

Comparison of three different dietary scores in relation to 10-year mortality in elderly European subjects: the HALE project

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Abstract

Objective:

To investigate and compare the associations between dietary patterns and mortality using different European indexes of overall dietary quality.

Design, Setting and Participants:

The HALE (Healthy Ageing: a Longitudinal study in Europe) population includes 2068 men and 1049 women, aged between 70 and 90 years of 10 European countries. Subjects were followed for 10 years. This cohort study was conducted between 1988 and 2000.

Results:

During the follow-up period, 1382 people died. The Mediterranean Diet Score (MDS) (HR: 0.82 with 95% CI: 0.75–0.91), the Mediterranean Adequacy Index (MDI) (HR: 0.83 with 95% CI: 0.75–0.92) and the Healthy Diet Indicator (HDI) (HR: 0.89 with 95% CI: 0.81–0.98) were inversely associated with all-causes mortality. Adjustments were made for age, gender, alcohol consumption, physical activity, smoking, number of years of education, body mass index, chronic diseases at baseline and study centre.

Conclusions:

The MDS, the MDI and the HDI were significantly inversely related with mortality.

Sponsorship:

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Keywords:

dietary patterns, mediterranean diet, mortality, elderly

Introduction

During the previous decades most studies on the relationship between diet and mortality investigated the role of single nutrients, foods, or food groups (Huijbregts *et al.*, 1997; Osler *et al.*, 2002; Kant, 2004). However, it is often difficult to separate the specific effects of nutrients or food groups because of the highly interrelated nature of dietary exposures (Jacques and Tucker, 2001). A current trend is to study also dietary patterns that overcome this problem. Two different approaches have been used to derive dietary patterns: theoretically or '*a priori*' defined dietary patterns and empirically or '*a posteriori*' derived dietary patterns. The first involves use of diet-quality scores based on recommended diets or dietary guidelines, while the second approach involved statistical exploratory methods as factor analysis, cluster analysis, principal component analysis, and reduced rank regression to accomplish pattern derivation (Jacques and Tucker, 2001; Schulze *et al.*, 2003; Hoffmann *et al.*, 2004). In Europe, also different diet-quality scores are used to investigate the association between dietary patterns and mortality risk. Trichopoulou *et al.* (1995, 2003, 2005a, 2005b) proposed a Mediterranean Diet Score (MDS), which measures the adherence to a traditional Greek Mediterranean type of diet. In Greek adults aged between 20 and 86 years, a higher degree of adherence to the Mediterranean diet was associated with a lower total mortality risk (Trichopoulou *et al.*, 2003).

Alberti-Fidanza *et al.* proposed the Mediterranean Adequacy Index (MAI) to assess how close a diet reflects the Italian Reference Mediterranean Diet. The diet consumed in 1957–1960 by men of the Nicoterra cohort (Calabria, Italy) of the Seven Countries Study (SCS) was selected as reference diet (Alberti-Fidanza *et al.*, 1999; Fidanza *et al.*, 2004; Alberti-Fidanza and Fidanza, 2004). Results of cohort studies on the associations between the MAI and mortality have not been published yet. However, a significant inverse correlation was found between the MAI and 25-year population death rates from coronary heart disease in the SCS (Fidanza *et al.*, 2004).

Huijbregts *et al.* (1997) found an inverse significant relationship between the Healthy Diet Indicator (HDI), which is based on WHO guidelines for the prevention of chronic diseases, and 20-year all-causes mortality in men aged 50–70 years at baseline from Finland, The Netherlands and Italy.

Besides these indexes based on the Mediterranean diet or dietary guidelines, two food-based scores were developed in Europe: the Food-based quality Index (Lowik *et al.*, 1999) and the Healthy Food Index (Osler *et al.*, 2001). Also, in the

USA, different diet-quality scores were proposed; for example, the Diet Quality Index (Patterson *et al.*, 2004), the Healthy Eating Index (Kennedy *et al.*, 1995; McCullough *et al.*, 2000), the Dietary Guidelines Index (Harnack *et al.*, 2002).

Hypothesis-based (i.e. 'a priori') scores seem preferable to assess the adherence to a Mediterranean food pattern (Trichopoulos and Lagiou, 2004) or even to be used in future large trials, but 'a posteriori' scores derived from cluster or factor analysis have also been used (Haveman-Nies *et al.*, 2001; Osler *et al.*, 2002). However, the relationships between different food indexes and all-causes mortality in the same population have not been investigated.

The aim of the present study is to investigate and compare the relationships between different diet scores and all-causes mortality in elderly men and women from 10 European countries in the HALE (Healthy Ageing: a Longitudinal study in Europe) population. Because we want to evaluate the association between diet scores and mortality in a European population, we only considered European scores, for example, the MDS, the MDI and the HDI. We excluded food-based scores, because different foods are consumed in different parts of Europe.

