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JAMA. 2004;292(12):1433-1439 (doi:10.1001/jama.292.12.1433)

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Mediterranean Diet, Lifestyle Factors, and 10-Year Mortality in Elderly European Men and Women

The HALE Project

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THE NUMBER OF OLDER PEOPLE IS growing rapidly worldwide. More than 580 million people are older than 60 years, and the number is projected to rise to 1000 million by 2020.¹ With the increase in life expectancy, the leading causes of death have shifted dramatically from infectious diseases to noncommunicable diseases and from younger to older individuals. In industrialized countries, about 75% of deaths in persons older than the age of 65 are now from cardiovascular diseases and cancer.²

Regardless of predisposing factors, diet and lifestyle influence morbidity and mortality during the course of life.² Because of the cumulative effect of adverse factors throughout life, it is particularly important for older persons to adopt diet and lifestyle practices that minimize their risk of death from morbidity and maximize their prospects for healthful aging.²

Dietary patterns and other modifiable lifestyle factors are associated with mortality from all causes, coronary

See also pp 1440 and 1490.

Context Dietary patterns and lifestyle factors are associated with mortality from all causes, coronary heart disease, cardiovascular diseases, and cancer, but few studies have investigated these factors in combination.

Objective To investigate the single and combined effect of Mediterranean diet, being physically active, moderate alcohol use, and nonsmoking on all-cause and cause-specific mortality in European elderly individuals.

Design, Setting, and Participants The Healthy Ageing: a Longitudinal study in Europe (HALE) population, comprising individuals enrolled in the Survey in Europe on Nutrition and the Elderly: a Concerned Action (SENECA) and the Finland, Italy, the Netherlands, Elderly (FINE) studies, includes 1507 apparently healthy men and 832 women, aged 70 to 90 years in 11 European countries. This cohort study was conducted between 1988 and 2000.

Main Outcome Measures Ten-year mortality from all causes, coronary heart disease, cardiovascular diseases, and cancer.

Results During follow-up, 935 participants died: 371 from cardiovascular diseases, 233 from cancer, and 145 from other causes; for 186, the cause of death was unknown. Adhering to a Mediterranean diet (hazard ratio [HR], 0.77; 95% confidence interval [CI], 0.68-0.88), moderate alcohol use (HR, 0.78; 95% CI, 0.67-0.91), physical activity (HR, 0.63; 95% CI, 0.55-0.72), and nonsmoking (HR, 0.65; 95% CI, 0.57-0.75) were associated with a lower risk of all-cause mortality (HRs controlled for age, sex, years of education, body mass index, study, and other factors). Similar results were observed for mortality from coronary heart disease, cardiovascular diseases, and cancer. The combination of 4 low risk factors lowered the all-cause mortality rate to 0.35 (95% CI, 0.28-0.44). In total, lack of adherence to this low-risk pattern was associated with a population attributable risk of 60% of all deaths, 64% of deaths from coronary heart disease, 61% from cardiovascular diseases, and 60% from cancer.

Conclusion Among individuals aged 70 to 90 years, adherence to a Mediterranean diet and healthful lifestyle is associated with a more than 50% lower rate of all-causes and cause-specific mortality.

JAMA. 2004;292:1433-1439

www.jama.com

heart disease (CHD), cardiovascular diseases (CVD), and cancer.³⁻⁸ As yet, few studies have investigated the combined effect of diet and other lifestyle factors.^{7,9}

In the current study, we investigated the association of individual and combined dietary patterns and lifestyle factors (alcohol use, smoking sta-

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tus, and physical activity) with mortality from all causes, CHD, CVD, and cancer in elderly men and women from 11 European countries in the Healthy Ageing: a Longitudinal study in Europe (HALE) population.

METHODS

Study Population

The HALE project included participants of the Survey in Europe on Nutrition and the Elderly: a Concerned Action (SENECA) and Finland, Italy, the Netherlands, Elderly (FINE) studies who were examined in 1988-1991 and were followed up for 10 years. Details about the SENECA and FINE studies have been described elsewhere^{10,11} and are briefly summarized herein.

