·24	0·21
Cheese		
Eggs		0·28
Fish	0·27	
Meat		0·36
Sausages		0·49
Liver paste, cold meat		0·53†
Butter, lard, margarine		0·41
Vegetable margarine		0·24
Low-fat margarine	0·22	
Tea	0·36	
Coffee	−0·26	
Eigenvalue	3·02	2·43
% Variance of food intake explained	10·80	8·67

* For details of procedures, see p. 221. Values of $< 0{\cdot}20$ were excluded from the table for simplicity.
† Indicates loadings 0·50 or greater.

category (i.e. those with 4 points), it was incorporated into the preceding category.

When the food intake data were aggregated by factor analysis, the components were rotated by an orthogonal transformation (Varimax rotation) to achieve a simpler structure with greater interpretability. The frequency of intakes of the twenty-eight items aggregated in six factors (components), with eigenvalues exceeding 1. These factors accounted for 45 % $(12 + 10 + 6 + 6 + 6 + 5)$ of the total variance. However, some of the components did not appear logical. One was associated with frequent intakes of pasta and rice, while another mainly reflected frequent intakes of oatmeal and milk. Furthermore, a plot of the total variance associated with each component (scree-plot) indicated that the two-factor model would be sufficient for our data. A second analysis allowing a two-factor model identified components with eigenvalues exceeding 2 and explaining nearly 20 % of the variance (Table 2). The first component (termed 'prudent dietary pattern') was positively associated with frequent intakes of wholemeal bread (and inversely with other types), pasta, rice, oatmeal products, fruits, vegetables, and fish. The second component (termed 'Western dietary pattern') was positively associated with frequent intakes of meat, sausages, potatoes, butter and white bread. It reflected the primary characteristics of traditional Danish main meals (Table 2). The results of the principal component analyses were consistent in all three surveys, for both men and women, and for the four age groups considered. The component score coefficients were estimated by the Anderson–Rubin method, which produces uncorrelated scores with a mean value 0 (SD 1).

Covariates

The anthropometric measurements were collected by the same trained nurse in all studies. BMI was calculated as weight (kg) divided by the square of height (m^2). Questions on smoking concerned current and previous habits (yes, occasionally, no/never), and the kinds and average daily quantities of tobacco consumed (cigarettes, cheroots, cigars, pipe). In the analyses of the data, only subjects who smoked daily were considered smokers. Participants were also asked about their weekly intake of beer (bottles), wine (glasses), or spirits (units). Alcohol consumption was asssessed by the average number of bottles of beer, glasses of wine and units of spirits consumed per week during the last year. These data were classified according to weekly alcohol intake: <1 drink per week, 1–14 drinks per week for women and 1–21 drinks per week for men, and a consumption of more than 14 or 21 drinks per week respectively. Data on leisure-time physical activity were based on answers to a question for which the participants had to mark one of four alternatives: A, mostly sedentary; B, walking, bicycling or otherwise active at a corresponding level at least 4 h per week; C, going jogging or demanding sports, or doing heavy activity during leisure for at least 3 h per week; D, long distance running or competitive sports several times per week. We defined

people in group A as being inactive the rest were considered active. This activity questionnaire has been used in other health studies, and has been shown to correlate well with physiological measures such as energy expenditure (Albanese *et al.* 1990). Educational attainment was assessed with questions about whether participants had any vocational education.

Follow up

Subjects were followed until 31 October 1998 for mortality. Cause of death was obtained from official death certificates coded at the National Board of Health using the 8th and 10th Revision of the International Classification of Diseases. Data permitted subdivision into cardiovascular deaths (ICD-8 codes 390–458, 782; ICD-10 codes I00–I52, I60–I99, R07·2–R07·9). In addition, an evaluation of the following selected end points was performed: ischaemic heart disease deaths (ICD-8 codes 410–414; ICD-10 codes I20–I25), and stroke (ICD-8 codes 430–438; ICD–10 codes I60–I69, G43).