Materials and methods

Study

The HALE project included subjects of the SENECA (Survey in Europe on Nutrition and the Elderly: a Concerned Action) and FINE (Finland, Italy, The Netherlands, Elderly) study who were examined in the period 1988–1991 and who were followed for 10 years (Knoops *et al.*, 2004). Details about the SENECA and FINE Study have been described elsewhere (Groot de *et al.*, 1996; Menotti *et al.*, 2001; Haveman-Nies *et al.*, 2002) and are briefly summarized here.

The SENECA study started in 1988 and consisted of a random age–sex stratified sample of elderly men and women, born between 1913 and 1918, from 19 European towns. Surveys were repeated in 1993 and 1998/1999. In the HALE project, men and women of the 13 centres that carried out a mortality follow-up were included: Hamme (Belgium), Roskilde (Denmark), Strasbourg (France), Valence (France), Iraklion (Greece), Padua (Italy), Culemborg (The Netherlands), Vila Franca de Xira (Portugal), Betanzos (Spain), Yverdon, Burgdorf and Bellinzona (Switzerland).

The FINE study consisted of the survivors of five cohorts of the Seven Countries Study: East Finland (Ilomantsi), West Finland (Pöytyä and Mellilä), Crevalcore and Montegiorgio in Italy and Zutphen in the Netherlands. The FINE study included men who were born between 1900 and 1920. Data of the surveys carried out around 1990, 1995 and 2000 were included in the HALE project.

Data collection

In both studies, food intake data were collected by trained dieticians using a dietary history method (Huijbregts *et al.*, 1995; Groot de *et al.*, 1996). This method provides information about the usual food consumption of the elderly during 1 month before the interview in SENECA, and 2–4 weeks in FINE. The central part of the dietary history was the same for both studies. The coding was based on frequency tables, which were the same in both studies, but in SENECA,

the start of the dietary interview about usual food patterns was based on a food record and on an oral interview in FINE. Both methods were validated (Groot de *et al.*, 1996; Kromhout *et al.*, 2002).

Food consumption data were arranged into food groups following the EUROCODE classification system (Arab *et al.*, 1987).

Information on alcohol consumption, physical activity, smoking, education (number of years) and the prevalence of myocardial infarction, stroke, diabetes and cancer was collected by questionnaires in a general interview. The prevalence of chronic diseases was confirmed by general practitioners and/or hospital registers in the FINE study but not in the SENECA study. Information on vital status was collected in 1999–2000 and was available for 99.6% of the subjects.

In the SENECA Study, the Voorrips questionnaire was used to obtain information on habitual physical activity, and in FINE, the Morris questionnaire (Voorrips *et al.*, 1990; Caspersen *et al.*, 1991). Both questionnaires were developed for retired elderly subjects and are focused on leisure time activities such as walking, cycling and gardening and included also household activities in the SENECA Study. To divide subjects in an inactive and active group, sex-specific tertiles were composed for the Voorrips and Morris questionnaire. Subjects with a score in the intermediate and the highest tertile were considered as physically active (Knoops *et al.*, 2004).

When alcohol was not included in the diet score, alcohol was divided into two categories: 0 g alcohol a day and more than 0 g alcohol a day (Knoops *et al.*, 2004). Based on literature, alcohol consumption was initially divided into three groups: 0 g alcohol a day, 1–29 g alcohol a day and 30 g or more gram alcohol a day (White *et al.*, 2002). The Kaplan–Meier survival curves of the three alcohol groups showed no difference in survival from all-causes mortality between subjects who consumed between 1–29 g alcohol a day and subjects who consumed 30 g or more alcohol a day. Therefore, we divided alcohol consumption in two groups: abstainers and users (Knoops *et al.*, 2004).

For smoking, subjects were divided into two groups: never smokers or past smokers more than 15 years ago and current smokers or past smokers for 15 years or less because the risk of mortality declines after cessation of smoking and after 10–15 years, it approximates the level of those who have never smoked (Kawachi *et al.*, 1993; Peto *et al.*, 2000; Doll *et al.*, 2004).

Body weight and height were measured at baseline (Rose and Blackburn, 1968; Groot de *et al.*, 1991; Menotti *et al.*, 2001). Standing weight was measured to the nearest 0.1 cm and body weight was measured to the nearest 0.5 kg. Calibrated scales were used. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). In the analysis, BMI was dichotomized as a BMI index less than or equal to $27 \text{ kg}/m^2$ and a BMI higher than $27 \text{ kg}/m^2$ (Heiat *et al.*, 2001).

Diet scores

Three different diet scores were composed: the MDS (Trichopoulou *et al.*, 1995, 2003), the MAI (Alberti-Fidanza *et al.*, 1999; Alberti-Fidanza and Fidanza, 2004; Fidanza *et al.*, 2004) and the HDI (Huijbregts *et al.*, 1997).

