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DIETARY QUALITY, LIFESTYLE FACTORS AND HEALTHY AGEING IN EUROPE

Annemien Haveman-Nies

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PROEFSCHRIFT

ter verkrijging van de graad van doctor
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Dietary quality, lifestyle factors and healthy ageing in Europe
Thesis Wageningen University – With references – With summary in Dutch

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STELLINGEN

1. Clusteranalyse en voedingsscores zijn complementaire methodes om de dagelijkse voedselinneming betekenisvol te kwalificeren.
   Dit proefschrift

2. Gezonde leefstijlfactoren op oudere leeftijd zijn positief gerelateerd aan overleving en vertragen de achteruitgang in gezond.
   Dit proefschrift

3. Cluster analysis, along with factor analysis, is much more of an art than a science.
   J. Hair et al. (1992): Multivariate data analysis with readings.

4. De BMI-grenswaarde voor overgewicht zou, in het licht van de door Sorkin *et al.* gepresenteerde conclusies, naar boven bijgesteld moeten worden indien ze op ouderen betrokken wordt.
   J. Sorkin et al. (1999): Longitudinal change in height of men and women: Implications for interpretation of the Body Mass Index. Am. J. Epidemiol. 150, 969-977.

5. Het leven is niet een kwestie van geven en nemen, maar van geven en ontvangen.

6. Net als voor ouder worden geldt ook voor de wetenschap dat kwaliteit boven kwantiteit gaat.

7. Leer een kind van jongsaf aan de juiste weg te volgen; ook als hij ouder wordt, zal hij er dan niet van afwijken.
   Wijsheid van Salomo

8. Wie lekker en gezond wil eten, moet tijd verliezen.
   Naar D. Schlettwein-Gsell et al. (1999): Meal patterns in the SENECA study: assessment method and preliminary results on the role of the midday meal. Appetite 32, 8-14.

Stellingen behorende bij het proefschrift
'Dietary quality, lifestyle factors and healthy ageing in Europe'.

Annemien Haveman-Nies
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Aan mijn ouders

ABSTRACT

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The contribution of diet and lifestyle factors to healthy ageing was investigated in European elderly, born between 1913 and 1918, of the SENECA study. First, the Mediterranean Diet Score (MDS), Healthy Diet Indicator (HDI), and cluster analysis were validated as measures of quality of dietary patterns in the SENECA study as well as the Framingham study. Cluster analysis, MDS, and HDI showed strong similarities in the classification of persons into dietary quality groups. High-quality diets were associated with nutritional status and health-related indicators. It is concluded that dietary quality can be assessed using diet scores as well as cluster analysis, the approaches being complementary.

The relationships of the three lifestyle factors diet, physical activity, and smoking habits to survival and maintenance of health at old age were investigated, using Cox's proportional hazards analysis and logistic regression. Single unhealthy lifestyle behaviours were related to an increased mortality risk. For men, the mortality risk for a low-quality diet was 1.2 (95 percent confidence interval (CI): 0.9, 1.7), for inactivity 1.4 (95% CI: 1.1, 1.7), and for smoking 2.1 (95% CI: 1.6, 2.6). For women, the mortality risk for smoking was 1.8 (95% CI: 1.1, 2.7), for inactivity 1.8 (95% CI: 1.3, 2.4), and for a low-quality diet 1.3 (95% CI: 0.9, 1.8). The risk of death was increased for all combinations of two unhealthy lifestyle behaviours. Men and women with three unhealthy lifestyle behaviours had a three to four-fold increase in mortality risk. Self-rated health and functional status both declined in men and women with healthy and unhealthy lifestyle habits over a 10-year follow-up period, but the deterioration in health was delayed by the healthy lifestyle behaviours, non-smoking and physical activity. Inactive men had a 2.8 (90% CI: 1.3, 6.2) times increased risk for a decline in self-rated health and a 1.9 (90% CI: 0.9, 3.9) times increased risk to become dependent. Smoking men had a two-fold increased risk (90% CI: 1.0, 4.1) for a decline in self-rated health and a 2.2 (90% CI: 1.1, 4.5) times increased risk to become dependent. In women, inactivity was related to a 2.6 (90%CI: 1.4, 4.9) times increased risk to become dependent.

In conclusion, a lifestyle characterised by non-smoking, physical activity and a high-quality diet contributes to healthy ageing. A healthy lifestyle at older ages is positively related to a reduced mortality risk and to a delay in the deterioration in health status. This postponement of the onset of major morbidity is likely to go together with a compressed cumulative morbidity. It is concluded that health promotion at older ages can contribute to healthy ageing.

Keywords: dietary quality, dietary patterns, lifestyle factors, smoking, physical activity, elderly, mortality, Mediterranean Diet Score, Healthy Diet Indicator, healthy ageing, self-rated health, functional status

CONTENTS

CHAPTER 1

GENERAL INTRODUCTION

CONSEQUENCES OF DEMOGRAPHIC DEVELOPMENTS IN EUROPE

In Europe, life expectancy increased rapidly in the last century. This increasing life expectancy was caused by the sharp drop in infant mortality in the first half of the century, and the decrease of mortality at middle and old ages in the second half of the century. The fight against infectious diseases had a large impact on the reduction of early mortality (de Beer, 1999). Around 1900, life expectancy at birth ranged from 35-40 years in Southern Europe to 50-55 years in the Scandinavian countries. In the twentieth century, life expectancy increased to 75 years or more in Western European countries. Within Western Europe, the rate of improvement varied significantly between individual countries (Kinsella, 1992; WHO, 1998). At present, different patterns of diseases and cause-specific mortality are observed in Europe. The proportion of subjects that die because of coronary heart disease is twice as high in Sweden as in France, and dying from specific types of malignancy varies highly between the European countries (Prinsze & Achterberg, 1997; WHO, 1998). For the twenty-first century, a further modest increase of the average life expectancy in Europe may be feasible. However, World Health Organisation calculations (1998) for life expectancy in European countries during the twenty-first century show beside improvement, also stagnation (e.g. in Danish women) or even a decline (e.g. Eastern Europe).

As a result of the increasing life expectancy and the decreasing number of children born in twentieth-century Europe, a growing share of elderly people in the population appeared. This proportion of elderly people in the population will increase unevenly within Europe (Verhoef & Garssen, 1999). In The Netherlands it is expected that the share of elderly people aged 65 and over will rise from 13% at present to 25% by 2040 (Statistics Netherlands, 2001). This doubling of the elderly population within the coming 40 years will result in a massive need for additional short- and long-term medical services.

The sharp rise in the ageing population is largely responsible for the increase of chronic diseases, in particular cancer and cardiovascular diseases, and is accompanied by an increasing amount of disability, functional impairment, and lowered quality of life (van Hoorn et al., 1999; Khaw, 1997; Matsubayashi et al., 1996). The process of ageing and the incidence of diseases is influenced by lifestyle factors, environmental factors, and biological factors (Fries, 1992; Verbrugge & Jette, 1994). This thesis investigates the relationship between a limited number of modifiable lifestyle factors and health status in a European elderly population.

HEALTHY AGEING

In view of the increasing number of elderly people, accompanied by the great demand for health care facilities, promotion of health at older ages is a major challenge of public health policymakers of Western European societies. Health is a multidimensional concept and is defined by the WHO (1948) as "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity". Other definitions emphasise that health is a dynamic and hypothetical concept without a direct empirical representation (Essink-Bot, 1995; Portrait, 2000). Wilson et al. (1995) and Verbrugge & Jette (1994) developed a sociomedical concept that proposes a classification scheme for different measures of health outcome. This model includes objective and subjective measures of health and is moving from the cell level to the individual level and from the individual level to the interactions of the individual as a member of society. Five levels of health outcomes were distinguished: biological and physiological factors, symptoms, functioning, general health perceptions, and overall quality of life. It follows from this model that health status has many aspects, and a combination of health indicators gives the best reflection of the broad concept of health status.

Health status is closely related to the ageing process. The biological process of ageing and its clinical manifestations reflect the interactions between our genetic inheritance and environmental influences. The ageing process includes progressive and irreversible biological changes, resulting in a growing risk of chronic diseases, cognitive impairments, impairment of functions, and an increased probability of dying (Bowling & Ebrahim, 2001; Jolles et al., 1995; Khaw, 1997; Verbrugge & Jette, 1994). The ageing process does not only manifest itself in physical and mental illness, but also influences a person's perception of health (Krause & Jay, 1994). As people become older, they are less likely to focus on the physical aspects of their health and value qualitative aspects higher (Borawski et al., 1996).

Two health patterns related to ageing are distinguished by Vellas et al. (1992): a gradual functional decline related to the normal ageing process, and a relatively rapid decline in functional status due to progressive illness or a catastrophic event, such as Alzheimer's disease or a hip fracture. In the description of healthy ageing by Campion (1998), the phases of a gradual and a rapid decline in health status also appear. The author describes healthy ageing as the ideal situation in which people survive to an advanced age with their vigour and functional independence maintained, and morbidity and disability compressed into a relatively short period before death. In this description the first phase encloses a long period of a few decades in which health status slowly deteriorates as a result of the normal ageing process. The second phase includes a short period of maximal a few years prior to death with an accelerated decline in health status, mainly as a consequence of progressive illnesses or catastrophic events (Campion, 1998; Fries, 1980). Because healthy ageing is a comprehensive concept, only a small part of it is discussed in this thesis. This thesis focuses on three health aspects: vital status (being alive or not), functional status, and self-rated health. Functional status is an objective indicator of health status, specifying the level of dependence in performing activities of daily living (Osler et al., 1991). Vital status is an objective indicator and has a very clear endpoint. Self-rated health is a subjective health indicator, summarising individual health aspects, weighed by personal values and preferences (Jylhä, 1994; Manderbacka, 1998). These health indicators are inclusive measures as they are considered to be the results of all kinds of underlying diseases and conditions. Especially in the elderly population inclusive measures are useful, because different diseases and conditions coexist.

DETERMINANTS OF HEALTH STATUS AND SURVIVAL

Health status and survival can be influenced directly and indirectly by many factors. **Figure 1** presents a conceptual model that describes the relationship between health status and endogenous determinants, exogenous determinants, and the health-care system.

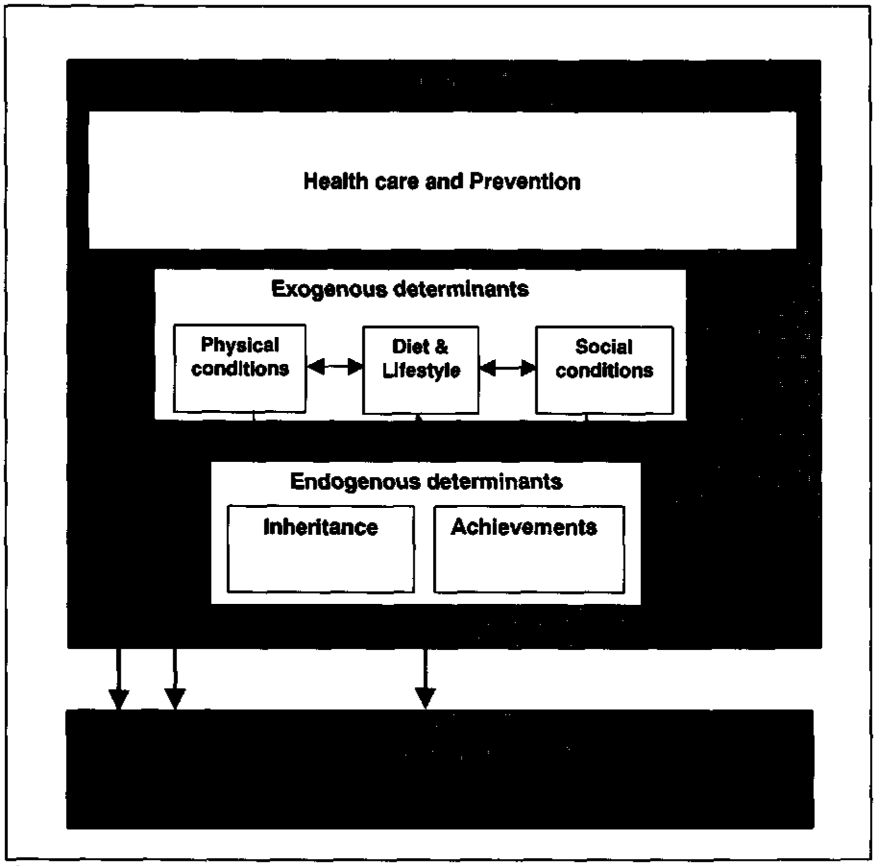

Figure 1. Determinants of health status, a conceptual model based on a model of the National Institute of Public Health and the Environment, The Netherlands (Maas et al., 1997)

Endogenous determinants of health status include hereditary (gender) and achieved (immunity) characteristics. Exogenous determinants are dietary and lifestyle factors and physical and social conditions, for example dietary patterns, smoking, climate, environmental pollution, social network, and economic situation. Health care and prevention is the third main determinant group and involves all activities to maintain and improve health status. **Figure 1** shows how these main determinant groups are interrelated. This thesis focuses on the three modifiable lifestyle factors: diet, physical activity, and smoking, which are correlated with physical and social conditions. For example, the physical condition climate has an effect on crop growth and may thereby influence dietary patterns. Social situation, such as the presence of meal facilities, can influence dietary quality. But on the other hand, smoking mediates the exposure to toxic substances, and inactivity reduces the prospects for social interactions. Health status is the outcome of the interaction between exogenous and endogenous determinants. Lifestyle habits weaken or strengthen the genetic expression of a disease and, in reverse, endogenous determinants affect a person's lifestyle habits. Health promotion programs can affect health status by promoting or facilitating a healthy lifestyle (Maas et al., 1997).

From the three modifiable lifestyle factors, dietary intake is the most complicated lifestyle factor. It can be quantified in many ways, for example in nutrients, food groups, or dietary patterns. This thesis focuses on dietary patterns including multiple dietary variables. The dietary pattern approach does justice to the highly interrelated nature of dietary variables and complexity of the diet, however, it is difficult to express the total diet into one variable. No "golden standard" method exists to assess dietary patterns, and therefore much attention has been paid to the assessment of dietary patterns in this thesis. The three modifiable lifestyle factors -diet, physical activity and smoking- differ across Europe. In both Northern and Southern Europe, a high proportion of men smoke, but Northern European women are more likely to smoke than Southern European women (Graham, 1996). Work, household, sport and leisure time activity patterns vary widely among elderly Europeans (Osler et al. 1991). Further, Schroll et al. (1993) and Huijbregts et al. (1995a) describe a wide variety in dietary patterns in elderly Europeans. The European setting is especially well suited for the study of lifestyle factors in relation to survival and health status, because of these substantial differences in smoking, dietary, and activity patterns.

THE LONGITUDINAL SENECA STUDY

In 1988, the European multi-centre SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) study was initiated to study cross-cultural differences in dietary patterns and lifestyle factors affecting health and performance. At baseline 2586 elderly persons from 19 European towns participated. Follow-up measures were performed in 1993 (Follow-up study) and 1999 (Finale study) in order to study changes in health status and lifestyle factors in a population that is moving from a rather healthy elderly population into a population with a deteriorated health status. From the 19 centres that started in 1988, nine towns in the following countries completed the three studies: Belgium, Denmark, France, Italy, The Netherlands, Portugal, Spain, Switzerland, and Poland. In addition, information on vital status (date and cause of death) was obtained for the 10-year follow-up period to relate lifestyle to mortality. At baseline, the SENECA subjects were selected from a random age- and sex-stratified sample of inhabitants from small European towns. All inhabitants born between 1913 and 1918 were eligible to be enrolled in the study, only subjects living in a psycho-geriatric nursing home were excluded at baseline. Dietary intake, lifestyle factors, vital status, indicators of health status, and other measurements were collected according to a strictly standardised methodology both over time and across Europe (de Groot & van Staveren, 1988). **Table 1** shows the vital status of the SENECA participants over the 10-year follow-up period.

Table 1. Number of survivors, participants that died during the follow-up period and number of participants lost to follow-up, by SENECA centre

	Men				Women			
	Baseline 1988/89	Finale study 1999			Baseline 1988/89	Finale study 1999		
		alive	deceased	lost to follow-up		alive	deceased	lost to follow-up
	N	n	n (%)	n	N	n	n (%)	n
Centre:								
Hamme, Belgium	126	56	70 (56)	0	105	75	30 (29)	0
Roskilde, Denmark	101	47	54 (54)	0	101	64	36 (36)	1
Haguenau, France	110	52	58 (53)	0	110	84	26 (24)	0
Romans, France	142	63	77 (55)	2	137	103	32 (24)	2
Padua, Italy	97	41	38 (48)	18	93	59	17 (22)	17
Culemborg, the Netherlands	114	47	67 (59)	0	124	84	40 (32)	0
Vila Franca de Xira, Portugal	111	60	51 (46)	0	111	74	37 (33)	0
Betanzos, Spain	88	45	41 (48)	2	119	84	35 (29)	0
Yverdon, Switzerland	123	64	58 (48)	1	126	94	31 (25)	1
Burgdorf, Switzerland	30	16	14 (47)	0	30	23	7 (23)	0
Bellinzona, Switzerland	30	16	14 (47)	0	30	18	11 (38)	1
Marki, Poland	19	7	12 (63)	0	23	15	8 (35)	0

OBJECTIVE OF THE THESIS

The overall objective of this thesis is to identify dietary and lifestyle factors that contribute to healthy ageing. This objective is investigated in three steps. First, different derivatives of dietary patterns are compared and evaluated as classifiers of dietary quality. These analyses provide insight in characteristics of measures of dietary patterns for usage in follow-up analysis. The second step is to identify initial dietary and lifestyle factors that are important for survival and the maintenance of health at old age. Finally, it is discussed how lifestyle factors of survival and health contribute to healthy ageing.

OUTLINE OF THE THESIS

The longitudinal SENECA study started with a baseline measurement in 1988/89, and was repeated in 1993 and 1999. Depending on the aim of the study in chapter 2 to 6, data of different measurement periods were used for the analyses. The results of chapter 2 are based on data of the baseline study. Chapter 3 and 4 include data of the follow-up study of 1993, and chapter 5 and 6 used data of all three measurement periods. Chapter 2 evaluates the dietary patterns of European and American elderly; the dietary pattern is described on the basis of the total daily food intake. Chapter 3 and 4 focus more specifically on snack patterns. In chapter 3 the contribution of snacks to total daily energy and micronutrient intake is investigated for the European countries, and in chapter 4 the contribution of snacks to total daily vitamin and mineral intake is investigated in more detail for The Netherlands. In chapter 5 the three modifiable lifestyle factors -diet, physical activity, and smoking- are related to mortality. For almost all SENECA participants that started at baseline in 1988, vital status was identified after the 10-year follow-up period. This information is related to the single and combined lifestyle factors. In addition, the same three lifestyle factors were related to other health measures (self-rated health and functional status) in a sample of elderly persons who survived the 10-year follow-up period and participated in all three measurement periods (Chapter 6). Finally, in chapter 7 the methodological problems are discussed and the general conclusion is drawn by discussing the three steps described above.

CHAPTER 2

EVALUATION OF DIETARY QUALITY IN RELATIONSHIP TO NUTRITIONAL AND LIFESTYLE FACTORS IN ELDERLY PEOPLE OF THE US FRAMINGHAM HEART STUDY AND THE EUROPEAN SENECA STUDY

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ABSTRACT

Objective of this study is to evaluate dietary quality of European and American elderly subjects using different derivatives of dietary patterns (dietary scores and clusters) and to investigate the relationship of these approaches to nutritional and lifestyle factors.
Data from the cross-sectional SENECA baseline study and Framingham Heart Study (original cohort and offspring) were used for data analysis. Food intake data were summarised into dietary clusters and into dietary scores (Healthy Diet Indicator and Mediterranean Diet Score). These measures of dietary quality were then tested for associations with lifestyle factors and measures of nutritional status. The study population, aged 70-77 years, consisted of 828 subjects from Framingham, Massachusetts (USA) and 1282 subjects from the following European centres: Hamme, Belgium; Roskilde, Denmark; Padua, Italy; Culemborg, The Netherlands; Vila Franca de Xira, Portugal; Betanzos, Spain; and Yverdon, Burgdorf, Bellinzona in Switzerland. Dietary intake varied widely across the European and American research centres. In general, Southern European centres and Framingham had higher mean diet scores, indicating a higher dietary quality, than Northern European centres (MD-scores: 4.2 – 4.4 vs 2.7 – 3.5). Cluster analysis identified the following five dietary patterns characterised by: 1) *Sugar & sugar products*; 2) *Fish & grain*; 3) *Meat, eggs & fat*; 4) *Milk & fruit*; and 5) *Alcohol intake*. The *Meat, eggs & fat pattern* had significantly lower average dietary quality, as measured with all three diet scores than all other clusters except the *Alcohol cluster*. The *Fish & grain cluster* had significantly better Mediterranean diet scores than all other clusters. High-quality diets were associated to less body fatness, non-smoking, and to greater physical activity. Dietary scores and dietary clusters are complementary measures to classify dietary quality. The associations with nutritional and lifestyle factors indicate the adequate categorisation into dietary quality groups.

INTRODUCTION

In addition to single dietary components or nutrients, measures of overall dietary patterns are important in investigating the relationship between diet and health status (Huijbregts et al., 1997a; Kant, 1996; Trichopoulou et al., 1995a). While the approach of dietary patterns seems to have many applications in nutritional research, no "golden standard" method has been developed to assess these dietary patterns (Oltersdorf et al., 1999). Therefore, more knowledge about dietary patterns is needed to relate diet to health status for identifying groups at nutritional risk.