Statistical analysis

Association between risk factors and mortality was analysed using Cox's proportional hazards regression models with age as underlying time scale and delayed entry accordingly. For the two dietary components Cox models were developed that controlled for smoking status (0, non-smoker, 1, smoker), physical activity (0, sedentary, 1, active), vocational education (0, yes, 1, no), BMI (as continuous in kg/m^2), weekly alcohol intake (<1 drink, 1–14 drinks for women and 1–21 drinks for men and over 14 or 21 drinks respectively), and evaluated for the index and each of the two components as predictors of death. Dietary components were analysed as both continuous and categorial (the components derived from factor analysis were divided into quartiles) variables. The proportional hazards assumption was evaluated for all variables by comparing estimated log–log survivor curves over the different categories of the variables being investigated. BMI was not linear in the model. This was obtained by including (BMI)^2 in the model for men and (BMI)^2 and (BMI)^3 in the model for women. All tests in the Cox regression models were two-sided Wald tests with the nominal level of significance of 0·05. Associations between the two dietary patterns and lifestyle characteristics were evaluated by correlation coefficients and *t* tests for differences in means between extreme categories of lifestyle variables.

Results

After exclusion of subjects with incomplete data, the study population comprised 2994 men and 2877 women, who were followed for median 15·0 years (range 0·1–16 years). During follow up, 398 men and 231 women died (Table 1). In bivariate analysis, physical activity, smoking behaviour, education, BMI, and alcohol intake were associated both with dietary scores (data not shown) and all-cause mortality (Table 3). These variables were included as confounders.

Table 3. Hazard rate ratio estimates and 95 % CI of all-cause mortality by smoking, physical activity, alcohol intake, BMI and education: results from Cox's proportional regression analysis*

	Men		Women	
	HRRE	95 % CI	HRRE	95 % CI
Smoking				
Non-smoker	1		1	
Smoker	1·98	1·60, 2·46	2·35	1·79, 3·08
Physical activity				
Sedentary	1		1	
Active	0·59	0·47, 0·71	0·56	0·43, 0·73
Alcohol intake (drinks/week)				
<1	1		1	
1–14	0·78	0·56, 1·09	0·77	0·58, 1·02
>14	1·10	0·96, 1·61	0·75	0·42, 1·33
BMI (kg/m^2)				
<20	2·93	1·41, 3·52	1·72	1·18, 2·45
20–24·9	1		1	
25–29·9	0·91	0·73, 1·14	1·05	0·76, 1·45
>30	1·15	0·86, 1·57	1·81	1·25, 2·01
Vocational education				
Yes	1		1	
No	1·31	1·06, 1·63	1·43	1·09, 1·85

HRRE, hazard rate ratio estimate.
* For details of procedures, see p. 222.

The healthy food index was inversely associated with all-cause mortality in both men and women, but the relations were attenuated after controlling for potential confounding factors (Table 4). When the food index was analysed in categories, men who had scored 1 point seemed to have the lowest risk (Table 5). Re-analysing the data using the food index in its original shape (without collapsing the two last categories), men in the upper category had a higher risk (hazard ratio 1·36, range 0·78–2·39) compared with those in the lowest (reference) category. However, there were only fifteen cases in the upper category. The food index was not significantly associated with cardiovascular mortality. In women, the *a posteriori*-defined prudent dietary pattern was associated with a reduced all-cause mortality (hazard ratio 0·63, range 0·56–0·72) per SD increase, and in men (hazard ratio 0·75, range 0·68–0·83). After adjustment for smoking, BMI, physical activity, alcohol consumption and education, the associations remained significant (Table 4). Table 5 shows that after adjustment, women in the highest quartile of the prudent pattern had a 54 % lower mortality compared with those in the lowest quartile. In men, the highest quartile had a 30 % lower mortality than the lowest. The prudent dietary pattern was also associated with a reduced risk of cardiovascular mortality. Nearly the same direction of the point estimates were found for ischaemic heart disease and stroke, but possibly due to the small number of cases the CI became wider and included one in both sexes (Table 4). The Western dietary pattern, which reflected the primary characteristics of traditional Danish main meals, was not associated with mortality of all-causes or cardiovascular diseases.