The SENECA study started in 1988 and consisted of a random age- and sex-stratified sample of inhabitants, born between 1913 and 1918, of 19 European towns. In the HALE project, 13 centers that carried out mortality follow-up were included. The original participation rate in the centers varied from 37% to 81%.¹² Surveys were repeated in 1993 and 1999. The response rates for SENECA were 68% in 1993 and 55% in 1999, and for FINE they were 86% in 1993 and 85% in 1999. All men and women of the following towns were included: Hamme, Belgium; Roskilde, Denmark; Strasbourg, France; Valence, France; Iraklion, Greece; Monor, Hungary; Padua, Italy; Culemborg, the Netherlands; Vila Franca de Xira, Portugal; Betanzos, Spain; and Yverdon, Burgdorf, and Bellinzona, Switzerland.¹⁰

The FINE study consists of the survivors of 5 cohorts of the Seven Countries Study: Ilomantsi, East Finland; Pöytyä, and Mellilä, West Finland; Crevalcore and Montegiorgio, Italy; and Zutphen, the Netherlands. The FINE study, which started in 1984 and continued to 2000, recruited men who were born between 1900 and 1920. For our study, we used the 1989-1991 baseline measurements of men aged 70 to 90 years.¹¹ Surveys were repeated in the years 1994-1995 and 1999-2000. The response rates in 1989-1991 were 92% for the Finnish cohorts, 74% for the

Dutch cohort, and 76% for the Italian cohorts.¹³

Because CHD, CVD, cancer, and diabetes increase the risk of mortality and can induce changes in diet and lifestyle, participants who had these diseases were excluded at baseline. The average follow-up time was 10 years in both SENECA and FINE.

In both studies, food consumption data were collected by trained dietitians using a dietary history method.^{10,11} This method provides information about the usual food consumption of the participants from the month before the interview in SENECA and from 2 to 4 weeks before the interview 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 the start of the dietary interview about usual food consumption patterns was based on a food record and by an oral interview in FINE. Both dietary histories were validated.^{10, 13}

Information on smoking status; physical activity level; educational achievement (number of years); the prevalence of CHD, stroke, diabetes, and cancer; the use of antihypertensive medication (only in FINE); and occupation (only in FINE) was collected using questionnaires. The prevalence of chronic diseases was confirmed by general practitioners, hospital registrants, or both in the FINE study only.

Information on physical habitual activity was obtained using the Voorrips questionnaire in SENECA and the Morris questionnaire in FINE.^{14,15} Both questionnaires were developed for retired elderly individuals and focus on leisure-time activities, such as walking, cycling, and gardening. SENECA also included household activities.^{14,15}

Weight, height, and waist circumference (SENECA only) measurements have been described in detail elsewhere.^{10,11} Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. In the analyses, BMI was dichotomized as 25 or less vs greater than 25. The HALE

study comprised 98.6% of individuals who lived independently.

Definition of Low-Risk Groups

To assess the association of diet and the lifestyle factors with mortality, a low-risk group was defined for diet and lifestyle factors. For dietary intake, the low-risk group was defined as those who had a score of at least 4 on a modified version of the Mediterranean diet score proposed by Trichopoulou et al.⁴

The modified Mediterranean diet score comprised 8 components: ratio of mono-unsaturated to saturated fat; legumes, nuts, and seeds; grains; fruit; vegetables and potatoes; meat and meat products; dairy products; and fish. Intake of each component was adjusted to daily intakes of 2500 kcal (10.5 MJ) for men and 2000 kcal (8.5 MJ) for women. The sex-specific median intake values were taken as cutoff points. The diet score varied from 0 (low-quality diet) to 8 (high-quality diet). For the components mono-unsaturated fatty acids to saturated fatty acids (MUFA to SAFA) ratio; fruits and fruit products; vegetables and potatoes; legumes, nuts, and seeds; fish; and grains, a value of 1 was assigned to persons whose consumption was at least as high as the sex-specific median value, and 0 to the others. The vegetables group of the original Mediterranean diet score was replaced by the vegetables and potatoes group because the European classification system (EUROCODE) was used when the 2 food groups were assessed together.¹⁶ For meat and meat products and dairy products, a value of 1 was assigned to persons whose consumption was less than the sex-specific median and 0 to the others.

The low-risk group for alcohol was defined as those who consumed more than 0 g of alcohol per day. Alcohol consumption was initially divided into 3 groups: 0 g, 1 to 29 g, and 30 g or more of alcohol per day. However, the Kaplan-Meier survival curves of the 3 alcohol groups showed no difference in survival between participants who consumed between 1 g to 29 g of alcohol per day and those who consumed 30 g or more alcohol per day.

For smoking, individuals were considered to be at low risk if they had never smoked or had stopped smoking more than 15 years ago.¹⁷⁻¹⁹

Individuals with a score in the intermediate and the highest tertile on the Voorrips or Morris questionnaire were considered the low-risk group for physical activity.^{14,15}

A lifestyle score was calculated by adding the individual scores for diet, physical activity level, smoking status, and alcohol intake. Individuals scored 1 point if they belonged to the low-risk group for diet or a particular lifestyle factor and 0 if they belonged to the high-risk group. In total, an individual could obtain 4 points: 1 point for a Mediterranean diet and 3 points for the healthful lifestyle factors.