To make dietary patterns operational, two common methods are cluster analysis (Akin et al., 1986; Haveman-Nies et al., 1998; Hulshof et al., 1992; Schroll et al., 1996; Tucker et al., 1992) and calculation of diet scores (Haines et al., 1999; Kennedy et al., 1995; Lasheras et al., 2000; Osler & Schroll, 1997; Patterson et al., 1994; Trichopoulou et al., 1995b). Cluster analysis explores the categorisation of persons into groups on the basis of similarity in food intake (for example *Alcohol drinkers*; *Milk, cereal & fruit eaters*). Diet scores are based on dietary guidelines and are applied to identify groups with good or poor nutritional status. In Europe and the United States, existing measures of overall dietary quality include the Diet Quality Index (Revised) (Haines et al., 1999), Healthy Eating Index (Kennedy et al., 1995), Mediterranean Diet Score (de Groot et al., 1996; Trichopoulou et al., 1995b) and the Healthy Diet Indicator (Huijbregts et al., 1997a). These diet scores differ in diet components, scoring rates and definition of cut-off values. In spite of these differences, diet scores as well as cluster analysis have been shown to be useful tools to identify groups with different nutritional status (Haines et al., 1999; Huijbregts et al., 1997b; Trichopoulou et al., 1995a; Tucker et al., 1992).

This article evaluates the dietary patterns of 1282 European subjects from the SENECA study and 828 American subjects from the Framingham Heart Study. These datasets permit us to calculate two European scores: the Healthy Diet Indicator and the Mediterranean Diet Score. We used these scores and cluster analysis to relate dietary quality to nutritional status and lifestyle factors.

METHODS

Subjects

Subjects, aged 70-77 years, were selected from the American Framingham Heart Study and the European SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) study. The Framingham Heart Study, initiated in 1948, is a longitudinal study to examine risk factors for heart disease. The study population, aged 30-62 years at baseline, was selected at random from residents in Framingham, Massachusetts (F/MA). These predominantly white subjects and, later on their offspring, are followed in 2 – 4 y cycles. For the present study, 828 elders from the original cohort (cycle 20, data collection between 1988 and 1990) and the offspring cohort (cycle 5, data collection between 1991 and 1994) were included. In this population, the age range of 70-77 years was selected to match that of the SENECA participants. Data for the 1282 European subjects of SENECA's baseline study were collected in 1988-1989 from a random age and sex-stratified sample of inhabitants from the following small European towns: Hamme, Belgium (H/B); Roskilde, Denmark (R/DK); Padua, Italy (P/I); Culemborg, The Netherlands (C/NL); Vila Franca de Xira, Portugal (V/P); Betanzos, Spain (B/E); and Yverdon, Burgdorf, Bellinzona in Switzerland (Y,Bu,Be/CH). Both studies included mostly non-institutionalised elders, ranging from 89% in Framingham/MA to 100% in Padua/I. The representation of men and women was almost equal in all centres (ranges: 43 - 57%). For a detailed description of the Framingham Heart Study and SENECA's baseline study, see elsewhere (Dawber et al., 1951; de Groot & van Staveren, 1988).

Assessment of food and nutrient intake

In the Framingham Heart Study, nutrient and food group intake were measured with the Willett 126-item semi-quantitative food-frequency questionnaire. This questionnaire has been extensively validated against diet records and biochemical indicators (Jacques et al., 1993; Rimm et al., 1992; Willett et al., 1985). The food-frequency questionnaire was mailed to subjects for completion at home and checked during their clinic visit. The food frequency questionnaire directed subjects to estimate their usual intake of a standardised portion of a given food item. Nine non-overlapping response categories, ranging from 'never, or less than once per month' to '≥ 6 times per day', were provided.

In the SENECA study, food intake data were collected by trained personnel using the modified dietary history method (de Groot & van Staveren, 1988). This method is characterised by a 3-day estimated record and a frequency checklist of foods, based on the meal pattern of the country. Portion sizes were based on standard portion sizes and/or checked by weighing. Foods were coded and analysed for nutrient composition in each participating centre separately, using country-specific food composition tables (van 't Hof et al., 1991). In both studies, the food and nutrient variables used for this analysis did not incorporate supplemental intake.

Food groups and dietary scores

To make food intake data of the Framingham Heart Study comparable to food intake data from SENECA's baseline study, 12 food groups, based on the EUROCODE system (Arab et al., 1987) were defined for both studies. **Table** 1 describes the composition of these 12 nutrient-specific food groups: 1) grains; 2) milk & milk products; 3) fruits & fruit products; 4) eggs; 5) meat & poultry; 6) fish/shellfish; 7) vegetables; 8) fats/oils; 9) legumes/nuts/seeds; 10) sugar & sugar products; 11) non-alcoholic beverages; and 12) alcoholic beverages. All food items not belonging to one of these 12 food groups (such as soups, sauces and spices) were not used for further analysis.

Table 1. Description of food items included in 12 main food groups

Main food group	Food items
1. Grains	Rice, wheat, bran, wheat germ, pizza, pancakes, corn products: bread, cereals, pasta
2. Milk & milk products	Milk, yoghurt, cream, cheese
3. Fruits & fruit products	Fruit: fresh, dried, frozen or canned
4. Eggs	Eggs/egg products
5. Meat & poultry	Poultry, game, beef, pork, sheep, processed meats
6. Fish/shellfish	Fish, shrimp, reptiles etc.
7. Vegetables	Vegetables and products, potatoes: french fried, baked, boiled, etc. (no chips)
8. Fats/oils	Oils, butter, margarine
9. Legumes/nuts/seeds	Pulses, lima beans, peas, soy beans, tofu, seeds, nuts, peanut butter
10. Sugar & sugar products	Chocolate, candy bars, cookies, cakes, pies, jams/jellies
11. Non-alcoholic beverages	Water, coffee/tea, lemonades, carbonated drinks, fruit and vegetable juices
12. Alcoholic beverages	Beer, wine, liqueur

In this study, the following diet scores were calculated: the Healthy Diet Indicator (HDI) and two Mediterranean Diet Scores (MDS). The HDI consisted of the following nine food/nutrient groups: saturated fatty acids; poly-unsaturated fatty acids; protein; complex carbohydrates; dietary fibre; fruits & vegetables; pulses/nuts/seeds; mono- & disaccharides; and cholesterol. A dichotomous variable was generated for each of these groups. If a person's intake was within the recommended borders of the WHO guidelines (1990) for the prevention of chronic diseases, this variable was coded one and if the intake was outside these borders, it was coded zero. Summation of all these dichotomous variables resulted in the healthy diet score (range 0 - 9). Since the high alcohol intake in some Southern European centres would lead to a diluting effect on macronutrient intake compared to the other countries, macronutrient intake was calculated as a percentage of energy intake without energy provided by alcohol (Huijbregts et al., 1997a). Two participants were excluded because of methodological errors in the calculation of energy and nutrient intake. For a detailed description of the HDI, see Huijbregts et al. (1997a).

The Mediterranean diet score was described by the following diet items: mono-unsaturated: saturated fat ratio; alcohol; legumes; cereals; fruits & nuts; vegetables; meat & meat products; and dairy products (range 0 - 8). We replaced the group legumes by the group legumes/nuts/seeds and the group fruits & nuts by the group fruits. Two Mediterranean diet scores were composed, one was based on the traditional Greek

Mediterranean diet using the sex-specific median intake values of a Greek population as cut-off values (G-MDS) and the other score was based on the sex and study-specific median intake values of the research population (FS-MDS). If the subject's intake was comparable to the Mediterranean diet, the diet item was coded one and if the intake was not in agreement with the Mediterranean diet, it was coded zero (for example: if fruit intake was above the median value it was coded one, and if it was below the median intake it was coded zero). Summation of these dichotomous variables resulted in a high score for a Mediterranean-like diet and a low score for other diets. For both Mediterranean scores, intake values were adjusted to daily intakes of 10.5 MJ (2500 kcal) for men and 8.4 MJ (2000 kcal) for women. For more details see Trichopoulou et al. (1995a).

Lifestyle factors and nutritional status indicators

Information on lifestyle factors was collected with a general interview and nutritional status was assessed by blood examination and anthropometric measurements. For the Framingham Heart Study and SENECA's baseline study, similar answer categories could be defined for self-perceived health. The questions on smoking habits differed in focusing on smoking in general (SENECA) or smoking of cigarettes (Framingham). Subjects were classified as current (cigarette) smokers or non-smokers. To quantify physical activity, the Framingham physical activity index was used in the Framingham Heart Study and the preliminary version of the Voorrips-score was used in SENECA's baseline study (Kannel & Sorlie, 1979; Voorrips et al., 1990). Both questionnaires included questions on duration and intensity of different daily activities. For both main studies sex-specific tertiles (low, moderate and high physical activity) were composed.
Body Mass Index (BMI) was calculated as measured weight (kg) divided by height squared (m^2) at time of examination. Weight, height and waist circumference measurements are described in detail elsewhere (Dawber, 1980; de Groot & van Staveren, 1988; de Groot et al., 1991). In the Framingham study and SENECA's baseline study, blood samples were collected and analysed for blood haemoglobin and serum albumin following standardised procedures, described in detail elsewhere (Dawber, 1980; de Groot & van Staveren, 1988; Dirren et al., 1991). Three subjects were eliminated from the calculation of haemoglobin, because of extreme values (Dirren et al., 1991).

Statistical analyses

Statistical analyses were carried out using the SAS statistical software package (version 6.12, 1989-1996, SAS Institute Inc., Cary, NC). The Wilcoxon rank sum test was used to evaluate differences in age, BMI, waist circumference, haemoglobin and serum albumin and the chi-square test was used to evaluate differences in BMI-categories, smoking and self-perceived health between men and women.

Cluster analysis was used to divide the study population into a limited number of clusters with maximally differing dietary patterns. This analysis was based on the daily intake (g/day) of the food groups described in **Table 1**, with the exclusion of the group non-alcoholic beverages and the replacement of total fat intake for the food group fats/oils. The food group non-alcoholic beverages was excluded, because the nutrient composition of the food items in this group varied highly (juices as well as carbonated beverages (regular and light)) and the intake of non-alcoholic beverages in Vila Franca de Xira/P was underreported (water per se was not recorded). The large difference in intake of the group fats/oils between the two studies is probably caused by the inability to include fat for cooking in the group oils/fats in the Framingham study and the focus of the FFQ on prepared items. For this reason the more reliable nutrient-group total fat intake was used for cluster analysis. Intakes of 11 food/nutrient groups were standardised to the mean energy intake of the Framingham and SENECA study separately to adjust for individual variation in energy needs, related to differences in gender, body size and activity level. Since variables with large variances tend to have more effect on the resulting clusters than the variables with small variances, data were transformed to Z-scores (mean zero and standard deviation one) to adjust for unequal variances of the variables. Ward's minimum variance method was used to compose clusters with a minimum of internal variance. We ran the clustering procedure for two to 10 clusters and the five cluster solution with energy adjusted variables transformed to Z-scores yielded the most characteristic and interpretable clusters (SAS Institute Inc., 1989; Hair et al., 1992).

Analysis of variance followed by the Tukey multiple comparison test was used to test for differences in diet scores between dietary clusters. The Wilcoxon rank sum test was used to test for differences in diet scores (HDI and FS-MDS) between smokers and non-smokers in Framingham and the Northern and Southern European centres. The Kruskal-Wallis test was used to test differences between the three activity tertiles. To investigate the relationship between dietary quality groups (HDI, FS-MDS, clusters) and nutritional status, regression analysis (PROC GLM) was carried out. Four indicators for nutritional status were selected: serum albumin, haemoglobin, BMI, and waist circumference. Adjustments were made for age at baseline, sex, smoking, physical activity and country. Dummy variables for the categories of smoking, physical activity and country were used in the analyses. Possible interactions of diet groups with the confounders were tested by including the product terms (diet variable * confounder) in the regression model. In **Table 7** least square means and p-values are presented.

RESULTS

Table 2 describes some characteristics of male and female participants from the Framingham Heart Study and the SENECA study. Men were more likely to smoke than women. In Hamme/B, Roskilde/DK and Betanzos/E almost half of the men were smokers. More women, especially in Hamme/B, Culemborg/NL and Betanzos/E, were obese (BMI > 30 kg/m^2) than men. Men, particularly from Hamme/B, Padua/I and Betanzos/E, were more positive about their own health status than women. In Vila France de Xira/P, the percentage of men and women that judged their own health as "good" was very low (men, 28%; women, 12%). In Framingham/MA, the highest percentages of men (87%) and women (89%) reported their health as "good". In general, blood measurements indicated that the majority of the study population were in good health, but healthy lifestyle behaviours and subjective health status varied extensively between sexes and centres.

Table 2. Background characteristics of participants, aged 70-77y, of the Framingham Heart Study and SENECA's baseline study, by sex

	Men n=986	Women n=1124	P-value
Age (y), mean (s.d.)	72.9 (1.9)	73.0 (1.9)	
Albumin (g/l), mean (s.d.)	42.2 (3.3)	41.8 (3.2)	*
Prevalence of low serum albumin (%)[1]	2	2	
Haemoglobin (g/l), mean (s.d.)	150 (13)	137 (12)	*
Prevalence of anaemia (%)[2]	6	6	
Waist circumference (cm), mean (s.d.)	97.5 (10.3)	88.0 (12.8)	*
BMI (kg/m^2), mean (s.d.)	26.7 (3.8)	26.9 (4.8)	
BMI (%)			*
< 20	3	5	
20 – 25	30	33	
25 – 30	51	38	
> 30	17	24	
Smoking (%)	24	10	*
Self-perceived health (%)			*
poor	5	7	
fair	21	22	
good	75	70	

[1] Cut-off value for low albumin: men and women: < 35 g/l. [2] Cut-off values for anaemia: men: Hb < 130 g/l, women: Hb < 120 g/l. * $P \leq 0.05$

For blood values: albumin and haemoglobin values were missing for Framingham participants of cycle 5, for the other variables data of only a few persons (max. 14 persons) were missing.

Wilcoxon rank sum test was used to test differences between continuous variables and chi-square test was used to test differences between categorical variables.

Table 3 shows the average daily intake of energy, macronutrients, vitamins, and minerals of the American and European research centres. Energy intake ranged from 7.4 MJ/day in Framingham/MA to 10.4 MJ/day in Betanzos/E. While men had a higher mean energy intake than women, the contribution of fat, carbohydrates, protein and alcohol to total daily energy intake was the same for both sexes [data not shown]. In Europe, two main macronutrient profiles appeared: a Northern profile (H/B; R/DK; C/NL; Y,Bu,Be/CH) where fat and carbohydrates contributed similarly to total energy intake, and a Southern profile (P/I; V/P; B/E) where carbohydrates delivered a higher energy percentage than fat. Fat and carbohydrate intakes of the Framingham elders were comparable to the Southern profile. The high intake of carbohydrates in the Southern centres was attributable to the high intake of polysaccharides in comparison with mono/disaccharides. In the Southern centres, total fat intake consisted of relatively low amounts of saturated fat and high amounts of monounsaturated fat (ms-ratio > 1.0) in comparison with the Northern centres (ms-ratio < 1.0). No geographical pattern was observed for the intake of polyunsaturated fat. In **Table 3** micronutrient intake unadjusted for energy intake is presented. These data as well as energy-adjusted data indicate that the Framingham elders had higher vitamin intakes than the Europeans. The macro- and micronutrients presented in **Table 3** are related to the intake of the nutrient-specific food groups presented in **Table 4**.

Vitamin C intake and consumption of fruits & fruit products was low in Roskilde/DK and high in Betanzos/E. A high intake of cholesterol in Roskilde/DK was associated with a high consumption of eggs and a high intake of mono/disaccharides in Culemborg/NL with a high intake of sugar & sugar products. The consumption of some food groups was characteristic for Northern or Southern centres, for example the consumption of grains and fish/shellfish was high in Vila Franca de Xira/P and Betanzos/E, consumption of fruits & fruit products was high in Padua/I and Betanzos/E and the consumption of sugar & sugar products was high in Hamme/B and Culemborg/NL. Further, the use of wine was characteristic for the Southern centres, while in the Northern centres drinking of beer was more common. Although the consumption of some food groups was related to the location of the research centres, intakes of some food groups (milk & milk products, vegetables) were not specific for Northern or Southern centres. The food group intake of the Framingham subjects was not characteristic of either a Northern or Southern European diet.

Table 3. Mean (s.d.) intake of energy and nutrients of participants, aged 70-77 years, of the Framingham Heart Study and SENECA's baseline study, by country

	Framingham, MA, USA n=828	Hamme, Belgium n=182	Roskilde, Denmark n=166	Padua, Italy n=167	Culemborg, The Netherlands n=192	Vila Franca de Xira, Portugal n=197	Betanzos, Spain n=136	Yverdon, Bu, Be, Switzerland n=242
Energy intake (MJ/d)	7.4 (2.5)	9.5 (2.4)	9.0 (2.1)	8.3 (2.5)	8.9 (2.3)	7.6 (2.9)	10.4 (3.3)	7.9 (2.2)
Energy percentage:								
carbohydrates[1]	55 (8)	43 (7)	44 (6)	55 (7)	44 (6)	57 (8)	51 (11)	43 (6)
mono/disaccharides	21 (7)	19 (6)	17 (6)	24 (6)	24 (6)	19 (7)	15 (8)	22 (6)
polysaccharides	34 (6)	25 (6)	22 (4)	31 (8)	20 (4)	38 (9)	36 (13)	21 (5)
total fat	31 (6)	43 (7)	43 (6)	34 (6)	42 (7)	27 (6)	37 (10)	43 (6)
saturated fat	11 (3)	17 (5)	17 (4)	12 (3)	17 (3)	8 (3)	11 (4)	17 (4)
monounsaturated fat	11 (3)	16 (5)	15 (4)	14 (3)	15 (3)	10 (3)	17 (7)	16 (3)
polyunsaturated fat	6 (2)	9 (5)	6 (2)	5 (3)	7 (3)	3 (1)	6 (5)	7 (3)
protein	17 (4)	14 (3)	13 (2)	15 (2)	15 (3)	18 (3)	17 (3)	15 (3)
Ms-ratio[2]	1.08 (0.20)	0.94 (0.42)	0.94 (0.28)	1.20 (0.30)	0.90 (0.13)	1.34 (0.37)	1.65 (0.75)	0.95 (0.19)
Cholesterol (mg)	233 (118)	295 (113)	354 (139)	230 (107)	306 (114)	214 (108)	312 (148)	294 (116)
Alcohol intake (g)	10 (17)	12 (19)	11 (14)	26 (29)	7 (12)	12 (22)	20 (37)	10 (14)
Fibre (g)	24 (10)	22 (8)	22 (8)	19 (7)	26 (8)	26 (11)	21 (11)	21 (6)
Vitamin B1 (mg)	1.39 (0.61)	1.14 (0.31)	1.13 (0.31)	0.83 (0.30)	1.11 (0.30)	1.07 (0.50)	1.34 (0.48)	0.95 (0.31)
Vitamin B2 (mg)	1.74 (0.80)	1.28 (0.35)	1.90 (0.55)	1.49 (0.56)	1.65 (0.46)	1.45 (0.68)	1.82 (0.74)	1.49 (0.47)
Vitamin B6 (mg)	2.02 (0.91)	1.41 (0.39)	1.25 (0.38)		1.53 (0.39)	1.53 (0.57)	1.50 (0.62)	1.09 (0.30)
Vitamin C (mg)	154 (82)	104 (58)	72 (41)	110 (68)	129 (50)	107 (66)	191 (131)	115 (60)
Calcium (mg)	718 (351)	727 (295)	1211 (419)	781 (358)	1147 (368)	731 (443)	1020 (457)	1012 (362)
Iron (mg)	13.5 (7.7)	13.8 (5.2)	12.6 (3.7)	12.3 (4.8)	12.3 (3.0)	12.7 (6.0)	14.6 (5.6)	12.0 (3.2)

1 Energy percentages of macronutrients are adjusted for alcohol intake. 2 Ms-ratio=mufa/saturated fat.

Table 4. Mean (s.d.), food group intake (g/day) and mean diet scores of subjects, aged 70-77 years, of the Framingham Heart Study and SENECA's baseline study, by country

	Framingham, MA, USA n=828	Hamme, Belgium n=182	Roskilde, Denmark n=166	Padua, Italy n=167	Culemborg, The Netherlands n=192	Vila Franca de Xira, Portugal n=197	Betanzos, Spain n=136	Yverdon, Bu, Be, Switzerland n=242
Food group (g/d):								
Grains	174 (111)	205 (82)	187 (95)	213 (93)	147 (55)	257 (148)	275 (177)	193 (84)
Milk & milk products	237 (230)	206 (155)	282 (233)	237 (192)	407 (212)	289 (277)	437 (268)	299 (203)
Fruit & fruit products	179 (142)	201 (170)	130 (98)	342 (181)	241 (142)	227 (189)	441 (354)	214 (135)
Eggs	11 (15)	9 (10)	22 (20)	9 (14)	15 (13)	11 (13)	26 (23)	12 (13)
Meat & poultry	98 (55)	162 (62)	124 (40)	94 (48)	131 (44)	75 (51)	130 (81)	103 (52)
Fish, shellfish	33 (28)	27 (25)	23 (20)	23 (21)	16 (16)	65 (38)	98 (77)	19 (16)
Vegetables	267 (145)	373 (137)	274 (117)	194 (135)	324 (138)	179 (106)	343 (254)	251 (98)
Fats/oils	6 (6)	59 (26)	43 (18)	31 (13)	43 (23)	15 (9)	48 (33)	38 (20)
Legumes/nuts/seeds	26 (24)	3 (9)	1 (3)	20 (16)	18 (21)	7 (15)	13 (23)	7 (12)
Sugar & sugar products	66 (61)	51 (40)	36 (33)	22 (20)	94 (52)	26 (22)	31 (41)	33 (24)
Non-alcohol beverages	906 (488)	905 (481)	1379 (741)	536 (325)	1087 (403)	114 (178)	632 (561)	1005 (434)
Alcoholic beverages	95 (231)	199 (326)	166 (223)	242 (261)	51 (105)	130 (234)	183 (312)	108 (143)
Healthy Diet Indicator	3.4 (1.4)	2.7 (1.1)	2.6 (1.1)	3.3 (1.3)	3.0 (1.1)	3.0 (1.3)	3.4 (1.5)	2.5 (1.1)
G-Mediterran. Diet Score	2.8 (1.3)	2.5 (1.1)	1.8 (1.1)	2.6 (1.2)	2.1 (1.1)	3.3 (1.3)	3.2 (1.4)	2.4 (1.2)
FS-Mediterran. Diet Score	4.2 (1.5)	3.3 (1.2)	2.7 (1.2)	4.4 (1.5)	3.1 (1.2)	4.3 (1.3)	4.2 (1.3)	3.5 (1.4)

Table 5 gives a description of the five composed clusters. Cluster 1, dominated by subjects from Culemborg/NL and Framingham/MA, was characterised by a high intake of sugar & sugar products and legumes/nuts/seeds and a moderate intake of other food groups. In cluster 2 participants of the Southern centres with a high intake of fish/shellfish and grains were grouped. The third cluster was characterised by high intakes of fat and of the food groups eggs and meat & poultry of persons from particularly the Northern centres. The *Milk & fruit cluster*, with mainly women (65%) from all centres, had high intakes of vitamins and calcium, while the *Alcohol cluster* was dominated by men (89%) and had the lowest intakes of vitamins and calcium.