Discussion

The main findings in the present prospective population-based study, comprising almost 6000 subjects, were that a

Table 4. Number of deaths, and hazard rate ratio estimates with 95 % CI of mortality by a predefined healthy food index and a prudent and a Western dietary pattern derived from factor analysis in 2994 men and 2877 women: results from Cox's proportional hazards regression analysis*

	Men					Women				
		Unadjusted		Adjusted†			Unadjusted		Adjusted‡	
	n	HRRE	95 % CI	HRRE	95 % CI	*n*	HRRE	95 % CI	HRRE	95 % CI
All cause	398					231				
Healthy food index		0·86	0·79, 0·96	0·95	0·86, 1·05		0·86	0·76, 0·97	0·96	0·85, 1·09
Prudent dietary pattern		0·75	0·68, 0·83	0·84	0·75, 0·93		0·63	0·56, 0·72	0·74	0·64, 0·85
Western dietary pattern		1·00	0·90, 1·11	1·01	0·90, 1·12		0·94	0·83, 1·06	0·91	0·80, 1·03
Cardiovascular	108					39				
Healthy food index		0·95	0·80, 1·14	0·98	0·82, 1·19		0·82	0·62, 1·11	0·92	0·68, 1·24
Prudent dietary pattern		0·83	0·69, 1·00	0·87	0·71, 1·06		0·55	0·40, 0·77	0·63	0·44, 0·90
Western dietary pattern		1·04	0·85, 1·28	1·06	0·86, 1·32		0·95	0·70, 1·30	0·924	0·69, 1·27
Ischaemic heart disease	58					20				
Healthy food index		0·95	0·74, 1·21	0·97	0·76, 1·26		1·04	0·69, 1·57	1·07	0·70, 1·64
Prudent dietary pattern		0·81	0·62, 1·05	0·85	0·64, 1·12		0·69	0·44, 1·09	0·71	0·43, 1·17
Western dietary pattern		1·00	0·75, 1·32	1·00	0·75, 1·32		0·88	0·58, 1·34	0·91	0·59, 1·40
Stroke	19					6				
Healthy food index		0·94	0·61, 1·45	1·02	0·64, 1·63		0·69	0·32, 1·49	0·83	0·39, 1·77
Prudent dietary pattern		0·93	0·59, 1·48	1·03	0·62, 1·70		0·45	0·20, 1·03	0·57	0·22, 1·46
Western dietary pattern		0·71	0·45, 1·12	0·79	0·50, 1·23		1·55	0·66, 3·74	1·55	0·59, 4·07

HRRE, hazard rate ratio estimates.
* For details of procedures, see p. 222.
† Cox-regression model adjusted for smoking status, physical activity, alcohol, education, BMI and BMI^2.
‡ Cox-regression model adjusted for smoking status, physical activity, alcohol, education, BMI, BMI^2 and BMI^3.

prudent dietary pattern, predominantly reflecting frequent intakes of wholemeal bread, vegetables, fruits, and fish, was associated with a better overall as well as cardiovascular survival in both men and women. The associations attenuated, but retained significant, after adjustment for relevant confounders. This is in agreement with the results from a recent study of the relationship between dietary patterns and mortality among 704 elderly Japanese men and women followed for 7 years (Kumagai *et al.* 1999). In this cohort study a factor analysis based on fifteen food items identified four factors. One factor, expressing a frequent intake of plant foods, was associated with reduced all-cause mortality. The three other factors, which reflected frequent intakes of: (1) meat and fats, (2) pickled vegetables and fish or (3) bread and rice, were not predictive. The predefined healthy food index measuring daily intakes of fruits, vegetables and wholemeal bread was inversely associated with all-cause mortality, but the associations attenuated after adjustment for relevant confounders. Surprisingly, men with only 1 point on the food index showed the lowest mortality. Most (70 %) of these men had obtained this point through a daily intake of wholemeal bread. In

Table 5. Number of deaths, and hazard rate ratio estimates with 95 % CI of all cause mortality by a predefined healthy food index and a prudent and a Western dietary pattern derived from factor analysis in categories in 2994 men and 2877 women: results from Cox's proportional hazards regression analysis*