Health Status

Information on vital status and causes of death was collected every 5 years in FINE and in 1999-2000 for SENECA and was available for 99.7% of participants. Causes of death were coded by an experienced physician and classified according to the *International Classification of Diseases, Ninth Revision (ICD-9)* coding system.²⁰ Codes 410-414 were used for defining CHD, codes 390-459 for CVD, and codes 140-240 for cancer. Causes of death were available for 92% of the participants in FINE and 72% of the participants in SENECA. Mortality from other causes was defined as total mortality minus the deaths from unknown causes, CHD, CVD, and cancer.

Statistical Analysis

Statistical analyses were carried out using the SAS statistical software version 8.2 (SAS Institute, Cary, NC). Before pooling the data for SENECA and FINE, a test for heterogeneity was performed, which was not significant ($P=.93$); no significant interactions between diet, lifestyle factors, and study were found. Cox proportional hazards models were used to estimate the single and the combined effect of diet, smoking status, alcohol consumption, and physical activity level on mortal-

ity.²¹ In the analyses for cause-specific mortality and mortality from other causes, individuals with a missing cause of death were excluded. For all models, the Cox proportional hazards assumption was tested and met. Dummy variables were created for the number of healthful dietary and lifestyle factors; a score of 0 or 1 for the healthful dietary and lifestyle factor was used as reference category.

All models were adjusted for the other diet and lifestyle factors, sex, age at baseline, BMI, and study population (SENECA vs FINE). To correct the estimates for socioeconomic status, the models were adjusted for the number of years of education.

Region (northern or southern Europe), center, occupation, waist circumference (continuous), marital status, and use of antihypertensive medication were tested as potential confounders but did not affect our estimates. Because several studies indicate that exposure to pesticides and industrialized environment increases the risk of mortality,²² we classified participants' occupation as farmers (an indicator of pesticide exposure) vs nonfarmers and whether individuals were exposed or not exposed to an industrialized environment. Occupation as farmer and exposure to an industrialized environment also did not affect our results.

To minimize the possibility that diet or lifestyle factors had changed in response to subclinical disease, the analyses were repeated after excluding the first 2 years of mortality follow-up.⁹ Interactions between all dietary and lifestyle factors and confounders were tested, but none of them was statistically significant at $\alpha=.1$. To ensure that the estimates were not biased by multicollinearity, the crude hazard ratios (HRs) for the dietary and lifestyle factors were also calculated and compared with the adjusted HRs. The crude HRs and the adjusted HRs were similar, indicating that the estimates were not biased by multicollinearity.

Population attributable risk, an estimate of the percentage of mortality in this population that would not have oc-

curred if all participants were in the low-risk group, was calculated.^{9,23}

The unadjusted Kaplan-Meier curves for the number of protective factors in relation to all-cause mortality were fitted and the log-rank test was calculated. $P<.05$ was considered to be statistically significant for all possible predictors in the model, but to investigate interaction between all predictors, we considered $P<.01$ to be statistically significant.

RESULTS

Information about diet, lifestyle factors, and vital status was available for 1507 men (781 from the SENECA study, 726 from the FINE study) and 832 women without CHD, CVD, diabetes, and cancer at baseline (TABLE 1). Men in the SENECA study were 7 years younger on average than men in the FINE study. The median of the diet score in the total population was 4; 3 in northern Europe vs 5 in southern Europe. The mean alcohol intake was 21 g/d for men and 6 g/d for women. In northern Europe, the mean alcohol consumption was 17.5 g/d for men and 5.5 g/d for women compared with 31 g/d for men and 6 g/d for women in southern Europe. The cutoff point for the lowest percentile for activity in the FINE study was 200 min/wk, which means approximately 30 minutes of activity per day, with an intensity higher than 2.0 kcal/kg per hour each day. In the SENECA study, there were almost 5 times as many male smokers as there were female smokers. The mean follow-up time was 10 years, with a range of 8.9 to 10.5 years. Twice as many men died during the 10-year follow-up as did women.

TABLE 2 shows that a Mediterranean diet, moderate alcohol consumption, moderate to high physical activity levels, and nonsmoking were associated with lower mortality rates from all causes, CHD, CVD, cancer, and other causes during the 10-year follow-up. The models were adjusted for sex, age, years of education, study, and BMI. Individuals with 2, 3, or 4 low-risk factors had a significantly lower risk of

Table 1. Baseline Characteristics and 10-Year Mortality Data of the SENECA and FINE Studies in Persons Without Prevalent Chronic Diseases