The original MDS of Trichopoulou *et al.* (1995) was composed of the following eight components: ratio of monounsaturated to saturated fatty acids, alcohol,

legumes, cereals, fruit, vegetables, meat and meat products, and dairy products. We replaced the group 'legumes' by the group 'legumes/nuts/seeds' and the group 'vegetables' by the group 'vegetables and potatoes' and 'meat and meat products' by 'meat and poultry' because these food groups were combined in the used European classification system (EUROCODE) (Arab *et al.*, 1987). Following the revised MDS of Trichopoulou *et al.* (2003), we added fish to the MDS. Because the component fish was added, the MDS consisted of nine items. Intake values were adjusted to daily intakes of 10.5 MJ (or 2500 kcal) for men and 8.5 MJ (2000 kcal) for women. The sex-specific median intake values were taken as cutoff points. The diet score varied from 0 (low quality diet) to 9 (high quality diet). For the components ratio between monounsaturated fatty acids and saturated fatty acids, fruits and fruit products, vegetables/potatoes, legumes/nuts/seeds, fish and cereals, a value of 1 was assigned to persons whose consumption was equal to or higher than the sex-specific median value, and 0 to the others. For meat and meat products and dairy products, a value 1 was assigned to persons whose consumption was less than the sex-specific median, and 0 to the others. The MDS was also computed without alcohol (Knoops *et al.*, 2004) and consisted of eight components.

In the original MAI index, the food groups expressed as percentage of total daily energy intake were divided in Mediterranean (bread, cereals, legumes (raw-dry or raw-fresh), potatoes, vegetables, fruit, fish, vegetable oils and red wine) and non-Mediterranean food groups (milk, cheese, meat, eggs, animal fats and margarines, cakes, pies and cookies, and sugar) (Alberti-Fidanza *et al.*, 1999; Alberti-Fidanza and Fidanza, 2004; Fidanza *et al.*, 2004). The MAI index is computed by dividing the sum of the Mediterranean food groups by the sum of the non-Mediterranean food groups. In the EUROCODE system (Arab *et al.*, 1987), the food group vegetable oils and margarines were combined. Therefore, we replaced vegetable oils by the intake of monounsaturated fatty acids and replaced the animal fats and margarines by saturated fatty acids, so the MAI was calculated as

$$\text{MAI} = \frac{\text{cereals} + \text{legumes} + \text{fruit} + \text{vegetables} + \text{potatoes} + \text{fish} + \text{monounsaturated fat} + \text{wine}}{\text{Milk and milk products} + \text{meat and poultry} + \text{eggs} + \text{sugar} + \text{saturated fat}}$$

These intake values were adjusted to daily intakes of 10.5 MJ (or 2500 kcal) for men and 8.5 MJ (2000 kcal) for women instead of calculating the food groups as the percentage of daily energy because these data were not available for each country (Alberti-Fidanza and Fidanza, 2004). In the MAI without alcohol, the consumption of wine was excluded.

The HDI proposed by Huijbregts *et al.* (1997) was calculated using the dietary guidelines for the prevention of chronic diseases, defined by the World Health Organization. If a person's intake was within the recommended intervals of the guidelines of the WHO, the person scored one point on that item, if the intake was outside this interval, the person scored zero on that item.

The following guidelines were taken into account: <10 percent energy intake from saturated fatty acids, 3–7% energy intake from polyunsaturated fatty acids, 10–15% energy intake of proteins, 50–70% energy intake of complex carbohydrates, 27–40 g of fibres a day, more than 400 g of fruit and vegetables a day, more than 30 g of legumes, nuts and seeds a day, <10% energy from monosaccharides and disaccharides a day, and <300 mg cholesterol a day. In total, a person could obtain nine points on the HDI.

The median of each diet score was calculated. Subjects with a score equal or higher than the median were considered as having a healthy diet; subjects who had a score below the median were considered as having an unhealthy diet (reference group) (Knoops *et al.*, 2004).

Besides the relationship between the three diet scores and mortality, we investigated the effect of the components of each diet score on mortality. For the MDS and the MAI, the median of the components were used as cutoff point whereas for the HDI the WHO guidelines were used. For the healthy items, the subjects who scored zero were used as reference group, whereas for the detrimental items, subjects with a high consumption were used as reference group.

Statistical analysis

Statistical analyses were carried out using the SAS statistical analysis computer package (version 8.0). The Cox proportional hazard model was used to estimate the effect of the diet scores and the different components. The models with a diet score, which included alcohol, were adjusted for gender, age at baseline, smoking, physical activity, BMI, years of education, prevalence of myocardial infarction, stroke, diabetes and cancer at baseline, and study. A random effect of each centre was taken into account in the model (Andersen *et al.*, 1999). The models with a diet score without alcohol were also adjusted for alcohol consumption.