	Men					Women				
		Unadjusted		Adjusted†			Unadjusted		Adjusted‡	
	n	HRRE	95 % CI	HRRE	95 % CI	*n*	HRRE	95 % CI	HRRE	95 % CI
Healthy food index										
0 points	109	1		1		36	1			
1 point	134	0·65	0·50, 0·84	0·73	0·56, 0·98	68	0·70	0·47, 1·05	0·80	0·53, 1·20
2 points	100	0·65	0·50, 0·86	0·78	0·59, 1·02	62	0·54	0·36, 0·81	0·71	0·46, 1·07
3+4 points	55	0·60	0·43, 0·83	0·82	0·58, 1·14	65	0·58	0·39, 0·87	0·82	0·54, 1·25
Prudent dietary pattern										
1st quartile	193	1		1		88	1		1	
2nd quartile	104	0·75	0·59, 0·96	0·87	0·68, 1·11	66	0·57	0·42, 0·80	0·69	0·50, 0·96
3rd quartile	64	0·58	0·44, 0·77	0·71	0·53, 0·96	48	0·44	0·31, 0·63	0·57	0·40, 0·82
4th quartile	37	0·52	0·36, 0·73	0·70	0·49, 1·00	29	0·30	0·20, 0·46	0·46	0·30, 0·72
Western dietary pattern										
1st quartile	81	1		1		93	1		1	
2nd quartile	93	0·83	0·61, 1·11	0·81	0·60, 1·09	62	0·98	0·71, 1·35	0·93	0·67, 1·29
3rd quartile	116	0·96	0·72, 1·27	0·97	0·73, 1·29	40	0·72	0·49, 1·04	0·65	0·44, 0·94
4th quartile	108	0·92	0·69, 1·22	0·92	0·69, 1·23	36	0·92	0·63, 1·36	0·87	0·59, 1·29

HRRE, hazard rate ratio estimate.
* For details of procedures, see p. 222.
† Cox-regression model adjusted for smoking status, physical activity, alcohol, education, BMI and BMI^2.
‡ Cox-regression model adjusted for smoking status, physical activity, alcohol, education, BMI, BMI^2 and BMI^3.

addition, wholemeal bread was the item that most strongly related to reduced all-cause mortality. In previous studies of healthy dietary indicators, defined *a priori* from current dietary recommendations, such scores have predicted survival among middle-aged and elderly people in the USA (Kant *et al.* 1993, 2000) and in different European countries (Nube *et al.* 1987; Trichopoulou *et al.* 1995; Huijbregts *et al.* 1997). In a 25 year follow-up study of 2820 middle-aged Dutch civil servants (Nube *et al.* 1987), all-cause mortality showed a significant negative association with porridge in both men and women, and in men also for brown bread, vegetables and fruits. In a 21 year follow-up of adult Seventh-Day Adventists in CA, USA, all-cause mortality was also negatively associated with starchy foods, fruit and vegetables (Kahn *et al.* 1984). In the same population high intake of wholemeal bread has predicted a decreased risk of ischaemic heart disease (Fraser *et al.* 1992). Thus, the present data also support the increasing evidence of the protective effects of fruits, vegetables, and wholegrain cereals on mortality from all-causes and cardiovascular diseases (Ness & Powles, 1997; Kushi *et al.* 1999). Further, the present study showed the expected association between moderate alcohol intake and lowered mortality, and a U-shaped relationship between BMI and mortality (Table 3). However, it should be noted that the estimates in Table 3 were not adjusted for other risk factors.

On the other hand, we were unable to identify an increased risk associated with a Western dietary pattern, reflecting the traditional Danish chief meals with a frequent intake of meat products and fats. One possible explanation for this is that the component for a Western dietary pattern also showed high loadings on foods such as potatoes and white ryebread, which through their content of dietary fibre and vitamins may have a protective effect (Kushi *et al.* 1999). Another explanation may be that the effects of diet on health is mainly protective, and possibly mediated through plant products. Hence, the high fat–disease relationship, found in studies based on single nutrients may just reflect a dietary pattern low in protective elements.