	SENECA		FINE
	Women (n = 832)	Men (n = 781)	Men (n = 726)
Age, mean (SD), y	73 (1.8)	73 (2.0)	77 (4)
Northern Europe, No. (%)	355 (43)	350 (45)	462 (64)
Years of education, mean (SD)	8 (3.5)	9 (4.0)	7 (4.5)
Mediterranean diet score, median (10-90 percentile)	4 (2-6)	4 (2-6)	4 (2-6)
Monounsaturated/saturated fat ratio, median (10-90 percentile)*	1 (0.70-1.63)	1 (0.73-1.55)	1 (0.58-2.90)
Food consumption, median (10-90 percentile), g/d*			
Vegetables or potatoes	272 (136-484)	306 (148-504)	248 (113-456)
Fruit	262 (74-519)	228 (43-528)	209 (47-457)
Legumes, nuts, or seeds	5 (0-31)	7 (0-38)	10 (0-46)
Meat and poultry	107 (53-181)	130 (66-217)	113 (58-181)
Milk and milk products	317 (90-624)	313 (80-683)	392 (28-969)
Fish	23 (0-73)	26 (2-90)	20 (0-57)
Grains	194 (116-302)	248 (144-389)	231 (133-379)
Alcohol users, No. (%)	466 (56)	647 (83)	555 (76)
Voorrips score, mean (SD)	12 (9)	19 (13)	NA
Cutoff point lowest tertile	5.5	9.5	NA
Morris score, mean (SD), min/wk	NA	NA	598 (605)
Cutoff point lowest tertile, mean (SD)	NA	NA	200
Never smoked or stopped > 15 years ago, No. (%)	731 (88)	337 (43)	444 (58)
Body mass index <25, No. (%)†	343 (41)	307 (39)	305 (42)
Causes of death, No. (%)			
All deaths	197 (24)	366 (47)	372 (51)
Coronary heart disease	18 (9)	45 (12)	59 (16)
Cardiovascular diseases	76 (39)	117 (32)	178 (48)
Cancer	35 (18)	96 (26)	102 (27)
Other causes	27 (13)	56 (15)	62 (17)
Unknown cause	59 (30)	97 (27)	30 (8)

Abbreviations: FINE, Finland, Italy, the Netherlands, Elderly; NA, not applicable; SENECA, Survey in Europe on Nutrition and the Elderly: A Concerned Action.

*Grams per day calculation is corrected for 2500 kilocalories per day for men and 2000 kilocalories per day for women. Median food components for all men: fat ratio, 1; vegetables or potatoes g/d, 284; fruit g/d, 214; legumes, nuts, or seeds g/d, 8; meat and poultry g/d, 123; milk and milk products g/d, 340; fish g/d, 23; and grains g/d, 240.

†Body mass index is measured as weight in kilograms divided by the square of height in meters.

all-cause and cause-specific mortality compared with individuals with 0 or 1 low-risk factor during 10 years of follow-up (TABLE 3). Sixty percent of all deaths were associated with not adhering to this low-risk pattern. For cause-specific mortality, 64% of deaths due to CHD; 61% due to CVD; 60% due to cancer, and 61% due to other causes during the 10-year follow-up period were associated with not adhering to this low-risk pattern. Including individuals with CHD, CVD, cancer, or diabetes at baseline in the analysis and adjusting for prevalence of these long-term diseases at baseline did not change our estimates.

Similar results were found after excluding from the analysis the 140 persons who died during the first 2 years of follow-up: adhering to a Mediterranean diet (HR, 0.77; 95% confidence interval [CI], 0.67-0.89), moderate alcohol consumption (HR, 0.83; 95% CI, 0.71-0.91), engaging in physical activity (HR, 0.65; 95% CI, 0.56-0.76), and nonsmoking (HR, 0.67, 95% CI, 0.57-0.78) were associated with a significantly lower risk of all-cause mortality. The combination of 4 low-risk factors lowered the all-cause mortality rate to 0.37 (95% CI, 0.29-0.47). For cause-specific mortality, the HRs for the single and the combined effects from dietary and lifestyle factors were also similar after excluding the first 2 years of follow-up.

The FIGURE shows the Kaplan-Meier curves for the number of healthful dietary and lifestyle factors. The cor-

Table 2. Cox Proportional Hazard Ratios for Dietary Pattern and 3 Lifestyle Factors for 10-Year All-Cause and Cause-Specific Mortality in Elderly Europeans

Variables	Causes of Death, Hazard Ratio (95% Confidence Interval)*				
	All Causes	Coronary Heart Disease	Cardiovascular Disease	Cancer	Other Causes
No. at risk	2339	2152	2152	2152	2145
No. of events	935	122	371	233	145
Protective factors†					
Mediterranean diet	0.77 (0.68-0.88)	0.61 (0.43-0.88)	0.71 (0.58-0.88)	0.90 (0.70-1.17)	0.61 (0.44-0.85)
Moderate alcohol consumption	0.78 (0.67-0.91)	0.60 (0.40-0.88)	0.74 (0.59-0.93)	0.73 (0.54-0.98)	0.63 (0.44-0.90)
Physical activity	0.63 (0.55-0.72)	0.72 (0.48-1.07)	0.65 (0.52-0.81)	0.64 (0.48-0.84)	0.52 (0.37-0.74)
Nonsmoking	0.65 (0.57-0.75)	0.80 (0.54-1.17)	0.68 (0.54-0.85)	0.47 (0.36-0.62)	0.92 (0.59-1.24)

*Model adjusted for the other dietary and lifestyle factors, age, sex, number of years of education, body mass index, and study.