Table 5. Mean (s.d.) food group intake of 70-77y elderly of the Framingham Heart Study and SENECA's baseline study, by dietary pattern cluster

	Sugar n=526	Fish & grain n=307	Meat,eggs & fat n=659	Milk & fruit n=525	Alcohol n=93
Northern centres (n) (total = 782)	101	18	511	129	23
Southern centres (n) (total = 500)	28	187	55	191	39
Framingham/MA (n) (total = 828)	397	102	93	205	31
Energy intake (MJ/d)	8.0 (2.5)	8.0 (3.1)	8.7 (2.5)	7.6 (2.6)	9.1 (2.7)
Food/nutrient groups (g/d):					
Grains	172 (86)	310 (176)	183 (80)	169 (92)	171 (93)
Alcoholic beverages	61 (100)	99 (159)	126 (176)	74 (129)	911 (423)
Milk & milk products	200 (169)	218 (175)	289 (213)	403 (293)	142 (147)
Fruits & fruit products	179 (129)	216 (149)	163 (126)	349 (251)	165 (148)
Eggs	12 (11)	10 (11)	18 (22)	10 (11)	15 (15)
Meat & poultry	97 (46)	87 (48)	142 (63)	92 (53)	103 (57)
Fish/shellfish	26 (21)	58 (43)	24 (24)	42 (49)	46 (52)
Vegetables	261 (131)	217 (138)	287 (132)	294 (191)	256 (143)
Total fat	70 (30)	59 (27)	96 (35)	65 (28)	66 (28)
Legumes/nuts/seeds	29 (28)	13 (16)	7 (12)	17 (20)	17 (24)
Sugar & sugar products	94 (68)	28 (24)	44 (34)	34 (35)	42 (50)
Diet scores:					
Healthy Diet Indicator	3.4 (1.3)^{b}	3.4 (1.3)^{b}	2.4 (1.1)^{a}	3.4 (1.3)^{b}	3.2 (1.3)^{b}
G-Mediterranean Diet Score	2.8 (1.3)^{b}	3.3 (1.2)^{c}	2.1 (1.2)^{a}	2.9 (1.3)^{b}	2.2 (1.2)^{a}
FS-Mediterranean Diet Score	4.2 (1.4)^{b}	4.6 (1.2)^{c}	3.1 (1.3)^{a}	4.1 (1.5)^{b}	3.4 (1.2)^{a}

^{a,b,c} ANOVA followed by the multiple comparison test was used to test differences in diet scores between dietary clusters. Means within rows with different letter superscripts (c>b>a) are significantly different, $P \leq 0.05$.

In addition to the presentation of single food groups, **Table 4** describes the mean scores of the summarised diet indicators. In general, Southern centres had more favourable mean diet scores than Northern centres. In particular, the Mediterranean diet score (FS-MDS) based on median values of the research population, differentiated all Southern centres (P/I; V/P; B/E) and Framingham/MA from the Northern centres (H/B; R/DK;

C/NL; Y,Bu,Be/CH). Mean diet scores are also presented for the five clusters (**Table 5**). The *Meat & fat cluster* had a lower mean HDI in comparison to the other four clusters. The two Mediterranean diet scores were both the highest for the *Fish & grain cluster* and the lowest for the *Meat, eggs & fat cluster* and *Alcohol cluster*. The three diet scores were significantly correlated in the total population as well as in the distinct centres (ranges: r=0.38 – 0.69; P ≤ 0.05).

Table 6 shows mean FS-MD-scores for smokers and non-smokers and subjects of three activity tertiles in Framingham and the Northern and Southern SENECA centres. No results on smoking are presented for women from the Southern centres, because in Betanzos/E and Vila Franca de Xira/P none of the women smoked. In the remaining centres the male and female non-smokers had a higher mean FS-MD-score than smokers in the three regions. Active men from Northern centres and women from Northern and Southern centres tended to have higher diet scores than less active persons. As an exception, active men of Southern centres had lower FS-MD-scores than less active men. No relationship between the diet scores and activity pattern was observed in Framingham/MA. The mean HDI scores for smokers and non-smokers and for subjects of the three activity tertiles pointed in the same direction.

Table 6. Mean (s.d.) diet scores for 70-77y persons differing in lifestyle factors in the Framingham Heart Study and SENECA's baseline study, by sex and region

	Framingham,MA		Northern centres		Southern centres	
	Men n=355	Women n=473	Men n=390	Women n=392	Men n=241	Women n=259
FS-Mediterranean Diet Score						
Smoking						
no	4.3 (1.5)	4.3 (1.5)	3.2 (1.3)	3.3 (1.3)	4.4 (1.4)	
yes	3.9 (1.1)	3.7 (1.4)	3.0 (1.3)	2.4 (1.4)	4.0 (1.2)	
P-value	*	*	**	*	*	
Activity						
tertile 1: low	4.1 (1.5)	4.2 (1.3)	3.0 (1.2)	3.1 (1.3)	4.6 (1.3)	4.1 (1.3)
tertile 2: moderate	4.4 (1.5)	4.3 (1.5)	3.2 (1.3)	3.1 (1.3)	4.3 (1.3)	4.4 (1.5)
tertile 3: high	4.2 (1.4)	4.2 (1.6)	3.3 (1.3)	3.4 (1.4)	4.1 (1.4)	4.4 (1.6)
P-value				*	**	

** P ≤ 0.10; * P ≤ 0.05

Wilcoxon rank sum test was used to test differences in diet scores between smokers and non-smokers. The Kruskal-Wallis test was used to test differences between activity tertiles.

Table 7 demonstrates indicators of nutritional status for different dietary quality groups. Albumin and haemoglobin were not related to the HDI and FS-MD groups. Haemoglobin values presented by cluster showed a higher haemoglobin value of the small *Alcohol cluster* in comparison to the other clusters. For both diet scores, waist circumference was highest in the groups representing low dietary quality. In all regression models, waist circumference tended to be highest for those in the *Meat & fat cluster* and lowest for those in the *Fish & grain cluster*. This relationship between body fatness and dietary quality was also demonstrated with BMI.

Table 7. Mean (s.d.) indicators of nutritional status, adjusted for confounding factors, in elderly subjects, aged 70-77y, of the Framingham Heart Study and SENECA's baseline study

a,b,c ANOVA followed by the multiple comparison test was used to test differences in nutritional status indicators between dietary quality groups. Means within rows with different letter superscripts (c>b>a) are significantly different, $P \leq 0.05$. * $P \leq 0.05$

	HDI		FS-MDS		Cluster				
	Low (≤ 3)	High (>3)	Low (≤ 3)	High (>3)	Sugar	Fish & grain	Meat & fat	Milk & fruit	Alcohol
Albumin (g/l)	n=1205	n=583	n=791	n=997	n=372	n=266	n=626	n=446	n=80
adj. for age, sex	41.9 (3.2)	42.2 (3.2)	41.8 (3.2)	42.1 (3.2)	42.3 (3.2)^{b}	42.1 (3.2)^{b}	41.6 (3.2)^{a}	42.1 (3.3)^{b}	42.0 (3.3)^{ab}
+ smoking, activity	41.7 (3.9)	42.0 (3.7)	41.7 (3.6)	41.9 (4.0)	42.1 (3.5)^{b}	42.0 (3.4)^{ab}	41.5 (3.5)^{a}	42.0 (3.6)^{b}	41.9 (3.3)^{ab}
+ country	41.8 (3.3)	41.9 (3.4)	41.9 (3.3)	41.8 (3.5)	41.8 (3.8)	41.8 (3.6)	41.9 (3.7)	41.8 (3.3)	41.9 (3.3)
Haemoglobin (g/l)	n=1076	n=493	n=720	n=849	n=347	n=213	n=594	n=357	n=60
adj. for age, sex	143.4 (12.8)	142.3 (12.8)	143.8 (12.8)	142.4 (12.8)*	142.7 (12.8)^{a}	141.4 (12.8)^{a}	143.9 (12.8)^{ab}	142.4 (12.9)^{a}	146.5
+ smoking, activity	143.9 (15.5)	142.9 (14.7)	144.2 (14.4)	143.0 (15.9)	143.1 (13.9)^{ab}	141.9 (13.7)^{a}	144.3 (14.1)^{bc}	142.9 (14.3)^{ab}	146.9 (13.1)^{c}
+ country	143.1 (13.1)	142.7 (13.4)	143.5 (13.1)	142.5 (14.0)	142.8 (15.2)^{a}	141.4 (14.4)^{a}	143.6 (14.0)^{ab}	142.5 (13.2)^{a}	146.4
Waist circumf. (cm)	n=1363	n=737	n=885	n=1215	n=523	n=306	n=658	n=522	n=93
adj. for age, sex	92.8 (11.7)	91.9 (11.7)	93.2 (11.7)	91.9 (11.7)*	91.9 (11.7)^{ab}	90.7 (11.7)^{a}	93.3 (11.7)^{c}	92.7 (11.8)^{bc}	94.0 (11.9)^{bc}
+ smoking, activity	91.9 (14.2)	91.0 (13.7)	92.4 (13.0)	90.9 (14.7)*	90.9 (12.9)^{ab}	89.7 (12.5)^{a}	92.5 (12.6)^{c}	91.8 (13.1)^{bc}	93.2 (11.9)^{bc}
+ country	92.1 (14.5)	91.1 (14.4)*	92.4 (13.5)	91.3 (15.7)*	91.4 (14.6)^{a}	91.3 (12.9)^{a}	93.7 (13.0)^{b}	92.6 (12.3)^{ab}	94.4 (11.8)^{b}
BMI (kg/m^2)	n=1359	n=737	n=885	n=1211	n=519	n=306	n=657	n=524	n=92
adj. for age, sex	26.9 (4.4)	26.5 (4.4)*	26.8 (4.4)	26.8 (4.4)	26.5 (4.4)	26.8 (4.4)	26.8 (4.4)	26.9 (4.4)	27.4 (4.5)
+ smoking, activity	26.4 (5.3)	25.8 (5.1)*	26.3 (4.9)	26.1 (5.5)	25.9 (4.8)^{a}	26.1 (4.7)^{ab}	26.3 (4.7)^{ab}	26.2 (4.9)^{ab}	26.9 (4.5)^{b}
+ country	26.4 (5.4)	25.8 (5.4)*	26.4 (5.1)	26.1 (5.9)	26.1 (5.4)^{a}	26.4 (4.8)^{a}	27.1 (4.9)^{b}	26.6 (4.6)^{ab}	27.4 (4.4)^{b}

DISCUSSION

This study confirmed geographical differences in dietary intake. Two dietary patterns appeared at the macronutrient level: a profile high in complex carbohydrates and low in saturated fat in Framingham and Southern Europe and a profile low in complex carbohydrates and high in saturated fat in Northern Europe. At the food group and micronutrient level, a characterisation into two dietary patterns was not sufficient to cover differences between research centres. Cluster analysis made a more specific distinction into five dietary patterns: one pattern characterised Northern Europeans (*Meat & fat*), another pattern typified Southern Europeans (*Fish & grain*) and three other dietary patterns were evident (*Sugar*, *Milk & fruit*, *Alcohol*). Different approaches to measurement of dietary patterns (diet scores and cluster analysis) showed similarities in the classification of persons into dietary quality groups (low and high dietary quality). High quality diets were associated to less body fatness, non-smoking, and to greater physical activity.

Several attempts have been made to classify and quantify dietary quality (Huijbregts et al., 1997b; Kant, 1996; Trichopoulou et al., 1995a; Tucker et al., 1992). Because no ultimate method exists to classify dietary patterns, we related different dietary quality measures to nutritional and lifestyle variables. To include a high variety of dietary patterns, data from the multi-centre SENECA study and the Framingham Heart Study were used. A disadvantage of such an approach is the potential introduction of methodological bias. Two different methods to measure dietary intake were used: a food frequency questionnaire (FFQ) in the Framingham Heart Study and a modified dietary history in the SENECA study. Two validation studies (Nes et al., 1990; Jain et al., 1996) indicated that both the FFQ and the modified dietary history provide higher intakes of nutrients in comparison to an estimated record method as reference. Further, the study of Jain et al. (1996) showed that a FFQ is comparable to an interviewer-administered diet history as a predictor of nutrient intake.

The macronutrient distribution of the food intake of the Framingham subjects was highly comparable to the values of the Southern Europeans. Comparisons of Hulshof et al. (1993) between Northern European and US (CSFII) data confirm this Southern-related type of macronutrient profile of the US population. The high vitamin intake in Framingham can be explained by the different enrichment policies in Europe and the United States (Trichopoulou et al., 1995b). In Padua/I and Betanzos/E dietary fibre intake appeared to be relatively low in comparison to the high reported intakes of the groups grains, fruits & fruit products, vegetables, and legumes/nuts/seeds. In these centres, dietary fibre was not calculated following the standardised procedure (dietary fibre = sum of polysaccharides and lignin). As a result, dietary fibre may be underestimated and affect the calculation of the HDI for a few persons.

The result of the cluster analysis procedure is dependent on multiple factors, including the clustering method, definition of food groups, expressed unit of the variables and the standardisation of variables (see Methods section). As the composition of clusters has a large subjective component, we compared our results with other studies. The identified clusters in the current study were highly comparable to the results of Huijbregts et al. (1995b). They identified the following clusters in a study of Dutch elderly men: *Meat, Refined sugars, Alcohol*, and a *Healthy cluster* (high in fruit, vegetables and grains). Also in other studies in Giessen (Germany) and the Boston-area (MA, USA), a *Meat cluster*, a *Milk & fruit and/or grain cluster* and an *Alcohol cluster* appeared (Boeing et al., 1989; Tucker et al., 1992).

In Europe and the United States several diet scores have been developed to measure overall dietary quality. In the current study, we calculated the non-validated scores: HDI and MDS. The HDI is based on the WHO dietary guidelines for the prevention of chronic diseases (WHO, 1990) and is useful in a cross-cultural setting (Huijbregts et al., 1997a). The MDS is based on the low rates of chronic diseases and the high life expectancy in countries bordering the Mediterranean sea (Amorim Cruz et al., 2001; WHO, 1994). Despite this rationale behind the composition of these scores, neither score has been validated with dietary quality indicators. Therefore we related the diet scores with the individual diet components [data not shown]. From the lowest to the highest diet scores, the mean intake of all individual components improved in both MD-scores. For the HDI this relation appeared for all components, except for mono/disaccharides. Löwik et al. (1999) also observed that a higher dietary quality score (simplified version of the HDI) is associated with a higher proportion meeting the individual scoring items, except for mono- and disaccharides. Together, these results show that both HDI and MDS are reliable indicators of diet quality. A comparison of the diet scores in our study to scores in the literature is difficult, because few studies report reference values; the HDI has been calculated but not replicated in an elderly population and the MDS has no definite cut-off values. However, in line with our results, Huijbregts et al. (1997b) showed a higher mean HDI for the Southern centre Italy in comparison with the Northern centres Finland and The Netherlands.

We compared diet scores and clusters to assess internal consistency. The three diet scores were highly correlated and the mean MDS distinguished clusters with a low (*Alcohol cluster*, *Meat & fat cluster*), average (*Sugar cluster*, *Milk & fruit cluster*) and high (*Fish & grain cluster*) diet score. The HDI was only lower for the fat & meat cluster in comparison to the other four clusters. This reduced capability of the HDI to classify the five clusters probably results from the strict dietary guidelines for carbohydrates. Only 5% of the subjects met the dietary guideline of mono/disaccharides (≤ 10 energy%) and only 3% met the dietary guideline for polysaccharides (50–70 energy%). In contrast to the WHO guidelines, the Dutch and US dietary guidelines are less strict for total carbohydrates (US: 50 – 60 energy%; NL: ≥ 55 energy%) and mono- and disaccharides (NL: 15 - 25 energy%) (Hulshof et al., 1993; Millen et al., 1997). Lowering the lower limit of the complex carbohydrates from 50 to 35 energy% and increasing the upper limit of mono- and disaccharides from 10 to 15 energy% led to a 20% fulfilment of these dietary guidelines. Applying these limits to the HDI-score in the current study yielded a result comparable to the MDS [data not shown]. The results of the diet scores and the five-cluster solution in our study affirmed the existence of different dietary patterns, with the *Meat & fat cluster* and the *Fish & grain cluster* as the two extreme patterns. In a US population, Hu et al. (1999) recently identified two major dietary patterns (using factor analysis) highly similar to our extreme patterns: 1) a *Prudent dietary pattern* characterised by a high intake of fruits, vegetables, legumes, grains and fish, and 2) a *Western pattern*, characterised by a high intake of meat, butter, high-fat dairy products, eggs and refined grains.

In the two main studies SENECA and Framingham, smoking and physical activity were asked for with questionnaires that differed in some aspects. In the European centres the number of male smokers was greater than in Framingham, but included pipe and cigar use (about 10%). The physical activity questionnaires in both studies included the same type of questions (intensity and hours/day of activities), but the SENECA survey queries included specific household, sports and leisure time activities in more detail than did the Framingham activity questionnaire. As a result, the activity scores of the European subjects were more highly dispersed than were those of the Framingham elders. This may explain the lack of association between physical activity and diet in Framingham. In the Southern European centres, a high-quality diet was not related to physical activity in men. Most likely, the explanation for this is that inactive Southern Europeans lived more often with their children than did physically active persons. Men who lived with their children had a higher diet score than men who lived alone. Considering these cultural differences, we found that in general the two healthy lifestyle behaviours non-smoking, and physical activity were associated with higher dietary quality in most individual centres as well as in the grouped centres (**Table 6**). In line with this, Farchi et al. (1994) described an increasing number of non-smokers and physically active subjects in the groups with high-quality diets. Greenwood et al. (2000) reported that a group of middle-aged women with healthier food consumption patterns were more likely to take vigorous physical exercise. Several authors have demonstrated that non and past smokers had diets more in line with the dietary guidelines than did smokers (Cade & Margetts, 1991; Ma et al., 2000; Margetts & Jackson, 1993).

In multi-centre studies, nutritional and lifestyle factors are influenced by cultural differences between research centres (de Groot et al., 1996; Trichopoulou & Lagiou, 1997). Consequently, we carried out regression analysis with and without 'country' in our model. Adjustment for country is likely to result in an over-correction of the true association between dietary pattern and nutritional status, but with disregard of this confounder no adjustments are made for the higher valued non-diet related differences across sites.

In our study we found no association between dietary quality and albumin and haemoglobin. In this population, albumin status and haemoglobin values were mainly within the normal range, reflecting the absence of serious health problems more than an optimal nutritional status (Dirren et al., 1991). As an indicator for overweight, waist circumference (Molarius et al., 1999) was related to dietary quality. The analysis was replicated for men and women and all results pointed in the same direction: subjects with a low-quality diet were more overweight in comparison to subjects with a high-quality diet. This association between body composition and dietary quality has also been demonstrated in other studies (Greenwood et al., 2000; Haveman-Nies et al., 1998; Wirfält & Jeffery, 1997).

In conclusion, the highly varied dietary intake in our European and American research populations could be summarised into a limited number of dietary patterns. Dietary scores and dietary clusters are two complementary measures to classify dietary quality. High-quality diets were positively associated to other healthy lifestyle variables, including less body fatness, non-smoking, and greater physical activity.

CHAPTER 3

SNACK PATTERNS OF ELDERLY EUROPEANS

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ABSTRACT

This study aims to describe the snack consumption of elderly people from several European towns. Subjects with similar snack patterns are clustered into groups to explore the contribution of snacks to daily energy and micronutrient intake. The study population in SENECA's follow-up study (1993) consisted of 379 men and 428 women, aged 74 to 79 years, who were inhabitants of the following small traditional towns: Haguenau, France; Romans, France; Padua, Italy; Culemborg, The Netherlands; Yverdon, Switzerland; and Marki, Poland. Food intake data collected by the 3-day estimated record method were used for grouping snack foods into 15 snack groups. From the food intake data, daily energy intake and intake of calcium; iron; vitamins B1, B2, B6, and C were calculated. Additional self-reported data were collected for health status, presence of chronic diseases and activity level. Cluster analysis was used to classify subjects into groups based on similarity in snack patterns. In general, elderly people from the various European towns consumed the same snack types. Five distinct snack patterns emerged from our analyses. The large group *Light snackers* had a low snack use and low energy and micronutrient intakes. *Alcohol drinkers* and *Dairy snackers* had a high snack use and high intakes of energy and several vitamins and minerals. *Fruit & vegetable snackers* and *Sweet drinkers* often had intake values between the other three groups. Our study indicates the existence of identifiable snack patterns that coincide with different intakes of energy and micronutrients. Especially in countries in which people derive high percentages of energy through snacking, the identification of snack patterns can improve dietary advice, gearing it to personal needs.

INTRODUCTION

In Europe a variety in the frequency and the amount of snacks eaten by elderly people has been observed (Schlettwein-Gsell & Barclay, 1996; Summerbell et al., 1996; Winkler et al., 1995). In these studies snacks were defined as 'everything that is not consumed as part of a meal (breakfast, lunch, dinner)'. The use of snack foods between meals contributes to total daily energy and micronutrient intake. Especially when daily energy need declines, as occurs in elderly people, the choice of foods is of importance to provide adequate intakes of energy and nutrients (Schroll et al., 1996; van der Wielen, 1995).