Although scoring techniques have great intuitive appeal in nutritional epidemiology because they offer a means of constructing dietary patterns which may reflect closely dietary variables, the use of such methods in examining diet–disease relationships remains controversial (Willett, 1998). Constructing healthy dietary indices have been questioned, especially as they do not overcome the problems with multicollinarity. In the present study frequent intake of white bread was positively correlated with infrequent intakes of wholemeal bread; further, white bread seems to be positively related to mortality, whereas coarse bread showed an inverse relation. The use of dietary patterns derived from principal component analysis take into account the high intercorrelations of foods within diet. However, this method may also be questioned. The main reservations refer to the number of factors extracted and their interpretation. Further, it has been questioned whether the results from a factor analysis can be replicated in a similar population. In the present study, the identified dietary patterns and their association with mortality were nevertheless surprisingly consistent when data were stratified by survey, sex and age. The two components were also easy to interpret and the dietary patterns which emerged were much like those found in previous studies using factor analysis. Indeed, comparable studies from Northern Ireland (Barker *et al.* 1992), Great Britain (Prevost *et al.* 1997; Williams *et al.* 2000), Switzerland (Gex-Fabry *et al.* 1988), Japan (Kumagai *et al.* 1999), and USA (Slattery *et al.* 1998; Hu *et al.* 1999) also identified major dietary patterns, for a prudent diet, mainly expressing high intakes of fruits and vegetables, whereas another pattern typically reflected high intakes of meat and fat.

Determining the number of components to be included in the model is a crucial step in the principal component solutions to factoring, and here theory exerts a critical effect. In the present study we initially identified six components with eigenvalues exceeding 1. However, some of the components did not appear logical and a scree-plot indicated that a two-factor model would be sufficient for our data. By reducing the number of components from six to two we obtained two components which reflected theory, but we also increased the probability for one food item being represented in both components. The two major components only explained some 20 % of the variance. This is in agreement with the two studies from the USA (Slattery *et al.* 1998; Hu *et al.* 1999) in which a prudent dietary pattern and a Western dietary pattern, derived from forty and thirty-five food groups respectively, explained 20 % of the variance. However, in this context, it should be noted that the explained variances largely dependent on the total number of variables included in the analysis.

Possible limitations of the present study include that of measurement bias, since all dietary variables are measured with substantial amounts of error. However, in a previous study we documented that the mean food intake, measured by a diet history interview, increased with increasing frequency category of the FFQ, indicating that the FFQ was able to identify levels of food intake correctly (Osler & Heitmann, 1996). In the present study we also found a negative correlation between the prudent dietary pattern and total cholesterol ($r = -0,16$), while the Western pattern showed no significant association to cholesterol. We also had data on energy and nutrient intakes from a subsample of 1863 participants in MONICA 1 survey, who volunteered to complete a 7 d food record (Jørgensen, 1992). When these data were correlated with the dietary scores derived by principal component analysis from the short FFQ, we found that in both men and women the prudent dietary pattern was positively correlated with intakes of energy from carbohydrate, dietary fibre, β-carotene, vitamin C, vitamin E and folate. It was negatively correlated with energy from fat and saturated fat. The Western dietary pattern was positively correlated with intakes of energy, energy from fat and saturated fat and negatively correlated with β-carotene. Studies from Great Britain (Barker *et al.* 1992; Williams *et al.* 2000) and the USA (Hu *et al.* 1999) comparing dietary patterns, defined by factor analysis on food intake data, have also shown correlations between factor scores, nutrient intakes and biomarkers, such as total and HDL cholesterol in the expected directions. The use of dietary patterns may account for the high intercorrelation of foods within the

diet, and we used techniques of stratification and adjustment in the analyses to adjust for possible confounding. Although data on cholesterol and blood pressure were available, these variables were not included in the multivariate model, because they were regarded as intermediate factors rather than confounders to the diet–disease relations.

In conclusion, dietary patterns, defined by traditional scoring techniques, seem to be a useful approach to examining diet–disease relations, and the dietary patterns associated with the lowest all-cause and cardiovascular mortality are those which signify a diet with frequent intakes of wholemeal bread, fruits, vegetables, and fish. Thus, this study supports the new direction in public health promotion, where recommendations to increase populations' intakes of fruits, vegetables, and wholegrain cereals are displacing those focusing on reducing intakes of high-fat food times.

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