The interaction of the diet scores and region was tested but was not significant at alpha equal to 0.1. We also stratified our analysis for region because several studies indicated a difference in food patterns between northern and southern Europe (Menotti *et al.*, 1999; Agudo *et al.*, 2002) and the MAI values in the present study were higher in southern than in the northern Europe before the analyses started. The study centres of Finland, Denmark, The Netherlands, Belgium, the centre Strasbourg in France and the study centre Burgdorf in Switzerland were considered as northern European. The study centres of Italy, Spain, Portugal and Greece, and the centre Valence in France, Yverdon and Bellinzona in Switzerland were considered as southern Europe.

To minimize the possibility that diet or lifestyle factors had changed in response to subclinical disease or morbidity, the analyses were repeated without subjects with chronic diseases at baseline (myocardial infarction, stroke, diabetes and cancer) and subjects who died during the first 2 years of follow-up (Stampfer *et al.*, 2000).

Cohen's Kappa was calculated to measure the agreement between the diet scores in classifying subjects in a group with a healthy diet or unhealthy diet.

Results

Information about diet and vital status was available for 2044 men and 1049 women. In the HALE population, 55% of the men and 44% of the women lived in northern Europe. Baseline characteristics of the HALE population for northern and southern Europe are presented in Table 1. The mean age of the men in the FINE Study was higher than that in the SENECA Study, in both northern and southern Europe. Only 17% of the women in northern and 8% of the women in southern Europe were smokers or had stopped 15 years ago or less, compared with 51% of

the men in northern and 48% in southern Europe. The mean Voorrips score was higher in men than in women, in both northern and southern Europe. Men and women in southern Europe were more active than their counterparts in northern Europe. Women consumed less often alcohol than men, 47% of the women in northern and 57% of the women in southern Europe did not use alcohol compared to 27% of the men in northern and 17% in southern Europe. The mean number of years of education was higher in northern Europe than in southern Europe. During the 10-year follow-up period, 659 (58%) men and 137 (30%) women died in northern and 441 (48%) men and 147 (25%) women in southern Europe.

Table 1 - Baseline characteristics and 10-year mortality data of the HALE population.

	Northern Europe			Southern Europe		
	SENECA Women (n=459)	Men (n=462)	FINE Men (n=667)	SENECA Women (n=590)	Men (n=554)	FINE Men (n=361)
Age (years) (mean \pm s.d.)	73 \pm 2	73 \pm 2	76 \pm 4	73 \pm 2	73 \pm 2	78 \pm 4
Never smoked or stopped >15 years (%) (n)	83 (380)	34 (156)	59 (396)	92 (542)	50 (276)	55 (198)
Mean activity score (mean \pm s.d.)						
Voorrips score	11 \pm 9	16 \pm 12		12 \pm 10	19 \pm 13	
Morris score (min/week)			560 \pm 556			604 \pm 651
% Alcohol users (n)	53 (241)	78 (359)	70 (467)	43 (254)	80 (445)	87 (314)
Years of education (mean \pm s.d.)	9 \pm 2	10 \pm 3	8 \pm 5	7 \pm 4	8 \pm 4	5 \pm 2
BMI \leq 27 kg/m ² (%) (n)	53 (241)	64 (295)	68 (453)	59 (349)	58 (321)	60 (218)
<i>Prevalence (%) (n)</i>						
Coronary heart disease	15 (68)	19 (86)	15 (99)	16 (90)	15 (86)	8 (27)
Stroke	2 (10)	4 (20)	4 (29)	1 (8)	3 (16)	7 (25)
Diabetes	7 (36)	5 (25)	9 (61)	10 (59)	9 (50)	10 (36)
Cancer	2 (10)	1 (5)	10 (68)	2 (12)	2 (9)	6 (23)
<i>Causes of death, (%) (n)</i>						
All deaths	30 (137)	55 (256)	60 (403)	25 (147)	47 (261)	50 (180)
Cardiovascular diseases	35 (48)	32 (81)	50 (201)	41 (61)	37 (97)	51 (91)
Cancer	18 (24)	21 (55)	29 (115)	17 (25)	25 (66)	25 (45)
Other causes	11 (16)	14 (36)	18 (73)	15 (21)	16 (41)	9 (17)
Unknown cause	36 (49)	33 (84)	3 (14)	27 (40)	22 (57)	15 (27)

In Table 2 the median for the diet scores and median intake for their different components are presented. The median for the MDS without alcohol was 4 for men and women in northern and southern Europe. The medians of the MAI with and without alcohol were higher for both men and women in southern than in northern Europe. The HDI is 1 point higher for men in FINE in southern Europe, compared with northern Europe. For SENECA men, there is no difference in HDI between northern and southern Europe. The monounsaturated/saturated fatty acids ratio, the consumption of fruit, legumes/nuts/seeds, cereals, complex carbohydrates and the alcohol consumption were higher for men and women in southern than in northern Europe. However, the consumption of vegetables/potatoes, eggs, saturated fatty acids and sugar/sweets/cookies is higher in northern than in southern Europe.