The nutritional implications of snack consumption mostly have been studied in relation to energy intake (Drummond et al., 1996; Green & Burley, 1996; Murphy et al., 1990). These studies showed contradictory outcomes in regard to the relationship between snack use and energy intake. Some studies have reported a compensation of a higher energy intake from snacks by a lower energy intake from meals (Green & Burley, 1996). Other studies observed a higher total energy intake as a result of a higher snack consumption (Booth, 1988; Murphy et al., 1990). These conflicting outcomes may be ascribed to the choice of quantitative snack parameters (number of snacks and percentage energy from snacks) used in these studies. Although the amount of consumed snacks is of concern for the relationship between snack consumption and energy and micronutrient intake, the quality of snacks is important and should also be used as a parameter of snack consumption. This qualitative approach was chosen in several studies on dietary patterns in which the elderly population was categorised into groups on the basis of similarity in total food intake (Akin et al., 1986; Schroll et al., 1996; Tucker et al., 1992; Wirfält & Jeffrey, 1997). In these studies different food pattern types are related to nutritional status: for example, elderly people with a food pattern characterised by a high intake of milk products and fruits have a high micronutrient intake and the best hematology profile (Tucker et al., 1992).

This study describes the snack consumption of elderly people in different European towns. Subjects with similar snack patterns are clustered into groups to explore the contribution of snacks to daily energy and micronutrient intake. Furthermore, these snack patterns are associated with some parameters of health status to get a first impression of the health characteristics of the clusters.

METHODS

Subjects

In our study, data from the Survey in Europe on Nutrition and the Elderly: a Concerted Action (SENECA) follow-up study were used. Data were collected from inhabitants from small traditional towns in Europe. All inhabitants born between 1913 and 1918 were eligible to be enrolled in the study. The only criteria for exclusion were living in psycho-geriatric nursing homes; not being fluent in the country's language; and not at all able to answer questions independently (de Groot & van Staveren, 1988). Data from 379 men and 428 women of the following towns were available: Haguenau, France (H/F); Romans, France (R/F); Padua, Italy (P/I); Culemborg, The Netherlands (C/NL); Yverdon, Switzerland (Y/CH); and Marki, Poland (M/PL).

Estimated record method

Food intake data were collected by trained personnel using the 3-day estimated record method (Cameron & van Staveren, 1988). Each participant was asked to record all the food they ate, describing the foods and portion sizes in as much detail as possible. A record day was divided into 8 feeding periods: 1) before breakfast; 2) breakfast; 3) during the morning; 4) lunch; 5) during the afternoon; 6) evening meal; 7) evening snack; and 8) during the night. Portion sizes were based on standard portion sizes and/or checked by weighing. Food consumption data had been converted into energy and the following micronutrients: calcium, iron, thiamin, riboflavin, pyridoxine, and ascorbic acid. Country-specified food composition tables based on local food products were used to improve the accuracy of calculation of daily energy and nutrient intake (van 't Hof et al., 1991).

Snack consumption

From the data, two quantitative parameters of snack use were calculated for each participant: the number of feeding periods per day, and the percentage of energy delivered by snacks. Snacks were defined as all foods and drinks consumed during feeding periods 1, 3, 5, 7, and 8. Snack foods were grouped into the following 15 food groups: coffee/tea & (mineral)water; milk & milk products; soft drinks/lemonades; alcoholic drinks; fruit juices; soup; fruits & vegetables; cakes & pastry; bread & grain products; sweet spreads/sauces & sugar; meat & meat products; chocolate snacks/sweet confectionery; savoury snacks; cheese; and savoury spreads & oils/fats.

Biochemical data

After subjects had fasted overnight, blood samples were collected by venipuncture between 7:30 and 9:30 am. A total of 25 ml blood was collected. Plasma samples were frozen and stored at -80°C. For an extensive description of the blood collection method and vitamin analyses, see Haller et al. (1996).

Parameters of health status

Body Mass Index (BMI) was derived by dividing a person's weight in kilograms by the square of his stature in meters. Standing height was measured to the nearest 0.1 cm with the person standing erect and wearing no shoes. Standing height was recorded as missing when stature could not be measured because of kyphosis. Weight was recorded to the nearest 0.5 kg. Calibrated scales fit on a wooden board were used, and subjects were weighed wearing undergarments in the morning after breakfast and after voiding. In a general questionnaire, questions were asked about subjective health (poor, fair, good), chronic diseases (e.g. diabetes, ischemic heart disease), and activities of daily living (ADL). An activities of daily living score was calculated as a sum of 16 items. For each item, the level of competence was measured on a 4-point scale. Grades of difficulty were assigned to categories in terms of ability to perform an activity (1 = can do without difficulty, 2 = can do with difficulty but without help, 3=can do only with help, 4 = unable to complete).

Statistical analyses

Statistical analyses were carried out using the SAS statistical software package (SAS Institute Inc., Cary, NC). The Wilcoxon rank sum test ($P \leq 0.05$) was used to evaluate differences in snack consumption between men and women. Cluster analysis was used to divide the study population into a limited number of clusters with more identical snack patterns. For cluster analysis, data from all snack groups except coffee/tea & (mineral)water were used. Ward's minimum variance method was used to compose clusters with a minimum of internal variance. The number of clusters is chosen on the basis of the R^2 of the clusters and the composition of the clusters. Spearman rank correlation coefficients were calculated to determine the relationship between energy intake and the two quantitative parameters of snack use. Analysis of variance (ANOVA) followed by Tukey multiple comparison test was used to test differences in energy and micronutrient intake, percentage of energy derived from snacks, and biochemical data between the clusters ($P \leq 0.05$).

RESULTS

Table 1 presents the anthropometric characteristics, daily energy intake, and parameters of snack use of the study population. Mean BMI of men varied from 26.0 (Yverdon/CH) to 27.4 (Haguenau/F) and for women from 25.3 (Padua/I) to 28.3 (Haguenau/F; Marki/PL). The contribution of snacks to total daily energy intake was the highest in Culemborg/NL (29%). The lowest number of feeding periods was found in Romans/F and Marki/PL. Neither energy percentage of snacks nor number of feeding periods per day differed between men and women.

Table 1. Mean (s.d.) BMI, energy intake, and parameters of snack use of elderly men and women from six European towns

	Haguenau, France	Romans, France	Padua, Italy	Culemborg, Netherlands	Yverdon, Switzerland	Marki, Poland
				Men		
	n=55	n=69	n=67	n=53	n=71	n=47
BMI (kg/m^2)	27.4 (4.0)	26.8 (3.5)	26.2 (3.5)	26.2 (3.0)	26.0 (3.8)	26.5 (4.8)
Energy intake (MJ/d)	8.9 (2.8)	8.5 (1.7)	8.3 (1.8)	8.5 (2.0)	7.8 (1.9)	8.7 (3.2)
% Energy from snacks	10.2 (8.0)	6.5 (6.9)	6.3 (7.0)	29.2 (12.4)	8.6 (7.6)	10.0 (15.4)
No. of feeding periods	4.8 (1.2)	3.0 (0.7)	4.6 (1.1)	6.4 (0.8)	5.3 (1.3)	3.6 (1.0)
				Women		
	n=52	n=68	n=64	n=65	n=79	n=72
BMI (kg/m^2)	28.3 (4.8)	25.8 (4.6)	25.3 (4.3)	28.2 (4.1)	25.8 (4.3)	28.3 (7.1)
Energy intake (MJ/d)	7.1 (1.7)	6.3 (1.3)	6.8 (2.2)	6.6 (1.8)	5.9 (1.4)	8.4 (2.3)
% Energy from snacks	10.6 (9.8)	6.3 (5.5)	8.5 (6.9)	28.2 (10.3)	11.1 (8.3)	7.6 (11.8)
No. of feeding periods	4.7 (1.4)	2.9 (0.5)	4.9 (1.0)	6.7 (0.8)	5.5 (1.5)	3.4 (0.8)

Table 2 shows the types of snacks elderly people of six European towns consumed. Overall, coffee/tea & (mineral)water, milk & milk products, fruits & vegetables, fruit juices, alcoholic drinks, and cakes & pastry were most frequently eaten between meals. In these towns almost no differences in consumption of snacks from the 15 snack groups appeared between men and women, with the exception of alcoholic drinks that men consumed more than women. Similar types of snack foods were eaten in all towns, but the amount eaten varied considerably. Snack consumption in Poland was distinguished from that in the other towns by a higher consumption from the groups bread & grain products (45 ± 48 g/day) and meat & meat products (26 ± 58 g/day) than from the group cakes & pastry (7 ± 17 g/day).

Table 3 gives an overview of the intake of snacks of five composed clusters. The largest cluster *Light snackers* (n=391) was characterised by the lowest consumption from all snack groups. *Fruit & vegetable snackers* differed from the other clusters by a high consumption of the groups fruits & vegetables, bread & grain products, and meat & meat products. *Sweet drinkers* consumed large volumes of soft drinks, lemonades, and fruit juices. *Dairy snackers* were characterised by the consumption of sweetened milk products, cheese, and other non-sweetened dairy products. The consumption of sweet products from snack groups as cakes & pastry, sweet sauces/spreads & sugar, and chocolate snacks was also relatively high. In addition to alcoholic drinks, the small cluster of *Alcohol drinkers* consumed many snack products from various snack groups, such as coffee/tea & (mineral)water, bread & grain products, and savoury snacks.

Table 2. Mean (s.d.) daily intake of snacks, categorised in snack groups, of elderly Europeans, by town

	Total	Haguenau, France	Romans, France	Padua, Italy	Culemborg, The Netherlands	Yverdon, Switzerland	Marki, Poland
	n=681	n=106	n=132	n=129	n=118	n=141	n=55
Fluid snack group (g/d):							
Coffee/tea & (mineral)water	453 (407)	994 (457)	289 (205)	180 (180)	692 (317)	380 (266)	114 (150)
Milk & milk products	45 (90)	31 (81)	17 (47)	28 (64)	129 (139)	29 (54)	38 (72)
Soft drinks/lemonades	14 (50)	5 (25)	5 (16)	18 (49)	33 (70)	15 (67)	2 (11)
Alcoholic drinks	24 (76)	47 (126)	12 (42)	20 (66)	39 (83)	18 (61)	2 (9)
Fruit juices	24 (59)	32 (63)	19 (45)	14 (35)	31 (58)	32 (62)	14 (101)
Soup	1 (12)	2 (11)	1 (9)	0 (0)	5 (25)	0 (0)	0 (0)
Non-fluid snack group (g/d):							
Fruits & vegetables	50 (83)	51 (85)	32 (58)	39 (87)	71 (95)	53 (76)	64 (94)
Cakes & pastry	15 (26)	12 (24)	8 (17)	6 (16)	44 (33)	9 (18)	7 (17)
Bread & grain products	8 (25)	10 (25)	3 (11)	3 (13)	7 (17)	4 (9)	45 (58)
Sweet spreads/sauces & sugar	6 (12)	5 (9)	4 (7)	5 (8)	11 (14)	4 (6)	12 (27)
Meat & meat products	3 (20)	2 (7)	1 (4)	1 (6)	4 (19)	0 (3)	26 (58)
Chocolate snacks/sweet confectionery	2 (6)	3 (8)	1 (4)	1 (7)	4 (7)	2 (4)	1 (2)
Savoury snacks	1 (6)	1 (5)	1 (4)	0 (1)	4 (10)	1 (5)	0 (2)
Cheese	2 (8)	2 (9)	1 (3)	1 (5)	2 (5)	1 (6)	7 (18)
Savoury spreads/sauces & oils/fats	1 (4)	1 (2)	0 (2)	0 (1)	2 (8)	0 (2)	5 (8)

Table 3. Mean (s.d.) daily intake of snacks, categorised in snack groups, of elderly Europeans, by cluster

	Total	Light	Fruits & vegetables	Sweet drinks	Dairy products	Alcohol
	n=681	n=391	n=118	n=74	n=77	n=21
Haguenau, France (n)	106	61	15	12	8	10
Romans, France (n)	132	95	21	8	7	1
Padua, Italy (n)	129	88	18	11	9	3
Culemborg, The Netherlands (n)	118	32	21	21	39	5
Yverdon, Switzerland (n)	141	79	29	21	10	2
Marki, Poland (n)	55	36	14	1	4	-
Fluid snack group (g/d):						
Coffee/tea & (mineral)water	453 (407)	400 (388)	471 (415)	529 (385)	564 (454)	660 (437)
Milk & milk products	45 (90)	10 (22)	34 (44)	46 (62)	241 (126)	31 (82)
Soft drinks/lemonades	14 (50)	4 (14)	5 (24)	80 (116)	17 (40)	20 (54)
Alcoholic drinks	24 (76)	14 (39)	6 (18)	12 (34)	24 (92)	354 (99)
Fruit juices	24 (59)	11 (26)	7 (22)	126 (115)	27 (49)	6 (29)
Soup	1 (12)	1 (7)	2 (21)	3 (16)	1 (7)	0 (10)
Non-fluid snack group (g/d):						
Fruits & vegetables	50 (83)	12 (24)	168 (102)	51 (64)	63 (85)	52 (83)
Cakes & pastry	15 (26)	10 (20)	15 (28)	18 (25)	30 (34)	27 (42)
Bread & grain products	8 (25)	6 (21)	14 (34)	6 (10)	12 (31)	18 (26)
Sweet spreads/sauces & sugar	6 (12)	5 (8)	8 (19)	6 (10)	10 (15)	7 (9)
Meat & meat products	3 (20)	1 (7)	11 (43)	2 (8)	3 (11)	9 (14)
Chocolate snacks/sweet confectionery	2 (6)	2 (6)	2 (4)	2 (4)	4 (8)	2 (5)
Savoury snacks	1 (6)	1 (4)	2 (7)	2 (5)	2 (6)	7 (15)
Cheese	2 (8)	1 (4)	2 (8)	1 (2)	5 (16)	5 (14)
Savoury spreads/sauces & oils/fats	1 (4)	0 (2)	1 (5)	1 (3)	3 (9)	2 (4)

In contrast to the other clusters, the representation of men and women in this cluster was strikingly disproportionate (90% men vs 10% women). Participants from almost all towns were represented in each of the five clusters (**Table 3**). Two clusters contained relatively high numbers of persons from a specific town: about half of the *Dairy snackers* were inhabitants of Culemborg and about half of the *Alcohol drinkers* were inhabitants of Haguenau.

Table 4. Mean (s.d.) total daily energy and micronutrient intake and percentage of energy from snacks of elderly Europeans, by cluster

	Light	Fruits & vegetables	Sweet drinks	Dairy products	Alcohol
	n=384	n=115	n=73	n=75	n=20
Energy intake (MJ/d)	7.1 (1.9)^{a}	7.7 (2.5)^{ab}	7.8 (1.8)^{ab}	7.9 (2.7)^{b}	9.6 (3.1)^{c}
% Energy from snacks	7.9 (8.3)^{a}	16.1 (11.7)^{b}	17.0 (10.0)^{b}	26.5 (13.1)^{c}	24.3 (13.3)^{c}
Calcium (mg)	691 (303)^{a}	807 (341)^{b}	849 (280)^{b}	1059 (359)^{c}	713 (364)^{ab}
Iron (mg)	10.7 (3.5)^{a}	11.8 (4.2)^{a}	11.7 (3.7)^{a}	11.4 (4.3)^{a}	14.3 (4.2)^{b}
Thiamin (mg)	0.91 (0.41)^{a}	1.00 (0.49)^{a}	1.04 (0.54)^{a}	0.93 (0.34)^{a}	1.14 (0.53)^{a}
Riboflavin (mg)	1.43 (1.00)^{a}	1.59 (0.82)^{ab}	1.55 (0.84)^{ab}	1.76 (0.61)^{b}	1.38 (0.58)^{ab}
Pyridoxine (mg)[1]	1.25 (0.44)^{a}	1.42 (0.54)^{b}	1.35 (0.65)^{ab}	1.30 (0.44)^{ab}	1.60 (0.61)^{b}
Ascorbic acid (mg)	71 (44)^{a}	91 (46)^{bc}	103 (50)^{c}	79 (44)^{ab}	67 (56)^{ab}

^{a,b,c} Means within rows with different letter superscripts (c>b>a) are significantly different, $P \leq 0.05$; [1] Data from Padua, Italy were not available.

Table 4 gives the absolute energy and micronutrient intake and the energy percentage delivered by snacks per cluster. Total daily energy intake of *Alcohol drinkers* was the highest. Dairy snackers had a significantly higher energy intake than *Light snackers* ($P \leq 0.05$). *Alcohol drinkers* had a high energy intake and a high energy percentage delivered by snacks, and *Light snackers* with the lowest energy intake had the lowest energy from snacks. In some towns (Haguenau, Marki [men and women]; Yverdon [women], Padua [men]), parameters of snack use were correlated with energy intake (range: r=0.28 - r=0.54); a higher percentage energy from snacks and/or frequency of meals was related to a higher daily energy intake. In the other towns parameters of snack use were not correlated with energy intake. *Dairy snackers* had a higher total daily calcium and vitamin B2 intake than did *Light snackers* ($P \leq 0.05$). In the latter group, intake of most micronutrients was the lowest. *Alcohol drinkers* had the highest intakes of some micronutrients (iron, vitamin B6) and the lowest intakes of other micronutrients (calcium, and vitamins C and B2).

Table 5 shows mean plasma concentrations of several vitamins of the five clusters. In general, *Alcohol drinkers* had low plasma vitamin concentrations, except for the plasma value of retinol. In contrast with the results shown in **Table 4** *Light snackers* did not have the lowest plasma concentrations. *Fruit & vegetable snackers* had the highest plasma concentrations for vitamin B12. They also had highest vitamin B6 levels, but these data were known only for 17 persons.

Table 5. Mean (s.d.) plasma concentrations of several vitamins of elderly Europeans, by cluster

	Light	Fruits & vegetables	Sweet drinks	Dairy products	Alcohol
	n=332	n=92	n=65	n=64	n=18
Total carotene (µmol/l)	0.73 (0.60)[ab]	0.77 (0.47)[ab]	0.83 (0.60)[b]	0.67 (0.37)[ab]	0.37 (0.22)[a]
Retinol (µmol/l)	1.81 (0.48)[b]	1.73 (0.36)[ab]	1.80 (0.40)[ab]	1.63 (0.44)[a]	1.92 (0.61)[ab]
α-Tocopherol (µmol/l)	31.5 (7.7)[a]	31.9 (9.1)[a]	33.5 (7.4)[a]	32.7 (8.5)[a]	29.5 (11.9)[a]
Cobalamin (pmol/l)	294 (203)[a]	339 (277)[a]	317 (215)[a]	321 (190)[a]	272 (165)[a]
Pyridoxal-5 phosphate (nmol/l)[1]	58 (52)[a]	68 (44)[a]	37 (19)[a]	46 (20)[a]	33 (15)[a]

[a,b] Means within rows with different letter superscripts (b>a) are significantly different, $P \leq 0.05$; [1] Pyridoxal-5 phosphate data were only available for 144 persons. In the SENECA study the following criteria defined high risk of vitamin deficiency: retinol < 0.35 µmol/l, α-tocopherol < 11.6 µmol/l, cobalamin < 111 pmol/l, pyridoxal-5 phosphate < 20 nmol/l, total carotene: no criterion given (Haller et al., 1996).

Table 6 presents some parameters of health status. Almost no differences in ADL scores appeared between the five clusters. *Dairy snackers* and *Alcohol drinkers* had the highest BMI. The percentage of *Dairy snackers* with no self-reported chronic diseases was much higher in comparison with *Light snackers*. The *Dairy snacker* and *Alcohol snacker* clusters contained the highest percentages of people who judged their own health as 'good'.

Table 6. Parameters of health status of elderly Europeans, by cluster

	Light	Fruits & vegetables	Sweet drinks	Dairy products	Alcohol
	n=382	n=118	n=73	n=74	n=20
ADL-score[1], mean (s.d.)	20.8 (6.9)	20.7 (7.9)	20.7 (5.8)	20.6 (7.0)	19.9 (3.7)
BMI (kg/m^2)[2], mean (s.d.)	26.5 (4.4)	26.3 (4.5)	25.9 (3.7)	27.9 (3.9)	27.9 (3.5)
No self-reported chronic diseases (%)	27	31	34	41	35
Self-perceived health (%)					
good	56	58	56	68	65
fair	33	28	36	27	35
poor	11	13	8	5	0

[a,b] Means within rows with different letter superscripts (b>a) are significantly different, $P \leq 0.05$;

[1] ADL=Activities of Daily Living; [2] Data of 49 persons were not available.

DISCUSSION

In our study, elderly people from different towns in Europe consumed the same types of snacks. Five distinct snack patterns emerged from our analyses. The large cluster *Light snackers* had a low snack use and low energy and micronutrient intakes. *Alcohol drinkers* and *Dairy snackers* had a high snack use and high intakes of energy and some vitamins and minerals. *Fruit & vegetable snackers* and *Sweet drinkers* had moderate to high intakes of energy and micronutrients.

In our study population, clusters were distinguished on the basis of the consumption of snack products (in grams) categorised into snack groups. In other research, food patterns have only been described by using total daily food intake data (Akin et al., 1986; Tucker et al., 1992). In these studies food patterns were described on the basis of defined food groups. These defined food groups showed similarities and differences with the snack groups of our study. Akin et al. (1986) and Schroll et al. (1996) distinguished a large cluster with small and moderate eaters (called *Light eaters* and *Modest/Small eaters* in their studies) and a cluster characterised by the consumption of large amounts of dairy products (called *Milk drinkers* and *High-fat milk products consumers*). Furthermore, Akin et al. (1986) distinguished a very small cluster that consumed large amounts of alcoholic beverages and a cluster characterised by a high consumption of fruit & vegetable products, and whole grain products. Tucker et al. (1992) distinguished a large cluster with a diet high in milk, cereals, and fruits, and a small cluster consuming large amounts of alcohol. Clusters from our study corresponded with clusters from the literature. As an exception, the cluster *Sweet drinkers* is characterised by consumption of typical snack foods. Tucker et al. (1992) composed clusters on the basis of typical meal groups, such as a cluster characterised by a high consumption of meat and potatoes and a cluster with a high consumption of poultry. The occurrence of these clusters is probably linked to the choice of food groups that in our study are characteristic of the snack periods and that in literature are characteristic of total dietary intake (including meals).