†To achieve protective factors in each category, participants must have scored at least 4 points for the Mediterranean diet score, consumed more than 0 g of alcohol a day, scored in the intermediate or highest tertile for either the Voorrips or Morris questionnaires, and were nonsmokers or had quit smoking for at least 15 years.

responding log-rank test statistic was 101.9, $P < .001$.

COMMENT

During the 10-year follow-up, men and women between the ages of 70 and 90 years who had adhered to a Mediterranean diet, were nonsmokers or had stopped smoking more than 15 years ago, were physically active, and used alcohol moderately had less than half the mortality rate from all causes, CHD, CVD, and cancer, and mortality from other causes than those who did not.

Advantages of this Europe-wide study were its great diversity in dietary patterns and lifestyle factors, its prospective nature, its large sample size, and its measurements 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 measurement of risk factors. To ensure that the relationships between diet, lifestyle factors, and mortality could not be explained by a study effect, this variable was included as a potential confounder in all pooled analyses.

This study also had several limitations. Despite the large number of participants and long follow-up, few cases had no healthful diet or lifestyle factors. Therefore, we had to combine those who had scores of 0 or 1 in the healthful diet and lifestyle factor ranking to have a stable reference category. The initial response rate in the SENECA centers was lower (37%-81%) than in the FINE centers (74%-92%).^{12,13} In prospective cohort studies, distributions of dietary and lifestyle factors in the study population may have been affected by selective participation in the different cohorts. However, we had almost 100% mortality follow-up, so the relationships between dietary factors and mortality should not be distorted.²⁴ Another limitation is the low number of deaths due to cause-specific mortality; for example, only 122 deaths were from CHD. Due to these low numbers, it is possible that the power was too low to find a signifi-

cant effect of all dietary and lifestyle factors in the cause-specific analysis.

A Mediterranean diet score of 4 or more points was associated with a lower risk of all-cause and cause-specific mortality; the strongest association was ob-

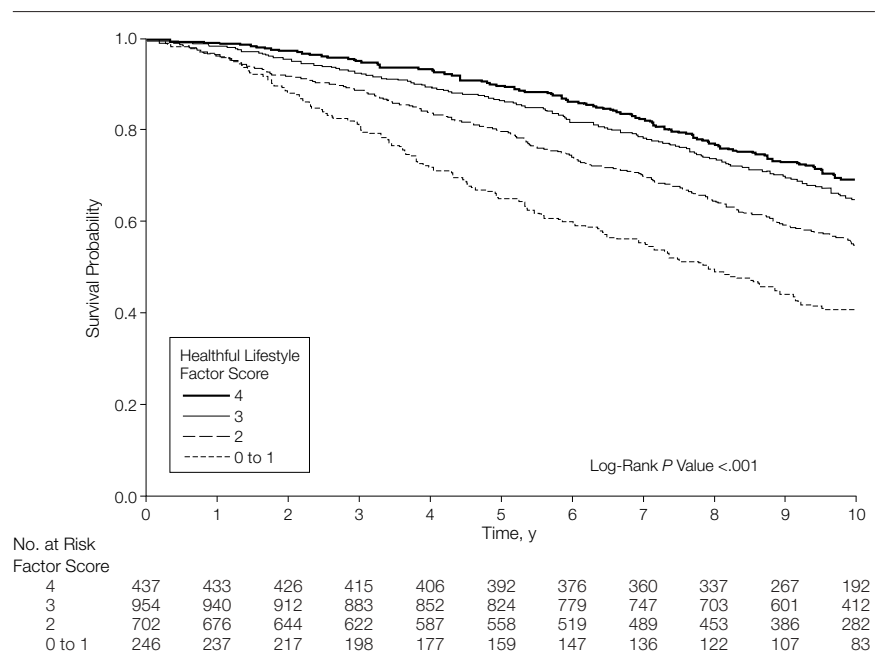
served for CHD. The Mediterranean diet scale relies on generally strong epidemiological evidence concerning the individual dietary components.^{4,6} The components of the diet score have been validated.²⁵ In previous studies^{4,6,7} in-