Table 2 - Median (p10–p90) of the different diet scores and their components in the HALE population.

	Northern Europe			Southern Europe		
	SENECA		FINE	SENECA		FINE
	Women (n=459)	Men (n=462)	Men (n=667)	Women (n=590)	Men (n=554)	Men (n=361)
<i>Mediterranean Diet Score</i>	4 (3–6)	5 (3–6)	4 (2–6)	5 (3–6)	4 (2–6)	5 (3–7)
Monounsaturated/saturated fat ratio ^a	0.86 (0.67–1.09)	0.93 (0.70–1.13)	0.8 (0.54–1.02)	1.12 (0.75–1.96)	1.08 (0.74–1.69)	2.4 (1.55–3.53)
Vegetables/potatoes (g/day) ^a	280 (158–481)	346 (202–529)	314 (167–509)	262 (108–505)	285 (123–528)	183 (81–324)
Fruit ^a (g/day) ^a	214 (50–411)	176 (27–415)	205 (51–441)	302 (101–602)	280 (78–612)	251 (53–524)
Legumes/nuts/seeds (g/day) ^a	2 (0–24)	0 (0–33)	10 (0–50)	5 (0–36)	8 (0–42)	11 (0–33)
Meat and poultry (g/day) ^a	129 (77–195)	160 (108–245)	113 (49–181)	94 (47–168)	116 (55–186)	123 (59–192)
Milk and milk products (g/day) ^a	341 (116–656)	314 (96–666)	574 (185–1063)	316 (72–671)	345 (75–746)	134 (13–483)
Fish (g/day) ^a	17 (0–44)	22 (9–35)	20 (0–94)	31 (7–111)	34 (10–109)	19 (2–52)
Cereals (g/day) ^a	173 (106–255)	217 (125–333)	199 (124–294)	215 (122–317)	275 (167–419)	311 (189–423)
Alcohol (g/day) ^a	1 (0–17)	11 (0–41)	3 (0–30)	0 (0–20)	20 (0–61)	36 (0–82)
<i>Mediterranean Diet Score without alcohol</i>	4 (2–6)	4 (2–6)	4 (2–6)	4 (2–6)	4 (2–6)	4 (2–6)
<i>Mediterranean Adequacy Index</i>	1.36 (0.75–2.57)	1.52 (0.81–2.86)	1.05 (0.52–2.04)	2.04 (0.96–1.34)	2.25 (1.09–5.59)	3.61 (1.51–8.43)
Eggs (g/day) ^a	13 (5–35)	14 (0–40)	18 (5–38)	11 (0–32)	13 (0–37)	7 (0–17)
Saturated fat (g/day) ^a	35 (26–48)	43 (30–57)	46 (34–62)	28 (15–41)	33 (17–51)	20 (14–30)
Monounsaturated fat (g/day) ^a	30 (22–40)	39 (28–51)	36 (27–47)	31 (20–46)	35 (23–50)	49 (36–64)
Sugar/sweets/cookies (g/day) ^a	39 (5–104)	47 (8–123)	74 (22–161)	24 (0–60)	28 (0–73)	30 (6–83)
Wine (g/day) ^a	0 (0–132)	0 (0–275)	0 (0–62)	0 (0–198)	188 (0–710)	328 (0–740)
<i>Mediterranean Adequacy Index without alcohol</i>	1.30 (0.74–2.48)	1.42 (0.75–2.42)	1.00 (0.48–1.94)	1.89 (0.90–4.02)	1.83 (0.91–4.34)	2.55 (1.14–5.39)
Healthy diet indicator	2 (1–4)	3 (1–4)	3 (1–4)	3 (1–5)	3 (2–5)	4 (2–5)
Saturated fatty acids (% energy intake)	16 (12–22)	16 (11–21)	17 (13–23)	13 (7–19)	13 (7–19)	8 (6–12)
Polyunsaturated fatty acids (% energy intake)	6 (4–12)	7 (4–12)	6 (3–11)	5 (3–11)	4 (2–9)	3 (2–6)
Protein (% energy intake)	15 (11–20)	14 (11–18)	15 (12–19)	15 (12–20)	15 (13–20)	14 (12–17)
Complex carbohydrates (% energy intake)	22 (16–29)	23 (17–31)	24 (17–39)	26 (16–42)	28 (18–45)	39 (29–48)
Monosaccharide and disaccharides (% energy intake)	21 (14–29)	19 (13–28)	20 (8–31)	20 (11–30)	19 (11–28)	14 (8–22)
Dietary fibre (g/day)	20 (12–30)	23 (14–35)	25 (17–38)	19 (9–29)	22 (12–35)	20 (14–29)
Fruit and vegetables/potatoes (g/day)	461 (255–738)	508 (278–806)	468 (260–745)	487 (229–900)	522 (262–887)	446 (207–670)
Legumes, nuts, seeds (g/day)	2 (0–22)	0 (0–29)	9 (0–43)	4 (0–29)	7 (0–38)	10 (0–34)
Cholesterol (mg/day)	288 (176–440)	326 (206–534)	294 (169–554)	222 (124–401)	280 (148–475)	182 (108–270)