As in other studies (Drummond et al., 1996; Summerbell et al., 1995; van der Wielen, 1995) snacks were defined as 'everything that is not consumed as part of a meal (breakfast, lunch, dinner)'. The estimated record method was used to measure food intake, because this method connects food consumption with feeding periods (Cameron & van Staveren, 1988). Livingstone et al. (1990) reported that underestimation of food intake occurred more during snack periods than during meal moments. On the other hand, Summerbell et al. (1995) found no evidence to suggest that underestimation of energy intake is biased toward snacks rather than meals. Moreover, the identification of snack patterns is not very sensitive to underreporting of a few snack products. The similarity observed to the clusters found in literature (Akin et al., 1986; Schroll et al., 1996; Tucker et al., 1992) does not indicate that our results would have been invalidated by bias. In our study, data related to micronutrient intake are not linked to the biochemical data because these data were not available for the same micronutrients, or because biochemical data were missing for many subjects (e.g. vitamin B6 date were only available for 144 persons).

An important issue for research on the nutritional importance of snacks is whether a higher consumption of snacks will be compensated for by a lower consumption of meals, or if snacking will cause overconsumption (and increase BMI). Results from our study and from the literature did not consistently indicate either of the mechanisms (Booth, 1988; Drummond et al., 1996; Murphy et al., 1990). In all of these studies only two rough measurements of snack use are defined: frequency of eating and percentage of energy from snacks. These two parameters of snack use do not include the quality of snack products that are consumed. In our study, subjects were clustered into groups on the basis of similarity in snack patterns. An advantage of this approach is that the broad concept of snack use is defined more clearly. In our study, *Light snackers* had much lower energy from snacks and frequency of meals than did *Fruit & vegetable snackers*, *Sweet drinkers*, *Dairy snackers*, or *Alcohol drinkers*. In the last four clusters, the various snack groups contributed to a different extent to energy derived from snacks. People with a snack pattern characterised by the consumption of fruit juices and soft drinks differed in their BMI from people with a snack pattern characterised by dairy products and sweet snack products or alcoholic drinks. This classification of subjects on the basis of similarity in snack choice may help to solve the problem of how snack consumption and energy and micronutrient intake are related.

Micronutrient intake and some parameters of health status varied considerably between the five clusters. In agreement with the results of several other studies, food consumption pattern is related to micronutrient intake (Akin et al., 1986; Schroll et al., 1996; Tucker et al., 1992). In the large cluster of *Light snackers,* energy, vitamin, and mineral intake was the lowest. These data indicate that, especially in this cluster of light eaters, people should be aware of the importance of their food choice.

This study indicates the existence of identifiable snack patterns that coincided with different intakes of energy and micronutrients and various health characteristics. Especially in countries in which people derive high percentages of energy through snacking, the identification of snack patterns can improve dietary advice, gearing it to personal needs.

CHAPTER 4

THE CONTRIBUTION OF SNACKS TO DAILY MICRONUTRIENT INTAKE OF DUTCH ELDERLY PEOPLE

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ABSTRACT

In this study the snack pattern of Dutch elderly people is described and the relationship between snack consumption and micronutrient intake is examined. The study population, aged 74-79 years, consisted of 118 subjects from Culemborg, The Netherlands. Estimated record data from the SENECA follow-up study in 1993 were used for data analysis. The total population is grouped into clusters with more comparable snack patterns, using cluster analysis. The following four clusters were composed: *Moderate snackers, Dairy snackers, Fruit snackers* and *Drinkers.* Most important snack products elderly subjects consumed came from the following snack groups: coffee/tea & water; milk & milk products; fruits & vegetables; and cakes & pastry. In general, the micronutrient content of snacks was lower than or equal to the micronutrient content of meals in the total population and in the four clusters. As an exception, snacks consumed by *Dairy snackers* had a higher vitamin B2 and calcium content in comparison with meals. In addition, total daily calcium and vitamin B2 intake of the *Dairy snackers* was significantly higher than the intake of *Moderate snackers, Fruit snackers* and *Drinkers.* Depending on the role of snack consumption in total daily energy intake (in addition to or in substitution for meals) snack consumption of other clusters (*Moderate snackers, Fruit snackers* and *Drinkers*) can influence total daily vitamin and mineral intake positively.

INLEIDING

Een veel voorkomend verschijnsel bij ouderen is de verlaagde inneming van vitaminen en mineralen door een verminderde energiebehoefte (van der Wielen, 1995). Deze verminderde energiebehoefte wordt veroorzaakt door een verminderde lichamelijke activiteit en een verandering in lichaamssamenstelling (Haveman-Nies et al., 1996; Poehlman & Horton, 1990; Vaughan et al., 1991). Andere factoren die bij ouderen kunnen bijdragen aan de verlaagde vitaminen- en mineraleninneming zijn: een verminderde eetlust, sociale isolatie en een laag inkomen. Functievermindering van een groot aantal organen kan tot gevolg hebben dat vitaminen en mineralen minder goed worden opgenomen door het lichaam (Löwik, 1989). Eén van de mogelijkheden om in de dagelijkse behoefte aan micronutriënten te voorzien, is het maken van een zorgvuldige voedselkeuze (Löwik, 1989; van der Wielen, 1995). Kennis van voedselpatronen van ouderen kan bijdragen aan een verbetering van de voedselkeuze. Aanpassingen in voedselkeuze kunnen betrekking hebben op de hoofdmaaltijden (ontbijt, lunch, diner) en op de dranken en producten die tussen de maaltijden door worden genuttigd (tussendoortjes of snacks). Tot dusverre is weinig literatuur verschenen over de bijdrage van tussendoortjes aan de dagelijkse vitaminen- en mineraleninneming, terwijl in landen als bijvoorbeeld Nederland, Duitsland, het Verenigd Koninkrijk en Denemarken de consumptie van tussendoortjes ongeveer een kwart van de dagelijkse energie-inneming uitmaakt (Schlettwein-Gsell & Barclay, 1996; Summerbell et al., 1995; Winkler et al., 1995).

In verschillende artikelen wordt de invloed van de totale dagelijkse voedselinneming op de voedingstoestand van ouderen besproken. Om deze invloed te onderzoeken worden ouderen ingedeeld in clusters op basis van gelijkenis in voedselkeuze. Tucker et al. (1992) onderscheidden vier verschillende voedingspatronen die gerelateerd zijn aan de inneming van een aantal specifieke vitamines. Ouderen met een voeding die rijk is aan melk, granen en fruit hebben de hoogste micronutriënteninneming en hoge vitaminegehaltes (B2, B6, B12, foliumzuur) in het plasma. Schroll et al. (1996) hebben een indeling in vier (mannen) en vijf (vrouwen) clusters gemaakt, gebaseerd op gegevens van Europese ouderen uit 12 landen. Een groot deel van de onderzoekspopulatie is ingedeeld in de groep *Kleine en matige eters*: deze groep wordt gekenmerkt door een lage energie- en micronutriënteninneming.

In dit artikel wordt de consumptie van tussendoortjes van Culemborgse ouderen in de leeftijd van 74-79 jaar in beeld gebracht. De bijdrage van tussendoortjes aan de dagelijkse vitaminen- en mineraleninneming wordt onderzocht in de totale onderzoeksgroep en bij verschillende snacktypes die samengesteld zijn op basis van clusteranalyse.

METHODE

Respondenten

Gegevens van de Nederlandse onderzoeksgroep van de SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) follow-up studie van 1993 zijn gebruikt voor het onderzoek. Bij aanvang van de SENECA studie is een steekproef genomen uit het inwonerbestand van Culemborg, een stad met een sociaal-economische- en populatiestructuur die representatief is voor Nederland. In principe kwamen alle ouderen van de geboortecohorten 1913-1918 in aanmerking voor deelname aan de SENECA-studie, behalve psychogeriatrische patiënten in verzorgingshuizen, mensen die de Nederlandse taal niet vloeiend spraken en mensen die niet in staat waren om de vragen zelfstandig te beantwoorden.

Meetmethode

De voedselconsumptie werd gemeten met behulp van een driedaagse opschrijfmethode. In speciale voedingsdagboekjes noteerden de deelnemers op twee doordeweekse dagen en één weekenddag de productnaam en de portiegrootte van alle voedingsmiddelen die werden gegeten (Cameron & van Staveren, 1988). Een dag werd verdeeld in de volgende acht eetperiodes: 1) vóór het ontbijt, 2) ontbijt, 3) in de loop van de ochtend, 4) lunch, 5) in de loop van de middag, 6) diner, 7) in de loop van de avond en 8) gedurende de nacht. De groep tussendoortjes bestond uit alle voedingsmiddelen die tijdens de eetperiodes 1, 3, 5, 7 en 8 werden geconsumeerd. De tussendoortjes werden gegroepeerd in snackgroepen op basis van overeenkomsten in nutriëntensamenstelling (indeling volgens de NEVO-tabel). De volgende snackgroepen zijn samengesteld: koffie/thee & (bron)water, melk & melkproducten, groente & fruit, koek & gebak, alcoholische dranken, frisdranken/limonades, vruchtensappen, zoet broodbeleg/sauzen & suiker, brood & graanproducten, soepen, noten/zoutjes, chocolade snacks/snoep, vlees & vleesproducten, kaas en hartig broodbeleg/sauzen & vetten. Met behulp van het voedingsberekeningsprogramma 'ORION' werd van de gegevens in de voedingsdagboekjes de nutriënteninneming van de respondenten berekend (Scholte, 1992). Verder werd de procentuele bijdrage van tussendoortjes aan de dagelijkse energie-inneming berekend en werd het aantal eetperiodes per dag bepaald.

Statistische analyses

De statistische analyses zijn uitgevoerd met het SAS-pakket. Om verschillen in snackconsumptie tussen mannen en vrouwen te toetsen is de toets van Mann-Whitney ($P \leq 0,05$) gebruikt. Met behulp van clusteranalysetechniek is de totale groep snackgebruikers ingedeeld in een beperkt aantal groepen op grond van overeenkomsten in snackkeuze. De clusterindeling is uitgevoerd met alle snackgroepen (gram/dag), behalve de groepen koffie/thee & (bron)water en soepen. De snackgroep koffie/thee & (bron)water is niet meegenomen in de analyse omdat deze de clusterindeling domineerde, terwijl de bijdrage van deze groep aan de dagelijkse energie- en micronutriënteninneming zeer gering is. Slechts zes personen consumeerden grote hoeveelheden van de snackgroep soepen. Buiten de analyses laten van deze snackgroep leidde tot een clusterindeling met een gelijkmatiger verdeling van de personen over de clusters. Om clusters samen te stellen met een minimum aan interne variantie is WARD's minimum variance method gebruikt. In de gehele onderzoeksgroep en in de vier afzonderlijke clusters zijn de verschillen in vitamine- en mineralengehaltes van tussendoortjes en hoofdmaaltijden getoetst met behulp van de rangtekentoets (P≤ 0,05). Verschillen in energie- en micronutriënteninneming tussen de clusters zijn getoetst met behulp van variantie-analyse (ANOVA) gevolgd door Tukey's multiple comparison test (P ≤ 0,05).

RESULTATEN

Tabel 1 geeft een beschrijving van de onderzoeksgroep, bestaand uit 53 mannen en 65 vrouwen. De Body Mass Index (BMI) van mannen was 26,1 en van vrouwen 28,1. Mannen hadden een significant hogere energie-inneming dan vrouwen, maar de procentuele bijdrage van tussendoortjes aan de dagelijkse energie-inneming verschilde nauwelijks. Het aantal eetperiodes per dag was voor mannen en vrouwen vergelijkbaar.

Table 1. Mean (s.d.) characteristics of the Dutch participants, born between 1913 – 1918, of the SENECA study, by sex

	Men n=53	Women n=65	P-value
Age (y)	77 (2)	77 (2)	
Body Mass Index (kg/m^2)	26.1 (3.0)	28.1 (3.4)	*
Energy intake (MJ/d)	8.5 (2.1)	6.5 (1.6)	*
% Energy from snacks	29 (12)	28 (10)	
No. of feeding periods	6.4 (0.8)	6.7 (0.8)	

Mann-Whitney test: men vs women, * P ≤ 0.05

In **Tabel 2** wordt een overzicht gegeven van de tussendoortjes, samengevoegd in 15 snackgroepen, die door mannen en vrouwen werden geconsumeerd. In de periodes tussen de hoofdmaaltijden was de consumptie van de groep koffie/thee & (bron)water verreweg het grootst. Andere groepen dranken die veel geconsumeerd werden, waren: melk & melkproducten, alcoholische dranken, frisdranken/limonades en vruchtensappen. Door enkele vrouwen (n=6) werd soep als tussendoortje gegeten. Vrouwen consumeerden meer van de groep vruchtensappen, terwijl mannen meer van de groep alcoholische dranken gebruikten. Van de 'niet-vloeibare' tussendoortjes werden producten uit de groepen groente & fruit, koek & gebak, zoet broodbeleg/sauzen & suiker en brood & graanproducten veel genuttigd.

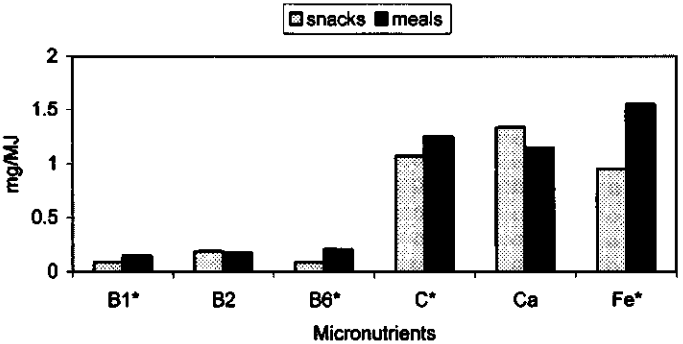
Table 2. Mean (s.d.) daily intake of snacks groups (g) of elderly men and women from Culemborg (NL), aged 74-79y

	Men n=53	Women n=65	P-value
Fluid snack groups (g/d):			
Coffee/tea & (mineral)water	733 (372)	658 (263)	
Milk & milk products	134 (163)	126 (120)	
Alcoholic drinks	67 (97)	17 (62)	*
Soft drinks/lemonades	37 (84)	29 (56)	
Fruit juices	20 (51)	39 (61)	*
Soup	0 (0)	9 (3)	*
Non-fluid snack groups (g/d):			
Fruits & vegetables	75 (109)	69 (83)	
Cakes & pastry	50 (39)	40 (27)	
Sweet spreads/sauces & sugar	16 (15)	8 (12)	*
Bread & grain products	10 (23)	5 (9)	
Savoury snacks	6 (12)	3 (8)	
Chocolate snacks/sweet confectionery	4 (7)	4 (7)	
Meat & meat products	6 (25)	3 (12)	
Cheese	3 (6)	2 (4)	
Savoury spreads/sauces & oils/fats	2 (4)	1 (3)	

Mann-Whitney test: men vs women, * P ≤ 0.05

In **Figuur 1** is het micronutriëntengehalte van tussendoortjes en hoofdmaaltijden tegen elkaar uitgezet. In de totale onderzoeksgroep was het vitamine B1-, B6-, C- en ijzergehalte (mg/MJ) van tussendoortjes significant lager dan dat van maaltijden. Er bestond geen significant verschil in het vitamine B2- en calciumgehalte tussen tussendoortjes en maaltijden.

Figure 1. Micronutrient content (mg/MJ) of snacks and meals of elderly participants from Culemborg (NL), aged 74-79 y



Signed rank test, snacks vs meals, * P ≤ 0.05. Vitamin C (cg/MJ), Calcium (dg/MJ)

Table 3. Mean (s.d.) daily intake of snacks (g) of elderly participants from Culemborg (NL), aged 74-79y, by cluster[1]

	Total	Light	Dairy products	Fruits & vegetables	Drinkers
	n=118	n=65	n=18	n=21	n=11
Fluid snack group (g/d):					
Coffee/tea & (mineral) water	692 (317)	721 (297)	568 (312)	704 (359)	720 (376)
Milk & milk products	130 (140)	58 (61)	391 (116)	162 (81)	99 (65)
Alcoholic drinks	39 (83)	28 (55)	38 (66)	22 (31)	34 (70)
Soft drinks/lemonades	33 (70)	8 (24)	6 (19)	56 (71)	182 (106)
Fruit juices	31 (58)	39 (69)	23 (51)	18 (27)	23 (37)
Soup	5 (25)	2 (11)	0 (0)	14 (52)	12 (28)
Non-fluid snack group (g/d)					
Fruits & vegetables	71 (95)	40 (49)	62 (75)	205 (129)	20 (21)
Cakes & pastry	44 (33)	49 (38)	36 (18)	43 (33)	33 (21)
Sweet spreads/sauces & sugar	11 (14)	12 (14)	8 (10)	11 (15)	10 (18)
Bread & grain products	7 (17)	2 (5)	12 (29)	15 (26)	9 (10)
Savoury snacks	4 (10)	3 (7)	7 (16)	4 (10)	6 (10)
Chocolate snacks/sweet confectionery	4 (7)	5 (8)	3 (6)	4 (5)	3 (6)
Meat & meat products	4 (19)	4 (22)	3 (6)	6 (20)	5 (16)
Cheese	2 (5)	1 (4)	4 (9)	4 (5)	3 (5)
Savoury spreads/sauces & oils/fats	2 (4)	1 (1)	3 (7)	2 (3)	3 (7)

[1] Results of the Alcohol drinkers (n=3) are not presented.

Tabel 3 geeft de dagelijkse inneming van tussendoortjes weer per cluster. Mannen en vrouwen waren gelijkelijk verdeeld over de clusters. De grootste groep *Matige snackers* (n=65) consumeerde een lage tot vrij hoge hoeveelheid van de diverse snackgroepen, terwijl van geen enkele snackgroep een uitzonderlijk hoge hoeveelheid werd genuttigd. De consumptie van de groepen melk & melkproducten, brood & graanproducten en kaas was laag, terwijl de consumptie van zoete producten uit de groepen vruchtensappen, koek & gebak, zoet broodbeleg/sauzen & suiker en chocolade snacks/snoep relatief hoog was. *Zuivelsnackers* kenmerkten zich door een hoge consumptie van producten uit de groep melk & melkproducten, kaas en noten/zoutjes. *Fruitsnackers* kenmerkten zich door een hoge consumptie van de groepen groente & fruit, brood & graanproducten met daaraan verbonden de twee groepen broodbeleg: vlees & vleesproducten en kaas. *Vochtsnackers* onderscheidden zich van de andere clusters door een relatief hoge consumptie van de diverse groepen dranken in verhouding tot de 'niet-vloeibare' snackgroepen. De consumptie van dranken ging gepaard met een relatief hoge consumptie van hartige producten. Naast deze vier clusters werd nog één klein cluster (n=3, niet weergegeven) gevormd dat werd gekenmerkt door een zeer hoge alcoholconsumptie.

Tabel 4 beschrijft de energie- en micronutriënteninneming van de vier grote clusters en het percentage dat afkomstig is van tussendoortjes. Er was geen significant verschil in energie-inneming tussen de vier clusters. De procentuele bijdrage van tussendoortjes aan de dagelijkse energie-inneming was voor de *Matige snackers* significant lager dan voor de *Zuivelsnackers* en *Fruitsnackers* (25% vs. 33% en 36%). *Zuivelsnackers* hadden een significant hogere calcium- en riboflavine (B2)-inneming dan de *Matige snackers*, *Fruitsnackers* en *Vochtsnackers*. Voor de andere micronutriënten gold dat er geen significant verschil in inneming was tussen de clusters.

Table 4. Daily intake of energy (MJ) and micronutrients (mg) and percentage of energy and micronutrients from snacks of elderly participants from Culemborg (NL), aged 74-79y, by cluster

	Light n=65	Dairy products n=18	Fruits & vegetables n=19	Drinkers n=11
Energy intake (MJ/d)	7.3^{a} $(25\%)^{a}$	7.7^{a} $(33\%)^{bc}$	7.5^{a} $(36\%)^{bc}$	7.6^{a} $(28\%)^{ac}$
Calcium (mg)	770^{a} (24%)	1161^{b} (51%)	885^{a} (37%)	777^{a} (29%)
Iron (mg)	9.4^{a} (18%)	10.3^{a} (19%)	10.0^{a} (24%)	10.4^{a} (19%)
Thiamin (mg)	0.90^{a} (15%)	1.01^{a} (27%)	0.96^{a} (30%)	1.02^{a} (17%)
Riboflavin (mg)	1.17^{a} (22%)	1.71^{b} (48%)	1.33^{a} (38%)	1.30^{a} (25%)
Pyridoxine (mg)	1.18^{a} (11%)	1.42^{a} (21%)	1.25^{a} (23%)	1.36^{a} (12%)
Ascorbic acid (mg)	78^{a} (20%)	88^{a} (30%)	99^{a} (41%)	77^{a} (15%)

a,b,c ANOVA followed by the multiple comparison test was used to test differences in energy and micronutrient intake between dietary clusters. Means within rows with different letter superscripts (c>b>a) are significantly different, $P \leq 0.05$.

In **Tabel 5** is het micronutriëntengehalte (mg/MJ) van hoofdmaaltijden en tussendoortjes weergegeven per cluster. In alle vier clusters was het thiamine (B1)-, pyridoxine (B6)- en ijzergehalte van tussendoortjes significant lager dan dat van de maaltijden. Daarentegen was bij *Zuivelsnackers* het riboflavine (B2)- en calciumgehalte van tussendoortjes significant hoger dan dat van maaltijden, terwijl in de overige drie clusters deze gehaltes nauwelijks verschilden. Het verschil in vitamine C-gehalte tussen maaltijden en tussendoortjes was bij met name de *Matige snackers* en de *Fruitsnackers* klein.