Table 3. Cox Proportional Hazard Ratios and Population-Attributable Risks of the Combined Diet and Lifestyle Factors for 10-Year All-Cause and Cause-Specific Mortality in Elderly Europeans

Mortality	No. of Protective Factors			
	0-1 (n = 246)	2 (n = 702)	3 (n = 954)	4 (n = 437)
All-cause				
HR (95% CI)	1.00	0.62 (0.51-0.75)	0.45 (0.37-0.54)	0.35 (0.28-0.44)
PAR (%)		14	37	60
Coronary heart disease				
HR (95% CI)	1.00	0.50 (0.29-0.85)	0.43 (0.26-0.71)	0.27 (0.14-0.53)
PAR (%)		18	38	64
Cardiovascular diseases				
HR (95% CI)	1.00	0.60 (0.44-0.82)	0.44 (0.33-0.60)	0.33 (0.22-0.47)
PAR (%)		13	38	61
Cancer				
HR (95% CI)	1.00	0.65 (0.45-0.96)	0.42 (0.28-0.62)	0.31 (0.19-0.50)
PAR (%)		14	38	60
Other causes				
HR (95% CI)	1.00	0.55 (0.34-0.90)	0.38 (0.23-0.61)	0.33 (0.19-0.58)
PAR (%)		20	40	61

Abbreviations: CI, confidence interval; HR, hazards ratio; PAR, population attributable risk.

Figure. Kaplan-Meier Curves for Number of Healthful Lifestyle Factors



The lifestyle score was calculated by adding the individual scores for diet, physical activity level, smoking status, and alcohol intake. Individuals scored 1 point if they belonged to the low-risk group for diet or a particular lifestyle factor and 0 if they belonged to the high-risk group. In total, an individual could obtain 4 points: 1 point for a Mediterranean diet and 3 points for the healthful lifestyle factors.

volving elderly persons in which a Mediterranean diet score similar to ours was used, the reduction in overall mortality associated with increased adherence to the Mediterranean diet was also similar to that found in our study. Similar results were also noted for mortality from CHD and cancer.⁴ Our results are also compatible with those of 2 randomized trials of secondary prevention of CHD through the use of variations of the Mediterranean diet.^{26,27}

In the Mediterranean diet score proposed by Trichopoulou et al,⁴ alcohol was also included. In our study, alcohol was considered as a separate lifestyle factor because many studies observed an independent effect of alcohol on survival.²⁸⁻³⁰ When we included alcohol in our diet score, we found that individuals scoring 4 or more points on the original Mediterranean diet score have a 14% lower risk of mortality compared with 23% in the present study. Participants who were physically active had a lower risk of all-cause and cause-specific mortality. Other studies found also that a sedentary lifestyle was associated with a significantly higher risk of all-cause and cause-specific mortality compared with being moderately active.^{17,31} Davis et al¹⁷ reported that nonrecreational physical activity was an even better predictor of survival time in older persons (aged 65-74 years) than in middle-aged persons (aged 45-54 years).¹⁷

Nonsmoking was associated with lower risk from all-cause and cause-specific mortality. Other studies also found that smokers had a higher mortality risk although the relative risk was lower in older persons than in middle-aged individuals.^{17,18}

Although diet and lifestyle habits can change over time, generally they are characteristic of a person's way of living and reflect lifelong health habits.^{32,33} For smoking, we contrasted persons who never smoked or stopped smoking more than 15 years ago with those who still smoked or stopped less than 15 years ago. This definition of the smoking variable takes a long exposure period into account. In SENECA, dietary and lifestyle factors were mea-

sured 5 years apart. The Spearman correlation coefficient for alcohol consumption, diet score, and physical activity between 1988-1989 and 1993 was highly significant ($P < .01$), suggesting that diet and lifestyle factors were stable in older individuals. Several other studies also found that smoking habits and activity patterns in middle-aged and many elderly men were stable over the years.^{32,33}

A multiplicative model was used to assess the combined effect of diet and lifestyle factors on all-cause and cause-specific mortality. The more healthful dietary and lifestyle factors a participant had, the lower the risk for all-cause mortality and cause-specific mortality. In the current study, 60% to 64% of mortality was associated with lack of adherence to this low-risk pattern. This supports the hypothesis that participants who follow a Mediterranean type of diet and maintain a healthful lifestyle are less likely to die from all-cause and cause-specific mortality even at ages 70 to 90 years. Establishing a causal relationship would require an intervention study, and the number of years an individual needs to maintain such a lifestyle to realize a benefit is unknown. However, a Mediterranean diet, rich in plant foods in combination with nonsmoking, moderate alcohol consumption, and at least 30 minutes of physical activity per day is associated with a significantly lower mortality rate, even in old age.