^a Grams/day, corrected for 2500 kcal/day in men, 2000 kcal in women.

Table 3 presents the proportional hazard rates for the different diet scores in relation to mortality. In the total population, all diet scores were significantly related to mortality and varied between 0.78 and 0.89. In northern and southern Europe separately, all diet scores were also inversely associated with mortality,

but only the MDS was significantly related to mortality in northern and southern Europe, and the MAI and MAI without alcohol in northern Europe. The association between the MAI and mortality was stronger in northern than in southern Europe. Similar results were obtained in the total population after excluding subjects with chronic diseases at baseline and subjects who died during the first 2 years of follow-up (prevalence of myocardial infarction: 454; stroke: 112; diabetes: 267, cancer: 127, number that died during the first 2 years of follow-up: 230, in total 977 subjects were excluded); MDS (HR: 0.87 with 95% CI: 0.74–1.02), MDS without alcohol (HR: 0.77 with 95% CI: 0.68–0.88), MAI (HR: 0.77 with 95% CI: 0.65–0.91), MAI without alcohol (HR: 0.85 with 95% CI: 0.72–1.01) and the HDI (HR: 0.92 with 95% CI: 0.81–1.05).

Table 3 - Cox proportional hazard ratios (HRs) of the different diet scores for 10-year mortality in elderly European men and women.

<i>Diet scores</i>	<i>Total population HR (95% CI)</i>	<i>Northern Europe HR (95% CI)</i>	<i>Southern Europe HR (95% CI)</i>
Mediterranean Diet Score ^a	0.82 (0.75–0.91) ^b	0.83 (0.74–0.93) ^b	0.88 (0.78–0.98) ^b
Mediterranean Diet Score without alcohol ^c	0.78 (0.71–0.87) ^a	0.89 (0.77–1.02) ^a	0.92 (0.84–1.02) ^a
Mediterranean Adequacy Index ^a	0.83 (0.75–0.92) ^b	0.79 (0.74–0.85) ^b	0.96 (0.86–1.08) ^b
Mediterranean Adequacy Index without alcohol ^c	0.87 (0.79–0.97) ^a	0.83 (0.74–0.92) ^a	0.97 (0.86–1.10) ^a
Healthy Diet Indicator ^a	0.89 (0.81–0.98) ^a	0.93 (0.85–1.02) ^a	0.93 (0.84–1.02) ^a

^a Model adjusted for age, gender, physical activity, smoking, number of years of education, BMI, chronic disease at baseline and study center.

^b Subjects with a score equal or higher than the median were considered as having a healthy diet; subjects who had a score below the median were considered as having an unhealthy diet (reference group).

^c Model additionally adjusted for alcohol.

In Table 4, the Cox proportional hazard rates for the different components of the diet scores are presented. The consumption of fruit, fish, cereals, dietary fibres and the Mediterranean component of the MAI were significantly inversely related to mortality. The intake of saturated fatty acids was positively associated with mortality in the total population.

Table 4 - Cox proportional hazard ratios (HRs) for the components of the different diet scores for 10-year mortality in elderly European men and women.