Table 5. Micronutrient content of meals and snacks (mg/MJ) of elderly participants from Culemborg (NL), aged 74-79y, by cluster

	Light n=65		Dairy products n=18		Fruits & vegetables n=19		Drinkers n=11	
	meals	snacks	meals	snacks	meals	snacks	meals	snacks
Calcium	111.0	105.8	117.3	249.6*	126.3	135.9	107.5	103.0
Iron	1.48	1.00*	1.64	0.77*	1.68	0.96*	1.58	0.94*
Thiamin	0.15	0.07*	0.15	0.11*	0.14	0.12*	0.15	0.08*
Riboflavin	0.17	0.15*	0.18	0.36*	0.18	0.21	0.18	0.15
Pyridoxine	0.20	0.07*	0.22	0.12*	0.21	0.12*	0.22	0.07*
Ascorbic acid	11.9	10.6	14.6	8.6	13.4	16.4	11.6	5.1*

Signed rank test, meals vs snacks,* $P \leq 0.05$

DISCUSSIE

Het grootste deel van de dagelijkse snackconsumptie bestond uit de consumptie van producten uit de groepen koffie/thee & (bron)water, melk & melkproducten, alcoholische dranken, groente & fruit en koek & gebak (**Tabel 2**). Het vitamine- en mineralengehalte (mg/MJ) van tussendoortjes was over het algemeen gelijk aan of lager dan het gehalte van de hoofdmaaltijden (**Figuur 1**). Alleen bij *Zuivelsnackers* was het riboflavine (B2)- en calciumgehalte van tussendoortjes significant hoger dan dat van de hoofdmaaltijden (**Tabel 5**). Ook de totale dagelijkse riboflavine- en calciuminneming was in dit cluster het hoogst (**Tabel 4**).

De respondenten van de SENECA follow-up studie waren allen afkomstig uit de onderzoeksgroep die in 1988 (baseline) voor het eerst deelnam aan het SENECA onderzoek. Vergelijking van de baselinegegevens van de respondenten met de non-responders laat zien dat er geen verschil in persoonskenmerken als leeftijd, burgerlijke staat en woonsituatie is. Wel lijkt de groep respondenten iets gezonder te zijn en een hogere opleiding te hebben genoten dan de non-responders. Vooral de jongere respondenten van deze onderzoeksgroep namen deel aan de follow-up studie, zodat de onderzoekspopulatie een betrekkelijk selectieve groep is (van 't Hof et al., 1991; van 't Hof & Burema, 1996).

De driedaagse opschrijfmethode is gebruikt om verschillen in micronutriënteninneming met de maaltijden en tussendoortjes te meten, omdat deze methode onderscheid maakt naar eetperiode. De voedselinneming die met de driedaagse opschrijfmethode is gemeten, is sterk gecorreleerd met de voedselinneming gemeten met de dietary history-methode (gouden standaard), al geeft de eerstgenoemde methode een consequent lagere schatting van de energie- en micronutriënteninneming dan de laatste. De sterke correlatie tussen de micronutiënten impliceert een nauwkeurige schatting van vitaminen en mineralen met de driedaagse opschrijfmethode, zodat vergelijking van micronutriëntengehaltes tussen snack- en maaltijdmomenten uitgevoerd kan worden (van Staveren et al., 1996).

In de huidige studie is de clusteranalysetechniek gebruikt om de totale onderzoeksgroep in te delen in clusters op basis van overeenkomsten in snackkeuze. Om de geldigheid van de geïdentificeerde clusters vast te stellen, dienen de uitkomsten van deze exploratieve methode getoetst te worden aan de literatuur. Tot dusverre zijn alleen voedingspatronen beschreven op basis van voedingsmiddelengroepen die zijn samengesteld met data van de totale dagelijkse voedselinneming (Akin et al., 1986; Schroll et al., 1996; Tucker et al., 1992). Vergelijking van de clusters die samengesteld zijn op basis van de totale dagelijkse voedselinneming (tussendoortjes en hoofdmaaltijden) met clusters samengesteld op basis van alleen de snackconsumptie laat zien dat er overeenkomsten zijn tussen de clusters. Zo komt het grote cluster *Kleine eters* dat Akin et al. (1986) en Schroll et al. (1996) hebben onderscheiden overeen met het cluster *Matige snackers* van het huidige onderzoek. Verder komt het cluster dat een voedingspatroon representeert dat wordt gekenmerkt door zuivelproducten (Akin et al., 1986; Schroll et al., 1996) overeen met het cluster *Zuivelsnackers* van het huidige onderzoek. Tucker et al. (1992) onderscheidden een cluster dat bestaat uit personen die een hoge melk-, granen- en fruitconsumptie hebben (vgl. *Fruitsnackers*). Akin et al. (1986) en Tucker et al. (1992) hebben verder nog een cluster gevonden dat bestaat uit personen die veel alcoholische dranken consumeren (vgl. *Alcohol drinkers*). Naast overeenkomsten in clusters die samengesteld zijn op basis van de totale dagelijkse voeding en clusters die samengesteld zijn op basis van de voedselinneming gedurende de snackperiodes, zijn er ook verschillen. In de huidige studie is een snackpatroon beschreven dat voornamelijk uit vloeibare snacks bestaat (*Vochtsnackers*), terwijl in de literatuur bijvoorbeeld een voedingspatroon is beschreven waar juist de aan de maaltijd gerelateerde voedingsmiddelengroepen aardappelen en vlees & gevogelte kenmerkend voor zijn (Tucker et al., 1992).

In de onderzoeksgroep als geheel was het micronutriëntengehalte (mg/MJ) van tussendoortjes over het algemeen gelijk aan of lager dan dat van de hoofdmaaltijden. Door deze groep in te delen in clusters op grond van overeenkomsten in snackkeuze kan meer inzicht in de vitaminen- en mineraleninneming van personen met een vergelijkbaar snackpatroon worden verkregen. Evenals voor de totale onderzoeksgroep was bij de vier clusters het vitamine B1-, B6-, en ijzergehalte van tussendoortjes significant lager dan de gehaltes van maaltijden. Daarentegen was er in de totale onderzoeksgroep geen significant verschil in vitamine B2- en calciumgehalte tussen tussendoortjes en maaltijden, terwijl dit verschil wel bij de *Zuivelsnackers* bestond. Dit cluster had in overeenstemming met het onderzoek van Akin et al. (1986) een hoge vitamine B2- en calciuminneming met de totale dagelijkse voeding. Het vitamine C-gehalte van tussendoortjes was voor de totale onderzoeksgroep significant lager dan dat van maaltijden, terwijl dit verschil bij een indeling in clusters alleen bij de *Vochtsnackers* is gevonden. Ondanks het lage vitamine- en mineralengehalte van tussendoortjes blijken de middelmatige snackers met een laag energiepercentage afkomstig van snacks niet de hoogste vitaminen- en mineraleninneming te hebben. Hoewel niet significant, hebben de *Matige snackers* juist de laagste totale dagelijkse vitamine- en mineraleninneming (gecorrigeerd voor verschil in energie-inneming). De bijdrage van snacks aan de dagelijkse vitaminen- en mineraleninneming lijkt niet zozeer bepaald te worden door de hoeveelheid geconsumeerde snacks, maar eerder door het type snacker.

Tussendoortjes kunnen direct door hun hoge vitamine- en mineralengehalte en/of indirect door verhoging van de totale dagelijkse energie-inneming de dagelijkse vitaminen- en mineraleninneming positief beïnvloeden. In diverse studies is onderzoek gedaan naar de invloed van het toedienen van energierijke supplementen op de totale dagelijkse energie-inneming. In het onderzoek van Fiatarone et al. (1994) levert het toedienen van energierijke voedingssupplementen geen verhoging van de totale dagelijkse energie-inneming op. Rolls et al. (1995) vinden wel een additioneel effect van de consumptie van een energierijk voedingssupplement. Zij suggereren dat andere persoonsfactoren een rol moeten spelen om het verschil in uitkomsten tussen deze studies te verklaren. Een mogelijkheid is dat verschillende type snackers verschillend reageren op de consumptie van snacks of energierijke supplementen. Juist voor ouderen is het van belang om meer van de relatie tussen snackconsumptie en energie-inneming te weten, omdat zij als gevolg van een verminderde energiebehoefte een verlaagde inneming van micronutriënten hebben. In het geval tussendoortjes een extra bijdrage aan de dagelijkse voedselinneming leveren zal consumptie hiervan bij kwetsbare ouderen over het algemeen gunstig zijn, ongeacht het snackpatroon. Wanneer personen geheel of gedeeltelijk compenseren voor het eten van tussendoortjes door minder te consumeren tijdens de hoofdmaaltijden moet goed afgewogen worden welke tussendoortjes wel of niet aanbevolen moeten worden. Nader onderzoek naar de invloed van snackconsumptie op de dagelijkse energie-inneming is nodig om de betekenis van tussendoortjes voor de dagelijkse vitaminen- en mineraleninneming te kunnen bepalen.

CHAPTER 5

DIETARY QUALITY AND LIFESTYLE FACTORS IN RELATION TO 10-YEAR MORTALITY IN ELDERLY EUROPEANS

- THE SENECA STUDY -

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ABSTRACT

The effect of the single and combined healthy lifestyle behaviours -non-smoking, being physically active, and having a high-quality diet- on survival was investigated in elderly people of the European SENECA study. This longitudinal study started with baseline measurements in 1988/89 and lasted until April 30, 1999. The study population, aged 70-75 y, consisted of 631 men and 650 women from the following countries: Belgium; Denmark; Italy; The Netherlands; Portugal; Spain; and Switzerland. A lifestyle score was calculated by adding the scores of the lifestyle factors physical activity, dietary quality, and smoking habits. The single lifestyle factors and the lifestyle score were related to mortality. Even at ages 70-75 y, the single unhealthy lifestyle behaviours smoking, having a low-quality diet, and being physically inactive were related to an increased mortality risk (Hazard Ratios ranged from 1.2 – 2.1). The risk of death was further increased for all combinations of two unhealthy lifestyle behaviours. Finally, men and women with three unhealthy lifestyle behaviours had a three to four-fold increase in mortality risk. Our results underpin the importance of a healthy lifestyle, including multiple lifestyle factors, and the maintenance of it with advancing age.

INTRODUCTION

Major causes of mortality at old age are diseases in which lifestyle plays an important role. The main factors of concern, i.e. nutrition, physical activity and smoking are modifiable and are important instruments in national health strategies. Changing these factors towards a healthier lifestyle pattern can postpone the age of onset of permanent morbidity and disability and may have a major effect on the quality of life (Bush et al., 1990; Verbrugge & Jette, 1994). So far, many reported studies focused on the relationship between one lifestyle factor and survival throughout life. These studies point to the importance of single healthy lifestyle factors – eating a high-quality diet, non-smoking, or being physically active – for achieving long-term health gain (Bath & Morgan, 1998; Huijbregts et al., 1997a; Paffenberger et al., 1993; Ruigomez et al., 1995). Several studies indicate that healthy lifestyle behaviours are mutually related (Farchi et al., 1994; Hu et al., 2000). However, only few studies investigated the relationship between lifestyle patterns, including multiple lifestyle factors, and survival (Breslow & Enstrom, 1980; Ferruci et al., 1999).

This article investigates the relationship between three modifiable lifestyle factors diet, smoking, and physical activity, separately and combined, and 10-year survival in people aged 70-75 y of the Europe-wide SENECA study.

METHODS

Study population and follow-up

Data of the SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) longitudinal study were collected from a random age- and sex-stratified sample of inhabitants from small European towns. All inhabitants born between 1913 and 1918 were eligible to be enrolled in the study. The only exclusion criteria were: living in a psycho-geriatric nursing home; not being fluent in the country's language; and not being at all able to answer questions independently (de Groot & van Staveren, 1988). For this study, data from 631 men and 650 women of the following towns were available: Hamme, Belgium (H/B); Roskilde, Denmark (R/DK); Padua, Italy (P/I); Culemborg, The Netherlands (C/NL); Vila Franca de Xira, Portugal (V/P); Betanzos, Spain (B/E) and Yverdon, Burgdorf, Bellinzona in Switzerland (Y/CH, Bu/CH, Be/CH). The follow-up period lasted from the baseline examination in 1988/89 until April 30, 1999. Information on vital status of the participants was obtained following a standardised procedure. First, the municipal registers were consulted for the individual death certificates. If they were not able to hand over this information, subsequently the medical doctor and the family were contacted. In our study population, vital status was known for 1251 (98 percent) subjects. About half of the male population and three-quarters of the female population survived (307 men and 472 women). Mean follow-up time was 7.5 years in men and 8.9 years in women.

Dietary assessment

Food intake data were collected by trained personnel using the modified dietary history method. This method is characterised by a three-day estimated record and a frequency checklist of foods, based on the meal pattern of the country. Portion sizes were based on standard portion sizes and/or checked by weighing (de Groot & van Staveren, 1988). Foods were coded and analysed for nutrient composition in each participating centre separately, using country-specific food composition tables (van 't Hof et al., 1991). Food intake data were arranged into food groups, according to the EUROCODE classification system (Arab et al., 1987). To express the dietary quality in one variable, we calculated the Mediterranean diet score (MDS). Trichopoulou et al. (1995a) considered a Mediterranean diet score composed of the following food items: monounsaturated:saturated fat ratio; alcohol; legumes; cereals; fruits & nuts; vegetables; meat & meat products; and dairy products. Intake values were adjusted to daily intakes of 10.5 MJ (2500 kcal) for men and 8.4 MJ (2000 kcal) for women. The sex-specific median intake values of the food items were used as cut-off point. If the subject's intake was comparable to the Mediterranean diet, the food item was coded one and if not, it was coded zero. We made minor adjustments to the original MDS. We replaced the group legumes by the group legumes/nuts/seeds and we placed the two groups vegetables and fruits & nuts together into one group vegetables & fruits. Based on literature, we defined the intake of dairy products in between the P25 - P75 values as the optimal intake instead of an intake below the median intake. In women, we increased the upper limit of the intake of alcoholic beverages from the median (0 g/day) to the P75 (8 g/day) and the upper limit of the intake of meat & meat products to 130 g/day (Hoffmeister et al., 1999; Khoeler et al., 1992; Löwik et al., 1999). This diet score ranged from 0 (low-quality diet) to 7 (high-quality diet). The adjusted Mediterranean is described in detail by van Staveren et al., 2001.

Health status and lifestyle factors

Information on lifestyle factors and health status was collected with a general interview, by blood examination, and by anthropometric measurements (de Groot & van Staveren, 1988). In the general interview, questions were asked about subjective health status (classified as poor, fair, and good), chronic diseases, smoking habits, and physical activity. The number of chronic diseases was determined by calculating the prevalence of the following chronic diseases: ischemic heart disease; stroke; respiratory problems; malignancy; arthritis; and diabetes. In a review paper of LaCroix & Omenn (1992) it is concluded that the overall risk of death of former smokers approaches that of those who never smoked after 15 to 20 years of abstinence. Also other studies show that mortality among former smokers approaches the level of never smokers after a smoking cessation time of 10 to 20 years (Kawachi et al, 1993; Paganini-Hill & Hsu, 1994; Van Domburg et al, 2000; Wannamethee et al, 2001). Therefore the group of past smokers was split into a group with a smoking cessation time less than 15 years, and a group with a cessation time of more than 15 years. The following two smoking groups were composed: 1) current smokers and past smokers for ≤ 15 years; 2) never smokers and past smokers for more than 15 years. Physical activity was measured with the Voorrips physical activity score including a household, sports, and leisure time component. To classify physical activity, sex-specific tertiles (low, intermediate, and high physical activity) were composed (Voorrips et al., 1990). Standing height was measured to the nearest 0.1 cm with the person standing erect and wearing no shoes. Weight was recorded to the nearest 0.5 kg. Subjects clothed in light undergarments were measured in the morning after breakfast and after voiding. Blood samples were collected after an overnight fast and serum albumin was analysed following standardised procedures at the Nestlé Research Centre in Lausanne, Switzerland (de Groot et al., 1991). For an extensive description of the measurement procedures, see the manual of operations (de Groot & van Staveren, 1988). A lifestyle score, ranging from 0 (poor) to 3 (good), was calculated by adding the scores of three lifestyle factors:

- Physical activity: lowest activity tertile (score 0); intermediate and highest activity tertile (score 1);
- Diet: low dietary quality group with diet score ≤ 4 (score 0); high dietary quality group with diet score > 4 (score 1);
- Smoking: current smokers and past smokers for ≤ 15 years, indicated as smokers (score 0); never smokers and past smokers for more than 15 years, indicated as non-smokers (score 1).

Statistical analyses

For statistical analyses, data of all participants with complete sets of information on dietary intake, lifestyle habits, health status, and mortality follow-up were used. Statistical analyses were carried out by using the SAS system (version 6.12, 1989-1996, SAS Institute Inc., Cary, NC). Kaplan-Meier survival curves, unadjusted for confounders, were plotted for the different categories of the lifestyle score. Cox Proportional Hazards survival analysis was used to investigate associations between single and combined lifestyle factors and all-cause mortality (Kleinbaum, 1996). First, the Proportional Hazard assumption was tested for all lifestyle factors and confounding factors. All variables met the PH-assumption and could be considered to have a constant Hazard Ratio over time. Region (Northern and Southern Europe) and health status (by means of number of chronic diseases, self-perceived health or albumin) turned out to be related to lifestyle factors as well as mortality and were therefore included in the model as confounding factors. Two other potential confounding factors, i.e. Body Mass Index (BMI) and socioeconomic status (type of education) were examined, but did hardly affect the results. Interactions between lifestyle factors were tested but none were found significant. Main lifestyle effects were estimated by using a Cox regression model including groups of physical activity, smoking, and dietary quality. Combined lifestyle effects were predicted assuming an additive model for the log hazard ratio, i.e. multiplicative effects on the Hazard Ratio itself. Allowance was made for region, health status and age at baseline.

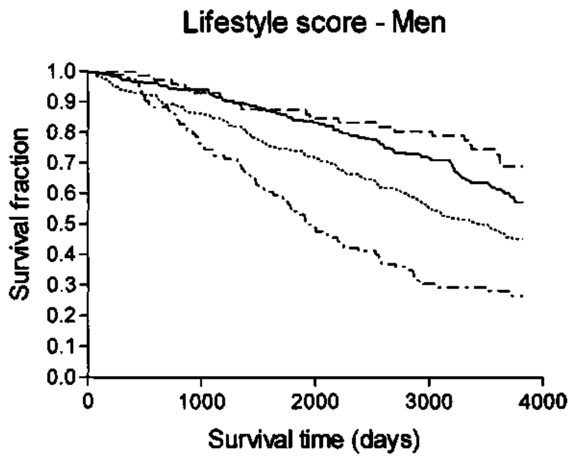
RESULTS

Table 1 presents the baseline health and lifestyle characteristics of the SENECA participants. Overall, men had a better subjective health status and BMI than women. In the male population, the percentage of subjects with a BMI exceeding 30 kg/m^2 was higher in the Southern centres than in the Northern centres. In the female population, no geographical pattern appeared. Although the percentage of men that ever smoked was very high (81 percent), the percentage of current smokers was only 32 percent. With the exception of Danish women (48 percent never smoked) the percentage of women that never smoked was very high (ranges: 75 percent Be/CH – 99 percent in V/P, B/E).

Table 1. Baseline health and lifestyle characteristics of European men and women, born between 1913 and 1918

	Men n=631	Women n=650
Age (y), mean (s.d.)	73.1 (1.8)	73.0 (1.7)
Chronic diseases[1] (%)		
no disease	53	46
one disease	34	39
two or more diseases	13	14
Prevalence of low serum albumin[2] (%)	2	2
Self-perceived health (%)		
poor	7	12
fair	26	30
good	68	57
BMI (%)		
< 20	3	4
20 – 25	33	29
25 – 30	49	41
≥ 30	14	26
Smoking (%)		
Never/past smokers for > 15 years	51	90
Voorrips-score, mean (s.d.)		
Household score	0.9 (0.7)	1.7 (0.5)
sport score	0.5 (1.4)	0.3 (1.0)
leisure time score	17.8 (12.9)	10.8 (9.4)
Mediterranean diet score, mean (s.d.)	3.5 (1.5)	3.9 (1.4)

[1] Including ischemic heart disease, stroke, respiratory problems, malignancy, arthritis, and diabetes. [2] Cut-off value for albumin: men and women: < 35 g/L.