Author Contributions: The principal investigator Mr Kromhout for the FINE study, Dr Van Staveren for the SENECA study, and Ms Knoops had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. **Study concept and design:** de Groot, Kromhout, Moreiras-Varela, van Staveren. **Acquisition of data:** Kromhout, Perrin, Menotti, van Staveren. **Analysis and interpretation of data:** Knoops, de Groot, Kromhout, van Staveren. **Drafting of the manuscript:** Knoops, de Groot, Moreiras-Varela. **Critical revision of the manuscript for important intellectual content:** de Groot, Kromhout, Perrin, Menotti, van Staveren. **Statistical analysis:** Knoops, Menotti. **Obtained funding:** Kromhout, van Staveren. **Administrative, technical, or material support:** Kromhout, Moreiras-Varela, van Staveren. **Study supervision:** de Groot, Kromhout, van Staveren. **Funding/Support:** This study, based on the HALE project, was supported by grant QLK6-CT-2000-

00211 from the European Union (Dr Kromhout).

Role of the Sponsor: The European Union did not participate in the design or conduct of the study; in the collection, analysis, or interpretation of the data; or in the preparation, review, or approval of the manuscript.

Acknowledgment: The following principal investigators contributed to the HALE project: *Belgium:* G. Backer, University of Ghent; *Denmark:* M. Schroll, Bispebjerg Hospital, Copenhagen; *Finland:* A. Nissinen, National Public Health Institute, Helsinki; *France:* M. Ferry, Centre Hospitalier de Valence, Valence, Schlienger J. L. Université Louis Pasteur, Strasbourg; *Greece:* A. Kafatos, University of Crete, Iraklion-Crete; *Hungary:* G. Zajkas, József Fodor National Center for Public Health, National Institute of Food-Hygiene and Nutrition, Budapest; *Italy:* G. Enzi, Università degli Studi di Padova, Padova, F. Danza, Perugia, S. Giampaoli, Istituto Superiore di Sanità, Roma, G. Maiani, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione, Roma, and A. Menotti, Associazione per la Ricerca Cardiologica, Roma; *the Netherlands:* L. de Groot, Wageningen University, Wageningen, D. Kromhout, National Institute for Public Health and the Environment, Bilthoven, W. van Staveren, Wageningen University, Wageningen; and M. Tijhuis, National Institute for Public and the Environment, Bilthoven; *Poland:* A. Brzozowska, Warsaw Agricultural University, Warsaw; *Portugal:* J. A. Amorim Cruz, Instituto Nacional de Saude, Lisbon; *Spain:* O. Moreiras-Varela, Universidad Complutense de Madrid, Madrid; *Switzerland:* D. Schlettwein-Gsell, Basel.

REFERENCES

1. Population ageing: a public health challenge. WHO, Fact Sheet N 135. Revised September 1998.
2. *Keep Fit for Life: Meeting the Nutritional Needs of Older Persons.* Geneva, Switzerland: World Health Organisation; 2002.
3. Bijnen FC, Caspersen CJ, Mosterd WL. Physical inactivity as a risk factor for coronary heart disease: a WHO and International Society and Federation of Cardiology position statement. *Bull World Health Organ.* 1994;72:1-4.
4. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med.* 2003;348:2599-2608.
5. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Cancer and Mediterranean dietary traditions. *Cancer Epidemiol Biomarkers Prev.* 2000;9:869-873.
6. Trichopoulou A, Kouris-Blazos A, Wahlqvist ML, et al. Diet and overall survival in elderly people. *BMJ.* 1995;311:1457-1460.
7. Haveman-Nies A, de Groot LP, Burema J, Cruz JA, Osler M, van Staveren WA, for the SENECA Investigators. Dietary quality and lifestyle factors in relation to 10-year mortality in older Europeans: the SENECA study. *Am J Epidemiol.* 2002;156:962-968.
8. Huijbregts P, Feskens E, Räsänen L, et al. Dietary pattern and 20-year mortality in elderly men in Finland, Italy, and the Netherlands: longitudinal cohort study. *BMJ.* 1997;315:13-17.
9. Stampfer MJ, Hu FB, Manson JE, Rimm EB, Willett WC. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med.* 2000;343:16-22.
10. De Groot CP, van Staveren WA, Dirren H, Hautvast JG. Summary and conclusions of the report on the second data collection period and longitudinal analyses of the SENECA Study. *Eur J Clin Nutr.* 1996;50(suppl 2):S123-S124.
11. Menotti A, Mulder I, Nissinen A, et al. Cardiovascular risk factors and 10-year all-cause mortality in elderly European male populations: the FINE study. *Eur Heart J.* 2001;22:573-579.
12. Van 't Hof MA, Hautvast JG, Schroll M, Vlachoni-