<i>Component of the diet score</i>	<i>Total population HRs (95 CI)^a</i>	<i>Northern Europe HRs (95 CI)^a</i>	<i>Southern Europe HRs (95 CI)^a</i>
<i>Mediterranean Diet Score^b</i>			
Monounsaturated/saturated fat ratio	0.89 (0.81–1.00)	1.03 (0.92–1.15)	0.77 (0.58–1.02)
Vegetables/potatoes (g/day)	0.99 (0.90–1.09)	0.99 (0.89–1.12)	1.05 (0.91–1.22)
Fruit (g/day)	0.86 (0.78–0.94)	0.98 (0.89–1.08)	0.87 (0.77–0.99)
Legumes/nuts/seeds (g/day)	0.95 (0.86–1.04)	1.00 (0.91–1.12)	0.99 (0.90–1.09)
Meat and poultry (g/day)	0.97(0.87–1.09)	1.07 (0.94–1.21)	0.92 (0.78–1.08)
Milk and milk products (g/day)	1.10 (1.00–1.21)	1.10 (0.94–1.29)	1.06 (0.87–1.28)
Fish (g/day)	0.89 (0.82–0.97)	0.89 (0.75–1.04)	0.88 (0.78–0.99)
Grains (g/day)	0.84 (0.77–0.92)	0.90 (0.84–0.97)	1.07 (0.92–1.25)
Alcohol	0.84 (0.77–0.92)	0.82 (0.67–0.99)	0.77 (0.64–0.94)
<i>Mediterranean Adequacy Index without alcohol^b</i>			
Mediterranean components	0.86 (0.79–0.93)	0.95 (0.85–1.07)	0.83 (0.73–0.94)
Non-Mediterranean components	0.91 (0.82–1.01)	0.91 (0.82–1.02)	1.00 (0.83–1.22)
<i>Healthy Diet Indicator^b</i>			
Saturated fatty acids	1.25 (1.10–1.41)	0.98 (0.61–1.56)	1.19 (0.95–1.48)
Polyunsaturated fatty acids	1.03 (0.94–1.13)	1.04 (0.96–1.13)	0.98 (0.82–1.17)
Protein	1.00 (0.93–1.08)	0.90 (0.82–0.99)	1.13 (1.02–1.24)
Complex carbohydrates	0.93 (0.81–1.08)	1.38 (0.60–3.19)	1.02 (0.87–1.20)
Dietary fibre (g/day)	0.90 (0.81–0.99)	0.86 (0.75–0.99)	0.93 (0.83–1.05)
Fruit & vegetables/potatoes	0.88 (0.78–0.99)	0.89 (0.76–1.03)	0.84 (0.68–1.05)
Legumes, nuts, seeds	1.10 (0.99–1.21)	1.19 (1.07–1.34)	1.07 (0.90–1.27)
Monosachharides and disaccharides	0.97 (0.87–1.08)	0.99 (0.89–1.11)	0.90 (0.79–1.03)
Cholesterol	0.99 (0.91–1.07)	0.89 (0.80–1.00)	0.96 (0.84–1.09)

^a Model adjusted for age, gender, physical activity, smoking, alcohol use, number of years of education, BMI, chronic disease at baseline and study centre.

^b The median of the items was used as cutoff point. For the healthy items, the subjects who scored zero were used as reference group, while for the detrimental items; subjects with a high consumption were used as reference group.

A moderate agreement was found between the MDS and the MAI (Kappa=0.45, 95% CI: 0.41–0.46) and the MDS without alcohol and MAI without alcohol (Kappa=0.49; 95% CI: 0.45–0.51). The agreement between the scores, which measure the agreement with the Mediterranean diet, and the HDI was fair; for the HDI and the MDS, the Kappa was 0.19 (95% CI: 0.15–0.22) and 0.22 (95% CI: 0.18–0.25) for the HDI and the MAI.

Discussion

Men and women aged 70 and 90 years at baseline in the HALE population, adhering to a Mediterranean type of diet or following the dietary guidelines for preventing chronic diseases proposed by the WHO, had a significantly lower risk of all-causes mortality. Because several studies have shown that alcohol consumption is an independent factor of mortality, the MDS and the MAI were also calculated without taking alcohol consumption into account. The results for the MDS and the MAI without alcohol were similar.

In previous studies in European elderly, the lower risk in overall mortality associated with increased adherence to the Mediterranean diet was similar to that found in the present study (Trichopoulou *et al.*, 1995, 2003; Haveman-Nies *et al.*, 2002). Excluding subjects with chronic diseases at baseline did not change the association between the diet scores and mortality. The results of the MDS and mortality in healthy subjects in the HALE population have, recently, been published (Knoops *et al.*, 2004). Trichopoulou *et al.* (2005a) found similar associations between the MDS and all-causes mortality and cardiac mortality in patients with coronary heart disease. This suggests that the Mediterranean diet is beneficial for elderly subjects with and without baseline chronic disease, and that the results could not be explained by residual confounding from health status at baseline.

The MDS relies on epidemiological evidence concerning the individual dietary components (Trichopoulou *et al.*, 1995, 2003). The components of the diet score have been validated (Gnardellis *et al.*, 1995). However, Trichopoulou *et al.* (1995, 2003, 2005a, 2005b) did not find strong associations for the individual components of the MDS. Investigating the individual components of the MDS in our population, we found that the ratio of monounsaturated versus saturated fatty acids, cereals, fruit and fish were inversely associated with the risk of mortality in the whole population, but the effect was only borderline significant for the ratio of monounsaturated versus saturated fatty acids. The association between the ratio of monounsaturated versus saturated fat and mortality was stronger in southern compared with northern Europe. This may be because of a more favourable fatty acid pattern in the Mediterranean countries (Fernandez-Jarne *et al.*, 2002). A protective effect of alcohol consumption was found in this study. A similar effect of alcohol was found after excluding subjects with chronic diseases at baseline, those with a low self-perceived and those who were disabled in basic activities of daily living (Knoops *et al.*, 2005). The protective effect of moderate alcohol consumption on mortality is also confirmed in other studies (Liao *et al.*, 2000; Marmot, 2001; Mukamal *et al.*, 2003).