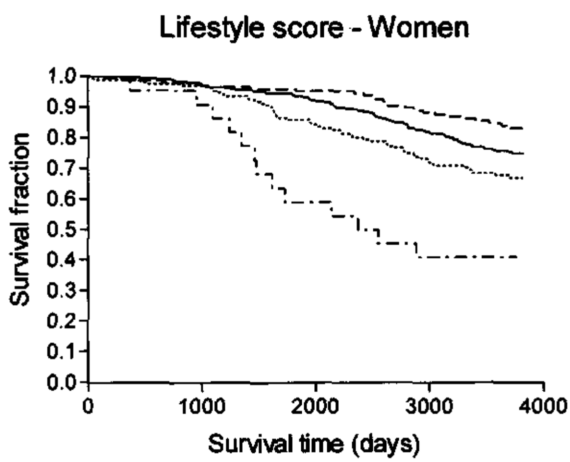


Figure 1. Kaplan-Meier survival curves of European men and women, born between 1913 and 1918, for all *levels of the lifestyle score, including the lifestyle factors diet, activity, and smoking*

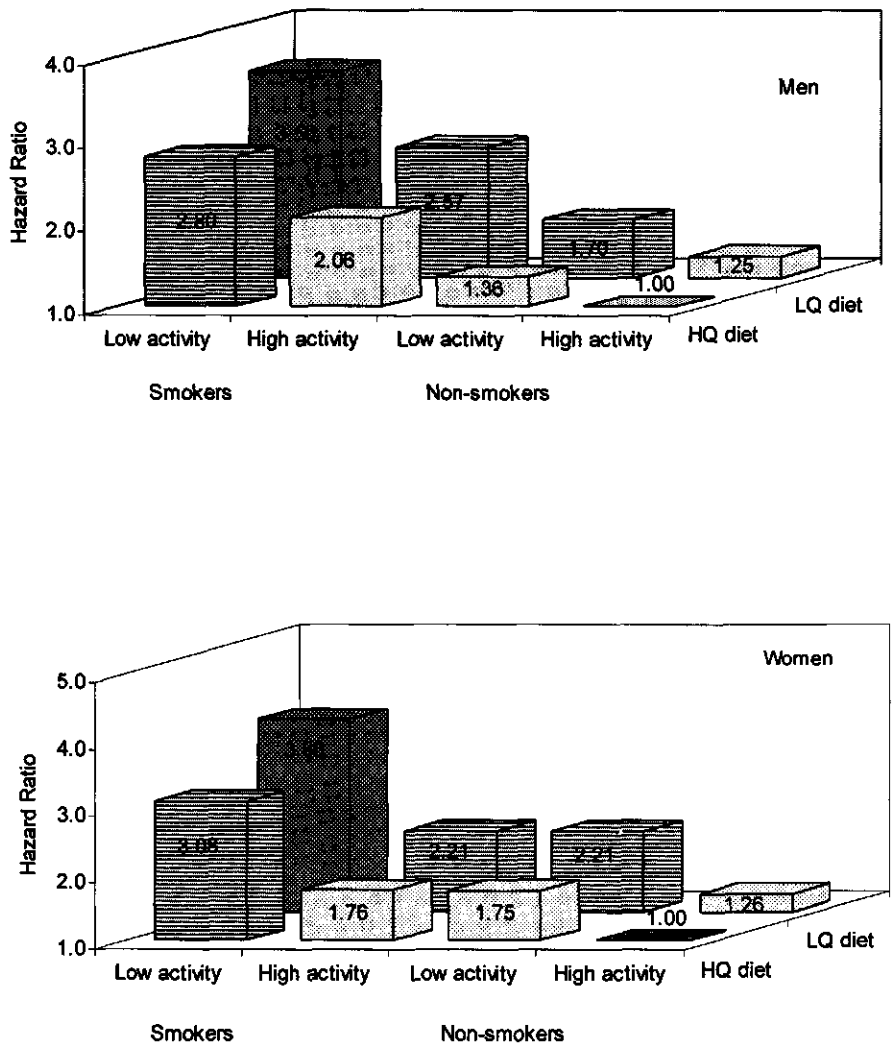


Figure 2. Hazard Ratios[1] of main and combined effects of the lifestyle factors diet, smoking and physical activity in European men and women, born between 1913 and 1918

[1] Adjustments were made for age at baseline, region, and number of chronic diseases. HQ diet = high-quality diet; LQ diet = low-quality diet.

▩ 3 unhealthy lifestyle behaviours; ▤ 2 unhealthy lifestyle behaviours; ⬚ 1 unhealthy lifestyle behaviour

In all centres, men had a higher leisure time score and a lower household score than women. For both men and women, the mean Mediterranean diet score was highest for participants of the Southern centres.

In **Figure 1** Kaplan-Meier curves are presented for the four categories (score 0-3) of the lifestyle score. For both men and women, an increasing number of unhealthy lifestyle behaviours appeared to be related to a higher mortality rate (log rank test $p \leq 0.001$). More women than men (23 vs 12 percent) had a healthy lifestyle, including non-smoking, a moderate/high activity level, and a high-quality diet. Because of the low number of smokers in the female group, only 22 women (3 percent) had three unhealthy lifestyle behaviours. About 75 percent of men and women had one or two unhealthy lifestyle behaviours.

Figure 2 shows the Hazard Ratios of single and combined lifestyle factors, adjusted for age at baseline, number of chronic diseases, and region. In both men and women, unhealthy lifestyle behaviours were related to an increased risk of death. For men, the mortality risk for a low-quality diet was 1.2 (95 percent confidence interval (CI): 0.9, 1.7), for inactivity 1.4 (95 percent CI: 1.1, 1.7), and for smoking 2.1 (95 percent CI: 1.6, 2.6). For women the mortality risk for smoking (1.8 (95 percent CI: 1.1, 2.7)) and inactivity (1.8 (95 percent CI: 1.3, 2.4)) was much higher than the risk associated with a low-quality diet (1.3 (95 percent CI: 0.9, 1.8)). The risk of death was increased for all combinations of two unhealthy lifestyle behaviours. Finally, men and women with three unhealthy lifestyle behaviours had a three to four-fold increase in mortality risk.

DISCUSSION

Even at ages 70 to 75, a high-quality diet, non-smoking and physical activity were positively related to survival in a European population. The combination of healthy lifestyle behaviours was even more strongly related to survival.

One of the strengths of this Europe-wide study is the inclusion of a large diversity in food and lifestyle factors measured with validated measures (de Groot et al., 1991; Voorrips et al., 1990). Further, in the SENECA-study many potential confounders were measured and their relationship to lifestyle factors and mortality was determined. Adjustments were made for variables that came out as confounding factors. Health status at baseline can affect lifestyle factors and is an important determinant of mortality. Therefore health status at baseline was taken into account in the Cox Proportional Hazard regression model for investigating the relationship between lifestyle factors and mortality. Adjustments for chronic diseases, self-perceived health or albumin (Corti et al., 1994), a more objective indicator of health status, did not change the relationship between the three lifestyle factors and survival, and neither did the exclusion of persons who died within one, two or three years after the first baseline measurement.

A multiplicative model was used to assess the effect of combinations of lifestyle factors on mortality (**Figure 2**). Consequently, the seven Hazard Ratios in each of the frames in **Figure 2** are not seven independent estimates for relative risk, since relative risks of combined lifestyle factors were derived from the relative risks of single lifestyle factors. Nevertheless, they fit remarkably well to the empirical results of **Figure 1**, despite the fact that the latter were not adjusted for covariates as age, region, and number of chronic diseases at baseline.

In line with our results, it has been found in previous studies that single healthy lifestyle behaviours are related to survival. A sedentary lifestyle was significantly associated with an increased mortality risk in comparison with being moderately physically active (Davis et al., 1994; Ruigomez et al., 1995). Davis et al. (1994) reported that non-recreational physical activity was even a better predictor of survival time in elderly subjects (65-74 y), than in middle-aged subjects (45-54 y). Overall, unhealthy dietary patterns, assessed by various methods, were associated with an increased risk of mortality (Farchi et al., 1994; Huijbregts et al., 1997a; Trichopoulou et al., 1995a). For smoking, most studies made a categorisation into three smoking groups: never smokers; past smokers; and current smokers. From these studies it is evident that smokers had a higher mortality risk than never smokers, although the mortality risk was higher in middle-aged than older subjects. For those who quit smoking, the mortality risk varied from an intermediate risk to a non-elevated risk in comparison to never smokers (Davis et al., 1994; Ruigomez et al., 1995; Sunyer et al., 1998).

Lifestyle habits are assumed to be characteristic of the person's way of living, though these habits may change over time. Changes in lifestyle habits can influence the relationship with mortality; at worst, it is possible that the greatest part of mortality risks is not determined by baseline lifestyle habits but by former lifestyle habits. The stability of lifestyle behaviours over a 4-year period is studied by Mulder et al. (1998) in specific age groups ranging from 30-70 y, using very sensitive scales of lifestyle measures. Smoking behaviour remained mostly the same in all age groups, but physical activity behaviour was more subject to change. In the SENECA study, where a categorisation of lifestyle measures in only two groups (healthy and unhealthy) was made, we studied changes in lifestyle factors over a 5-year period. In our research population, only a few persons changed their smoking habits (men: 15%; women: 3%), and 28-36% of the subjects changed their dietary and activity patterns. In several other studies, changes of the same magnitude were found for smoking habits and activity patterns in middle-aged and elderly men (Paffenberger et al., 1993; Wannamethee et al., 1998). Although most persons seem to have rather stable lifestyle habits, changes in lifestyle habits appear, and may influence the relationship with mortality. For the three lifestyle factors of our study it is now discussed what the impact of former, totally different, lifestyle habits is on the assessment of mortality risk. In the present study, former smoking habits, before the age of 70, were related to mortality. Past smokers who stopped smoking for more than 15 years had a survival curve comparable to that of never smokers. This information on former smoking habits was already incorporated in the smoking variable used in the present study. On the contrary, a different former activity and dietary pattern can not be related to mortality in the SENECA study, because no information on activity and dietary patterns before the age of 70 is available in the data set. However, in the longitudinal Seven Countries Study it was found that the variation in dietary patterns between different cultures in Europe has become smaller over a period of 20 years (Huijbregts et al., 1995a). Although this may have resulted in attenuation of the association between diet and mortality, cultural differences in dietary patterns are still existing in the SENECA baseline study (Haveman-Nies et al., 2001). For physical activity, it is observed that latest activity patterns are more strongly related to mortality than former activity patterns (Bijnen et al., 1999; Wannamethee et al., 1998). In summary, it may be said that most SENECA participants have stable lifestyle habits, and as a result the assessed mortality risks are the risks of long lasting lifestyle habits. For persons who changed their lifestyle habits, the assessed mortality risks can be underestimated by baseline measures of dietary quality, while baseline measures of activity patterns can be relevant measures in the assessment of mortality risks.

Although lifestyle habits are intercorrelated (Farchi et al., 1994; Haveman-Nies et al., 2001; Huijbregts et al., 1997a; Ruigomez et al., 1995), the joint influence of lifestyle factors on mortality is hardly investigated. To our knowledge only two studies investigated the relationship between multiple lifestyle factors and mortality (Breslow & Enstrom, 1980; Ferruci et al., 1999). Breslow & Enstrom (1980) performed a study on health practices and mortality of adults, including seven lifestyle factors: smoking; physical activity; alcohol use; hours sleep; maintaining proper weight; eating breakfast; and eating between meals. Age-adjusted mortality rates decreased with an increasing health practice score, but the weak statistical methodology and measurements of the lifestyle variables should be taken into account (Breslow & Enstrom, 1980). Recently, a 6-year follow-up study in elderly men and women, aged 65 and over, demonstrated a positive joint influence of the two healthy lifestyle behaviours non-smoking and physical activity on longevity (Ferruci et al., 1999). Our 10-year follow-up study of elderly men and women, aged 70-75 years, stresses the importance of a high-quality diet in addition to non-smoking and physical activity for survival. A healthy lifestyle pattern, including these three healthy lifestyle factors, was related to the highest survival rate.

In conclusion, the positive effect of the single healthy lifestyle factors -non-smoking, being physically active, and having a high quality diet- on survival still existed in a European elderly population, aged 70-75 years, and the combination of these lifestyle factors was even more strongly related to survival than the individual factors. Our results emphasise the importance of a healthy lifestyle, including multiple lifestyle factors, and the maintenance of it with advancing age.

CHAPTER 6

RELATIONSHIP OF DIETARY QUALITY, PHYSICAL ACTIVITY, AND SMOKING HABITS TO 10-YEAR CHANGES IN HEALTH STATUS IN ELDERLY EUROPEANS OF THE SENECA STUDY

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Submitted for publication

ABSTRACT

Objective of this study is to investigate the effect of the healthy lifestyle behaviours -being physically active, non-smoking, and having a high-quality diet- on self-rated health and functional status over a 10-year follow-up period in elderly persons of the SENECA study. Health status and lifestyle measurement were examined in 1988/89, 1993, and 1999 in 216 men and 264 women, born between 1913 and 1918, from the following European countries: Belgium; Denmark; Italy; The Netherlands; Portugal; Spain; and Switzerland. Self-rated health and functional status declined in men and women with healthy and unhealthy lifestyle habits over a 10-year follow-up period. In the group with a good baseline health status, inactive and smoking men had a two to three times increased risk for a decrease in self-rated health or to become dependent as compared to active or non-smoking men. In women, inactivity increased the risk of dependence. No effect of a Mediterranean-like diet on the deterioration in health status was observed. In conclusion, the healthy lifestyle behaviours being physically active and non-smoking delay the deterioration in health status in elderly participants of the SENECA study.

INTRODUCTION

A major challenge today is how we can improve overall health and quality of life at older ages. In Western societies, the average life expectancy has increased greatly in the past century, resulting in a much greater proportion of people surviving to older ages (Kinsella, 1992). Increasing age is associated with co-morbidity, cognitive impairments, with disability and loss of independence (Jolles et al., 1995; Khaw, 1997; Matsubayashi et al., 1996; Statistics Netherlands, 2001). If the average age of onset of ill health would remain unchanged, increased life span would mean for an individual more years of ill health before death. This is not the intended result of health promotion programs. Ideally, people should survive to an advanced age with their vigour and functional independence maintained, and morbidity and disability should be compressed into a relatively short period before death (Campion, 1998; Fries, 1980). In the search for determinants of healthy ageing, we investigate if the lifestyle factors non-smoking, being physically active, and having a high-quality diet, that are related to a higher survival rate (Ferruci et al., 1999; Haveman-Nies et al., 2001) are also related to a better health status at older ages.

Health status has many dimensions: i.e. physical, emotional, and social (WHO, 1948), and can be made operational by assessing these different dimensions or by subjective self-assessments of overall health. In this study we focus on two indicators of health status: self-rated health and functional status (self-care). Functional status is an objective indicator of health status, specifying the level of dependence in performing activities of daily living. Self-rated health is a subjective health indicator, summarising individual health aspects, weighed by personal values and preferences (Jylhä, 1994; Manderbacka, 1998). In addition to these individual differences, gender, age and culture are related to the judgement of self-rated health (Benyamini et al., 2000; Hoeymans et al., 1997; Idler et al., 1997; Jylhä et al., 1998; Kempen et al., 1998; Krause & Jay, 1994; Schroll et al., 1996). Self-rated health and functional status are good predictors of mortality (Harris et al., 1989; Heistaro et al., 2001). A review by Idler and Benyamini (1997) demonstrates the very consistent relationship between self-rated health and mortality in 23 community studies. The positive relationship between good self-ratings of health status and survival remained, even after the inclusion of covariates as socio-economic status, chronic conditions, functioning, medication use, physician visits, and hospitalisation, implying that survey respondents' perceptions of health status are holistic. The authors conclude that self-rated health seems to be a more inclusive and accurate measure of health status than the covariates measured.

Lifestyle factors are related to different manifestations of unhealthiness, e.g. physical and mental diseases, dysfunction, and disability (Fries, 1992; Verbrugge & Jette, 1994). Several conditions usually go together in elderly people, therefore overall measurements as self-rated health and functional status are useful indicators to examine the effect of lifestyle factors on health status.

This study investigates the relationship between initial healthy lifestyle behaviours -being physically active, non-smoking, and having a high-quality diet- on 10-year changes in functional status and self-rated health of participants, aged 70-75 years, of the European SENECA study.

METHODS

Study population

The SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) study is a longitudinal study, including three times of measurement in 1988/89, 1993, and 1999. At baseline, subjects were selected from a random age- and sex-stratified sample of inhabitants from the following small European towns: Hamme, Belgium (H/B); Roskilde, Denmark (R/DK); Padua, Italy (P/I); Culemborg, The Netherlands (C/NL); Vila Franca de Xira, Portugal (V/P); Betanzos, Spain (B/E); and Yverdon, Switzerland (Y/CH) (van 't Hof et al., 1991). All inhabitants born between 1913 and 1918 were eligible to be enrolled in the study. The only exclusion criteria were: living in a psycho-geriatric nursing home; not being fluent in the country's language; and not being at all able to answer questions independently (de Groot & van Staveren, 1988). At baseline, 759 men and 779 women started the SENECA study. About half the male population and a quarter of the female population died during the 10-year follow-up period. From the remaining population, 69% participated in the study in1993 and 58% participated in the study in1999 (**Figure 1**).

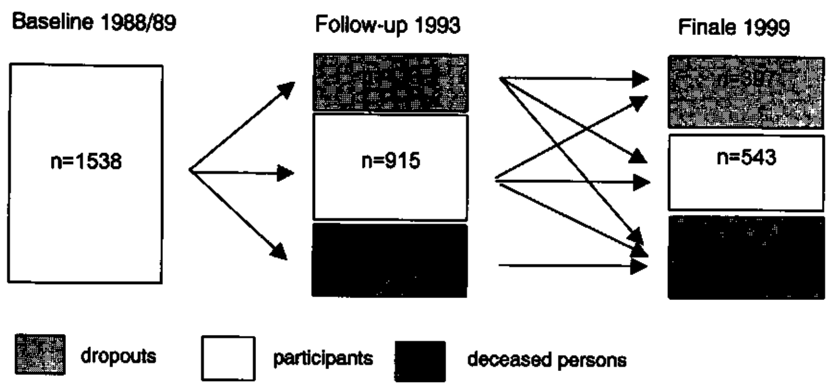


Figure 1. Flow of subjects in the longitudinal SENECA elderly study.

Health status and lifestyle factors

Information on *health status* was collected with a general interview (de Groot & van Staveren, 1988). Questions were asked about chronic diseases, self-rated health, and functional status. The number of chronic diseases was determined by calculating the prevalence of the following chronic diseases: ischemic heart disease; stroke; respiratory problems; malignancy; arthritis; and diabetes. Self-rated health was measured by the question "How would you judge your present health in general?" The answer categories were "very poor", "poor", "fair", "good", and "very good". In all three surveys, this question is preceded by questions on chronic diseases, medication and physical functioning. The answer categories were classified into a group with a (very) good health status and a group with a fair or (very) poor health status. Functional status was measured by the following self-care activities of daily living: walking between rooms, using the toilet, washing, (un)dressing, getting in and out of bed, and feeding. The level of competence was expressed as "no difficulty to perform an activity", "with difficulty but without help", "only with help", "not able to perform this activity" (Osler et al., 1991). Functional independence was defined as no difficulty or difficulty in performing only one self-care activity.

Anthropometric measurements were collected using standardised methodologies. Standing height was measured to the nearest 0.1 cm with the person standing erect and wearing no shoes. Weight was recorded to the nearest 0.5 kg. Subjects clothed in light undergarments were measured in the morning after breakfast and after voiding. The *lifestyle factors* smoking and physical activity were measured with a general interview and food intake data were collected by using the modified dietary history method (de Groot & van Staveren, 1988; van 't Hof et al., 1991). Two smoking groups were composed: 1) current smokers and past smokers for ≤ 15 years, indicated as smokers; 2) never smokers and past smokers for more than 15 years, indicated as non-smokers (LaCroix & Omenn, 1992). Physical activity was measured with the Voorrips-score including a household, sports, and leisure time component. To classify physical activity, sex-specific tertiles (low, intermediate and high physical activity) were composed based on data of the total baseline population (Voorrips et al., 1990). Two activity groups were composed: 1) an inactive group with subjects from the lowest activity tertile; 2) an active group with subjects from the intermediate and highest activity tertile. Dietary quality groups were based on the Mediterranean Diet Score (Trichopoulou et al., 1995a; van Staveren et al., 2001). The score included the following food items: monounsaturated:saturated fat ratio; alcohol; legumes/nuts/seeds; cereals; vegetables & fruits; meat & meat products; and dairy products. Intake values were adjusted to daily intakes of 10.5 MJ (2500 kcal) for men and 8.4 MJ (2000 kcal) for women. For most food items, the sex-specific median intake values of the total baseline population were used as cut-off point. If the subject's intake was comparable to the Mediterranean diet, the food item was coded one and if not, it was coded zero. Based on literature, we defined the intake of dairy products in between the P25 - P75 values as the optimal intake instead of an intake below the median intake. In women, the upper limit of the intake of alcoholic beverages was set upon the P75 (8 g/day) and the upper limit of the intake of meat & meat products on 130 g/day (Hoffmeister et al., 1999; Khoeler et al., 1992; Löwik et al., 1999). The modified Mediterranean diet score ranged from 0 (low-quality diet) to 7 (high-quality diet). Two dietary groups were composed: 1) a low dietary quality group with diet scores ≤ 4; 2) a high dietary quality group with diet scores > 4.

Statistical analyses
Statistical analyses were carried out using the SAS system (version 6.12, 1989-1996, SAS Institute Inc., Cary, NC). Baseline lifestyle factors and health status were described for the subjects who participated in all three SENECA surveys in 1988, 1993, and 1999 (full participants), the dropouts in survey 1993 and/or 1999, and the persons who died during the 10-year follow-up period. Health status measures and lifestyle factors of the male and female full participants were compared to the deceased persons and dropouts by using χ^2-test for categorical variables and Wilcoxon rank sum test for continuous variables ($P \leq 0.05$). Longitudinal changes in self-rated health and self-care ability over the period 1988-1999 were tested for the full participants with the Wilcoxon signed rank test in men and women (**Table 2**) and in the groups with healthy and unhealthy lifestyle factors (**Figure 2**). To investigate the effect of lifestyle factors on the deterioration of health status, Odds Ratios and 90%-confidence intervals were calculated (PROC LOGISTIC) in a sub-sample of participants that were functionally independent at baseline, and a sub-sample that reported their baseline health status as "good". Odds Ratios on deterioration in health status were calculated for groups of physical activity, smoking, and dietary quality, in men and women separately. In this logistic model, allowance was made for country and age at baseline. Because of the deviant low number of persons in Vila Franca de Xira that reported their own health as "good", the Portuguese subjects were excluded from the calculation of Odds Ratios on deterioration in self-rated health.

RESULTS

Table 1 describes the baseline characteristics of the full participants, the dropouts, and the deceased persons. At baseline, full participants had a better health status and more favourable health behaviours than deceased persons. Minor differences between dropouts and full participants were found. In general, men had a better health status than women in all three participant categories.