- kolis IG, for the Euronut SENECA investigators. Design, methods and participation. *Eur J Clin Nutr*. 1991; 45(suppl 3):5-22.
13. Kromhout D, Menotti A, Blackburn H. *Prevention of Coronary Heart Disease: Diet, Lifestyle and Risk Factors in the Seven Countries Study*. Boston, Mass: Kluwer Academic Publishers; 2001.
14. Voorrips LE, Revelli AC, Dongelmans PC, Deurenberg P, Van Staveren WA. A physical activity questionnaire for the elderly. *Med Sci Sports Exerc*. 1991; 23:974-979.
15. Caspersen CJ, Bloemberg BP, Saris WH, Merritt RK, Kromhout D. The prevalence of selected physical activities and their relation with coronary heart disease risk factors in elderly men: the Zutphen Study, 1985. *Am J Epidemiol*. 1991;133:1078-1092.
16. Arab JS, Wittler M, Schetter G. *European food composition tables in translation*. Berlin, Germany: Springer-Verlag; 1987.
17. Davis MA, Neuhaus JM, Moritz DJ, Lein D, Barclay JD, Murphy SP. Health behaviors and survival among middle-aged and older men and women in the NHANES I Epidemiologic Follow-up Study. *Prev Med*. 1994;23:369-376.
18. Kawachi I, Colditz GA, Stampfer MJ, et al. Smoking cessation in relation to total mortality rates in women: a prospective cohort study. *Ann Intern Med*. 1993; 119:992-1000.
19. Peto R, Darby S, Deo H, Silcocks P, Whitley E, Doll R. Smoking, smoking cessation, and lung cancer in the UK since 1950: combination of national statistics with two case-control studies. *BMJ*. 2000;321: 323-329.
20. World Health Organization. *International Classification of Diseases, Ninth Revision (ICD-9)*. Geneva, Switzerland: World Health Organization; 1977.
21. Kleinbaum DG. *Survival Analysis: A Self-Learning Text*. New York, NY: Springer-Verlag Inc; 1996.
22. Beard J, Sladden T, Morgan G, Berry G, Brooks L, McMichael A. Health impacts of pesticide exposure in a cohort of outdoor workers. *Environ Health Perspect*. 2003;111:724-730.
23. Wacholder S, Benichou J, Heineman EF, Hartge P, Hoover RN. Attributable risk: advantages of a broad definition of exposure. *Am J Epidemiol*. 1994;140: 303-309.
24. Willett WC. *Nutritional Epidemiology*. 2nd ed. New York, NY: Oxford University Press; 1998.
25. Gnardellis C, Trichopoulou A, Katsouyanni K, Polychronopoulos E, Rimm EB, Trichopoulos D. Reproducibility and validity of an extensive semiquantitative food frequency questionnaire among Greek school teachers. *Epidemiology*. 1995;6:74-77.
26. de Lorgeril M, Renaud S, Mamelle N, et al. Mediterranean alpha-linolenic acid-rich diet in secondary prevention of coronary heart disease. *Lancet*. 1994; 343:1454-1459.
27. Singh RB, Dubnov G, Niaz MA, et al. Effect of an Indo-Mediterranean diet on progression of coronary artery disease in high risk patients (Indo-Mediterranean Diet Heart Study): a randomised single-blind trial. *Lancet*. 2002;360:1455-1461.
28. Mukamal KJ, Conigrave KM, Mittleman MA, et al. Roles of drinking pattern and type of alcohol consumed in coronary heart disease in men. *N Engl J Med*. 2003;348:109-118.
29. White IR, Altmann DR, Nanchahal K. Alcohol consumption and mortality: modelling risks for men and women at different ages. *BMJ*. 2002;325:191-198.
30. Liao Y, McGee DL, Cao G, Cooper RS. Alcohol intake and mortality: findings from the National Health Interview Surveys (1988 and 1990). *Am J Epidemiol*. 2000;151:651-659.
31. Ruigomez A, Alonso J, Anto JM. Relationship of health behaviours to five-year mortality in an elderly cohort. *Age Ageing*. 1995;24:113-119.
32. Paffenbarger RS Jr, Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *N Engl J Med*. 1993; 328:538-545.
33. Wannamethee SG, Shaper AG, Walker M. Changes in physical activity, mortality, and incidence of coronary heart disease in older men. *Lancet*. 1998; 351:1603-1608.

Artistic growth is, more than it is anything else, a refining of the sense of truthfulness. The stupid believe that to be truthful is easy; only the artist, the great artist, knows how difficult it is.
—Willa Cather (1873-1947)