Alberti-Fidanza *et al.*, proposed the MAI and calculated that MAI of the Reference Italian-Mediterranean Diet of Nicoterra in 1957 was 7.5 (Alberti-Fidanza *et al.*, 1999; Alberti-Fidanza and Fidanza, 2004; Fidanza *et al.*, 2004). In Crevalcore, the MAI was 2.9 in 1965 and 2.2 in 1991; and in Montegiorgio, 5.6 in 1965 and 3.9 in 1991, indicating that in Italy the MAI values differ in time and place. In the present study carried out around 1990, similar MAI values were found for southern Europe (ranging from 2.04 to 4.90). As expected, the MAI values were lower in northern Europe, indicating that subjects in southern Europe eat a more Mediterranean type of diet compared with northern Europe. The association between the MAI and all-causes mortality has not been investigated earlier, but a significant inverse association was found between MAI and population mortality rates from coronary heart disease in the SCS (Fidanza *et al.*, 2004). In the present study, the MAI and the MAI without alcohol were both inversely associated with mortality.

In a previous study, a significant inverse relationship between the HDI and mortality was found in elderly men although most of the individual components of the HDI were not statistically significantly related to mortality (Huijbregts *et al.*, 1997). Besides an association between the HDI and mortality, we found a significant inverse association between fibres and between fruit and vegetable intake and mortality.

Advantages of the present study carried out in 10 European countries are its great diversity in dietary patterns and lifestyle factors, its prospective nature, its

large sample size, its reliance on a sample of the general population in all countries and the measurement of many potential confounders. SENECA and FINE could be pooled because the estimates of the separate models were similar and there were no important differences in study population and measurements. To be sure that the relationships between diet and mortality could not be explained by a study effect, this variable was included as potential confounder in the analyses.

The present study had also several limitations. Because the European classification system (EUROCODE) (Arab *et al.*, 1987) was used, it was not possible to investigate the separate effects of vegetables and potatoes, of oils and margarines and of legumes, nuts and seeds. In the MDS, cereals were included as beneficially item and no distinction could be made between highly refined cereals and unrefined cereals (Martinez-Gonzalez and Sanchez-Villegas, 2004). Dietary patterns are highly determined by cultural and genetic differences between populations in the different research centres and between northern and southern Europe. In a multi-centre study, adjustment for study centre is needed to account for factors related to the outcome, which vary from centre to centre but do not adjust for instance for unmeasurable factors as the quality of the centres' staff (Andersen *et al.*, 1999). For this reason, a random intercept for each centre is taken into account in the adjusted models.

Although national heritage could be a confounder in our analyses, as suggested by Craighead (Craighead, 2005), we did not adjust for region (northern or southern Europe) in the analysis using the whole population because the variable region has a strong cultural component, which could be responsible for (a part of) the variation in dietary patterns. Adjustment for region would result in an overadjustment and an underestimation of the true association between diet scores and mortality.

To be sure that the associations between diet and mortality could not be explained by region, we repeated our analyses for northern and southern Europe separately. The strength of the associations between the MDS, the HDI and mortality were generally similar after stratification, although the absolute mortality risk was higher in northern than in southern Europe (Table 2). However, we found stronger associations between the MAI in relation to all-causes mortality in northern than in southern Europe. A possible explanation could be the 'arbitrary' choice of the median as cutoff point. The medians of the MAI and the MAI without alcohol were higher in southern Europe compared with northern Europe; for southern Europe, the medians were 2.33 for the MAI and 1.98 for the MAI without alcohol, while in northern Europe the medians were, respectively, 1.27 and 1.21. If we apply the cutoff points of northern Europe (respectively, 1.27 and 1.21) also in southern Europe, then the hazard rates of 0.90 with 95% CI: 0.81–1.00 for the MAI and 0.87 with 95% CI: 0.78–0.96 for the MAI without alcohol are quite similar to those in northern Europe. The medians of the MDS and the MDS without alcohol were similar for northern and southern Europe, respectively, 5 and 4. Applying these medians in northern and southern Europe gave similar results in northern and southern Europe, suggesting that this diet score is more generally applicable than the MAI.

In conclusion, the MDS, the MDI and the HDI were significantly inversely related with mortality.

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