Table 1. Baseline health and lifestyle characteristics of the full participants[1], dropouts[2] and deceased persons[3], *born between 1913-1918, of the longitudinal SENECA study*

	Men			Women		
	full participants	dropouts	deceased	full participants	dropouts	deceased
	n=216	n=166	n=377	n=265	n=293	n=221
Age (y), mean (s.d.)	72.6 (1.6)	72.8 (1.7)	73.2 (1.8)*	72.7 (1.7)	72.7 (1.7)	73.3 (1.7)*
No chronic disease[4] (%)	37	36	23*	28	22	16*
Self-perceived health (% good)	76	74	58*	63	64	42*
Self-care ADL (% independent)	97	92*	84*	93	91	78*
BMI (kg/m^2) (%)						
< 20	3	2	3	5	2*	5
20 – 25	33	31	36	35	27	26
25 – 30	51	49	47	39	42	41
≥ 30	13	18	14	20	30	28
Never smokers/past smokers for more than 15 years (%)	63	55	39*	93	88	84*
Intermediate/highest activity tertile (%)	75	68	56*	71	68	49*
High-quality diet, diet scores ≥ 4 (%)	36	20*	21*	40	33	29*

[1] Subjects participating in all three SENECA surveys in 1988, 1993, and 1999. [2] Dropouts in survey 1993 and/or 1999. [3] Persons who died during the 10-year follow-up period. [4] Including ischemic heart disease; stroke; respiratory problems; malignancy; arthritis; and diabetes. BMI values were missing for 124 persons, for the other variables data of max. 5 persons were unknown. To compare health status and lifestyle factors of the full participants with that of dropouts and deceased persons, χ^2-test for categorical variables and Wilcoxon rank sum test for continuous variables was used. * $P \leq 0.05$

Table 2 presents the results of two indicators of health status during three measurements. Self-rated health and functional status decreased significantly over the 10-year follow-up period in both male and female participants. The greatest deterioration in health status was observed over the period 1993 -1999. Small differences in health status were present between the European centres, except for Vila Franca de Xira. In this centre a very low proportion of persons judged their own health as “good”.

Table 2. Percentage of full participants with a good self-rated health[1] or that were functionally independent in the SENECA surveys 1988, 1993, and 1999, by sex and country

		Men					
		self-rated health (% good)			self-care ADL (% independent)		
	N	1988	1993	1999	1988	1993	1999
Hamme, Belgium	26	80	84	64	100	96	77
Roskilde, Denmark	20	85	75	80	95	100	85
Padua, Italy	38	74	71	63	100	95	89
Culemborg, The Netherlands	29	93	75	75	100	100	83
Vila Franca de Xira, Portugal	41	37	32	29	95	76	66
Betanzos, Spain	20	88	88	65	85	85	80
Yverdon, Switzerland	42	93	90	71	100	100	90
Total	216	76	71	62*	97	93	81*
		Women					
		self-rated health (% good)			self-care ADL (% independent)		
	N	1988	1993	1999	1988	1993	1999
Hamme, Belgium	18	71	88	65	94	83	56
Roskilde, Denmark	20	75	85	80	100	100	100
Padua, Italy	50	56	46	68	100	94	92
Culemborg, The Netherlands	49	74	68	57	96	98	82
Vila Franca de Xira, Portugal	39	13	24	11	67	79	62
Betanzos, Spain	31	77	80	43	97	84	77
Yverdon, Switzerland	57	88	77	79	100	98	84
Total	264	65	63	58*	94	92	80*

[1] Data of 10 persons were missing. The Wilcoxon signed rank test was used to test for changes in health status over the 10-year follow-up period. * $P \leq 0.05$

Figure 2A and B show that the lifestyle factors diet, smoking, and physical activity are related to self-rated health and functional status. In general, health status declined (significantly) over the period 1988 - 1999 in men and women with healthy as well as an unhealthy lifestyle behaviours, except for female smokers (n=19). However, active men and women kept their positive health ratings and level of independence on a higher level than inactive men. In addition, non-smoking men remained in a better health status than male smokers. An effect of a high-quality diet on self-ratings of health and functional status was not observed for men and women.

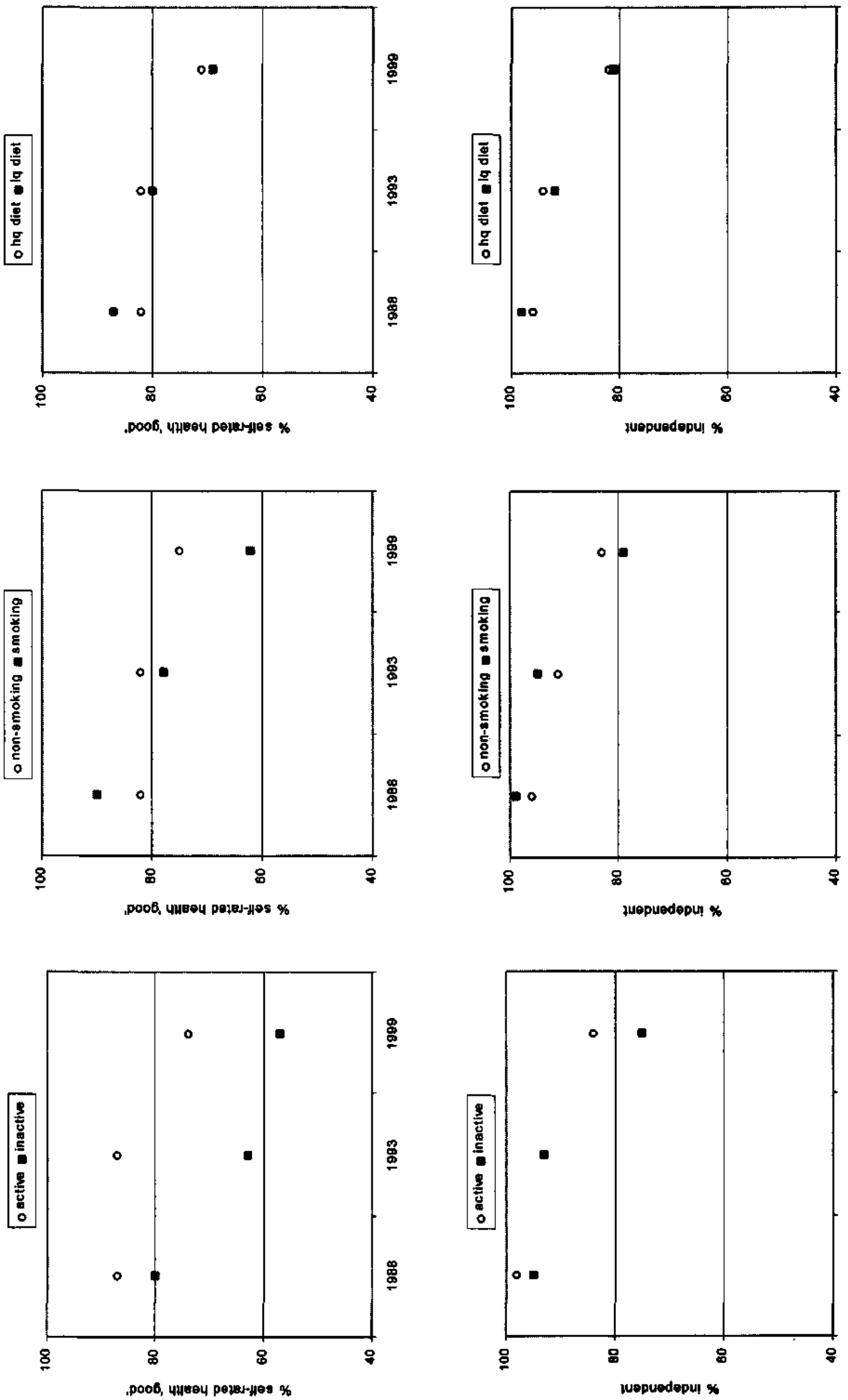


Figure 2A. Health status measures in 1988/89, 1993, and 1999 for healthy and unhealthy lifestyle behaviours in male participants, born between 1913 and 1918, of the European SENECA study

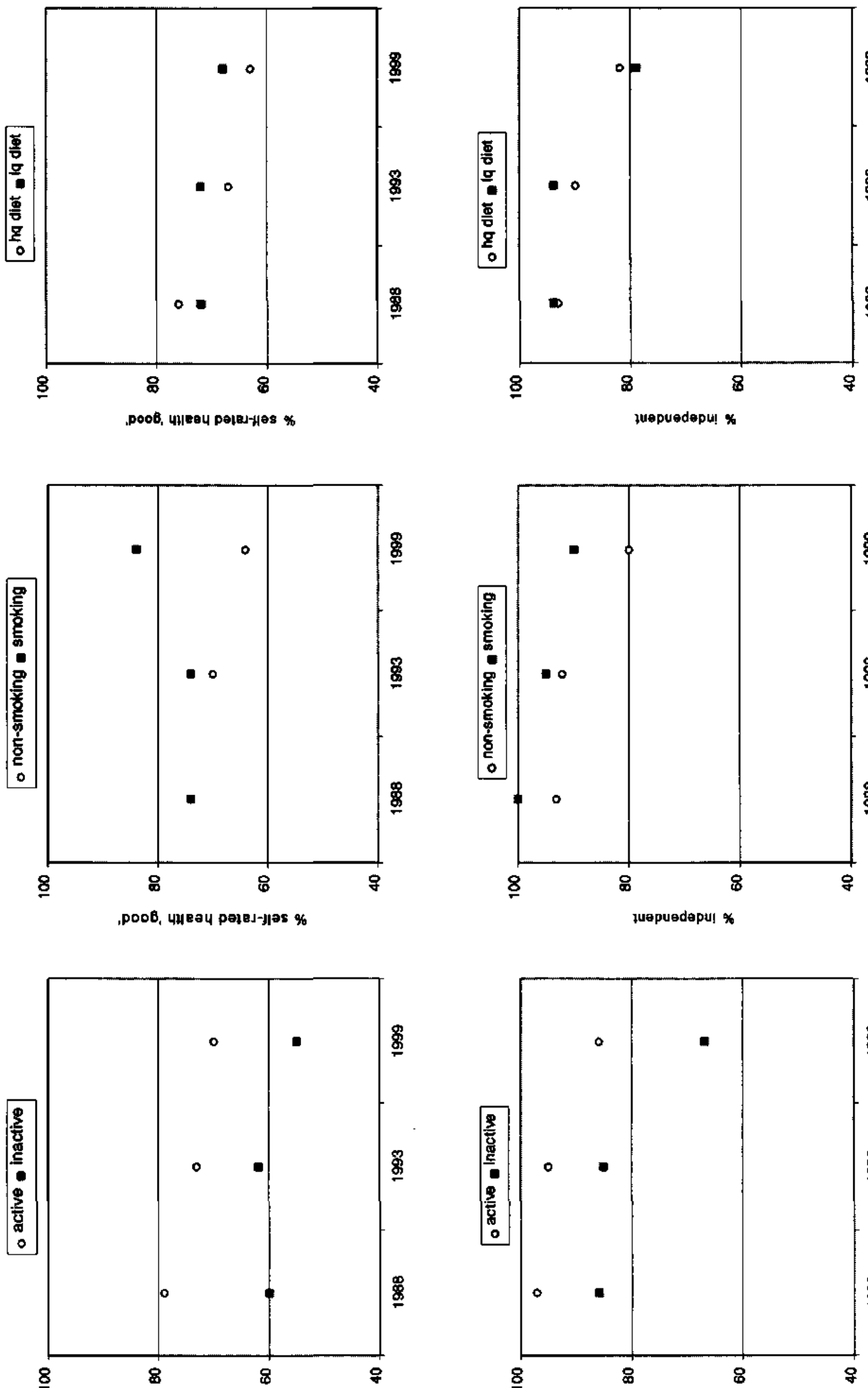


Figure 2B. Health status measures in 1988/89, 1993, and 1999 for healthy and unhealthy lifestyle behaviours in female participants, born between 1913 and 1918, of the European SENECA study

A majority of the men and women had the same health ratings (70%) and functional status (83%) at the beginning and end of the 10-year follow-up period. Only a quarter of this stable group had already negative self-ratings of health at baseline, and very few persons (3%) were already functionally dependent. Subjects with a good baseline health status were selected to investigate the effect of lifestyle on the deterioration of health status. Lifestyle habits of persons with a decrease in health status over the period 1988 -1999 were compared to the habits of persons who maintained a good health status (**Table 3**). Inactive and smoking men had a two to three times increased risk for a decrease in self-rated health or to become dependent as compared to persons with an active or non-smoking lifestyle. For women, no effect of inactivity on a decline in self-rated health was observed, but inactivity increased the risk of dependence. No relationship between diet and risk of deterioration in health status was observed for men and women.

Table 3. Risk of deterioration of health status over the period 1988 - 1999 (Odds Ratios and 90%-confidence intervals[1]) resulting from an unhealthy lifestyle, in European men and women, born between 1913 and 1918

	Men	Women
Self-rated health[2]	fall in self-rated health vs stable self-rated health n=39 vs n=104	fall in self-rated health vs stable self-rated health n=38 vs n=120
	OR (90% CI)	OR (90% CI)
Physical activity[3]	2.8 (1.3 – 6.2)	0.8 (0.3 – 1.7)
Dietary quality[4]	1.1 (0.5 – 2.3)	1.4 (0.7 – 2.8)
Smoking habits[5,6]	2.0 (1.0 – 4.1)	
Self-care ability	become dependent vs remain independent n=35 vs n=175	become dependent vs remain independent n=41 vs n=206
	OR (90% CI)	OR (90% CI)
Physical activity	1.9 (0.9 – 3.9)	2.6 (1.4 – 4.9)
Dietary quality	1.0 (0.5 – 2.2)	0.9 (0.5 – 1.8)
Smoking habits	2.2 (1.1 – 4.5)	

[1] Adjustments were made for age and country. [2] Analyses are performed without the data of Vila Franca de Xira/P. [3] Physical activity: lowest activity tertile vs intermediate and highest activity tertile. [4] Diet: low-quality diet with diet score ≤ 4 vs high-quality diet with diet score > 4. [5] Smoking: current smokers and past smokers for ≤ 15 years vs never smokers and past smokers for more than 15 years. [6] The relationship of smoking to functional status and self-rated health could not be investigated for women, due to the very low number of female smokers.

DISCUSSION

Overall, self-rated health as well as functional status declined in men and women with healthy and unhealthy lifestyle habits. Men with a healthy lifestyle, including non-smoking and being physically active, kept their overall health status on a higher level and had a delay in the onset of functional dependence, as compared to men with unhealthy behaviours. In women, only an active lifestyle was positively related to functional independence in this elderly population.

In this study an overall health indicator and a health indicator that focuses on functional independence were used as they were considered to be the results of all kinds of underlying diseases and conditions. Both self-rated health and self-care ability are good predictors of mortality (Harris et al., 1989; Idler & Benyamini, 1997) and are related to morbidity (Kempen et al., 1998; von Strauss et al., 2000). In the SENECA study, a majority of the population had one or more chronic diseases, but only a small percentage was functionally dependent or reported a "fair" or "poor" overall health. In line with this finding, literature shows that the impact of diseases on perceived disease burden is not straightforward. The type of disease or impairment (Portrait, 2000; Sprangers et al., 2000; von Strauss et al., 2000) and also other factors, such as positive mood and social support, affect people's perception of health (Benyamini et al., 2000). Because of the multidimensionality of health status, we used two indicators of health status to measure different manifestations of health in order to complement each other.

In contrast to the other European centres, most subjects from Vila Franca de Xira reported a "poor" overall health. In this town, the number of chronic diseases (self-reported) and depression was high as compared to other European centres (Schroll et al., 1991; Haller et al., 1996), but the mortality rate over the 10-year follow-up period was not correspondingly high (Amorim Cruz et al., 2001). Besides, lifestyle habits of Portuguese subjects were comparable to the habits of other Southern Europeans. It seems that Portuguese subjects were in the worst health condition, but this condition did not involve an increased mortality risk. A higher prevalence of non-fatal diseases, but also a tendency to over-report health problems could be possible explanations for these negative self-assessments of health. Self-rated health was not related to both morbidity and mortality, and in this way the Portuguese had deviant self-ratings as compared to the participants in other European centres. Therefore we decided to exclude the participants of Vila Franca de Xira from the pooled analyses of lifestyle factors with self-rated health.

Overall, self-rated health and self-care ability deteriorated for men and women over the period 1988-1999. The pattern of decline differed between the health indicators. The loss of independence was rather consistent throughout the individual centres, while for self-rated health this pattern was more dispersed and even an improvement of self-rated health was observed in some centres. Although both indicators are inclusive measures they focus on different aspects of health. Hoeymans et al. (1997) reported that the association between functional status and self-rated health weakens with increasing age. This could be explained by the finding that elderly respondents are more likely to base their health appraisal on attitude or behaviour rather than on conditions, symptoms or functioning compared to their younger counterparts (Borawski et al., 1996). More than self-care ability, self-rated health refers to changes in quality of life or well-being and together these health indicators reflect different aspects of changes in health status with ageing.

Selectivity of the research population can be introduced at different stages of the study. In the SENECA study, a tendency for healthier persons to participate in the baseline study was observed (van 't Hof et al., 1991). Besides this, Deeg (1989) stated that "an important limitation of longitudinal studies of elderly populations is sample attrition, or dropout, due to mortality, diseases or other reasons. Intra-group comparisons over time can only be performed in subjects participating in all subsequent cycles and crucial for inference is the completeness of follow-up." In the SENECA study, a high proportion of subjects dropped out of the study due to different reasons. In **Table 1** it is shown that the full participants had a better health status and health behaviours than the persons who died over the 10-year follow-up period. The high proportion of dropout due to mortality is inevitable in longitudinal studies of elderly populations. The full participants did not have a better health status than the dropout group. With regard to lifestyle habits, dropouts had comparable activity and smoking behaviours, but a lower dietary quality than full participants. Possibly, dropouts were less interested in diet and did not like the extensive report of their dietary intake. The dropout for other reasons than mortality does not impair the generalisation of the results to the survivor population.

During the last three decades, Southern European countries experienced higher gains in life expectancy than Northern European countries, mainly due to much lower heart disease death rates (van Hoorn & Garssen, 1999). Migration studies show that these differences are likely to be due to environmental rather than genetic factors. These results indicate that a proportion of the diseases associated with ageing can be prevented, or at least postponed (Khaw, 1997). The European SENECA study includes a great variation in cultural and environmental factors influencing dietary patterns and lifestyle habits (Haveman-Nies et al., 2001). As in other studies, these lifestyle factors appeared to be predictors of overall mortality (Davis et al., 1994; Ferrucci et al., 1999; Haveman-Nies et al., 2001; Huijbregts et al., 1997a; Trichopoulou et al., 1995a), hence the SENECA study includes valid measures of lifestyle factors to relate to health status.

The relationship between lifestyle and health status is investigated for the three modifiable factors, physical activity, smoking and dietary quality in a selective group of elderly survivors of a 10-year follow-up period. In our study, physical activity and non-smoking were related to better functioning and overall health status as compared to inactivity and smoking. In a sub-sample of subjects with a good baseline health status, these healthy lifestyle behaviours delay the deterioration in health status. In some cross-sectional and longitudinal studies, physical activity and non-smoking delay the deterioration of health status or are related to a better health status as compared to unhealthy behaviours (Kant & Schatzkin, 1999; Kawachi et al., 1999; Schuit et al., 1999; Stuck et al., 1999). The relationship between these two lifestyle factors and indicators of health status was more pronounced for men than for women. In women, only physical activity was related to a delay in onset of functional dependence. The low number of smokers but also a different process by which women incorporate information into their self-ratings of health seem to be responsible for this. The finding that self-rated health is less strongly related to mortality in women than in men affirms this and indicates that women are more likely to take subjective health aspects into account, while men are more likely to consider physical functioning (Idler & Benyamini, 1998; Kumpusalo et al., 1992).

In our study, having a high-quality, Mediterranean-like diet did not delay the deterioration of health status, as compared to having a low-quality diet. This is the first study that relates dietary pattern to the inclusive measures functional status and self-rated health (Stuck et al., 1999). Studies on chronic diseases show that dietary pattern predicts coronary heart disease and cancer (Hu et al., 2000; Huijbregts et al., 1997a; Khaw, 1997). Although in these studies associations between dietary patterns and diseases are observed, no association with health status was found in our study. As we found a relationship between physical activity, non-smoking, and health status in our study, probably the complexity of the dietary pattern, as well as the complicated relationship between diseases and perceived disease burden were leading to an attenuation of the association of dietary quality and health status.

To conclude, in this study two inclusive indicators of health status measured different appearances of health status in a selective group of healthier and more health-concerned elderly persons. As for men and women functional independence and a "good" self-rated health declined over a 10-year follow-up period, different patterns appeared for healthy and unhealthy lifestyle behaviours. The healthy lifestyle behaviours physical activity and non-smoking that were related to survival were also related to a delay in deterioration of health status. Gender differences appeared for the relationship between lifestyle factors and indicators of health status.

CHAPTER 7

GENERAL DISCUSSION

CONTENTS

The overall objective of this thesis is to identify dietary and lifestyle factors that contribute to healthy ageing. Step by step I will come to the final conclusion of this thesis. Different derivatives of dietary patterns (dietary scores and clusters) are compared and evaluated as classifiers of dietary quality. Second, the described relationship of diet, physical activity, and smoking to survival and health indicators in the SENECA population is discussed. Third, it is discussed how the lifestyle factors that appeared to be significant for survival and health maintenance, contribute to healthy ageing. The discussion is preceded by a section on the validity of the findings found in this thesis and is closed with a section on the implications of the findings for health promotion, and the general conclusion.

SENECA'S VALIDITY

The strengths and limitations of the approaches that led to the findings described in this thesis have been discussed in the accompanying chapters. In this paragraph more general issues that arise from the previous chapters are discussed.

Subjects

The longitudinal SENECA study started in 1988/89 with participants born between 1913 and 1918, and is repeated in 1993 and 1999. The study is designed to perform cross-sectional and longitudinal comparisons and therefore subjects were recruited from a random age- and sex- stratified sample of inhabitants of small European towns. Persons living in a psycho-geriatric nursing home were excluded from the study. Unintended selectivity of the baseline population entered the study because of selective non-response of less healthy and health concerned persons (de Groot & van Staveren, 1988; van 't Hof et al., 1991). As a result, the baseline study population included a small spectrum of health status, which made it more difficult to identify persons at risk of malnutrition, disability or other manifestations of unhealthiness in the baseline cross-sectional analysis (chapter 2). Bias due to losses to follow-up is a common problem in longitudinal studies. Although many complete sets of information of SENECA participants were retrieved, the dropout due to mortality or other reasons was high (chapter 6). Dropout due to mortality is inevitable in longitudinal studies of elderly populations. Data in chapter 6 show that the deceased group had a worse health status and worse health behaviours at baseline. The remaining group of dropouts had a much better health status than the deceased group, and is more comparable to the full participants. The implications for generalizability to the general population are discussed later in this chapter.

Measurement of food intake

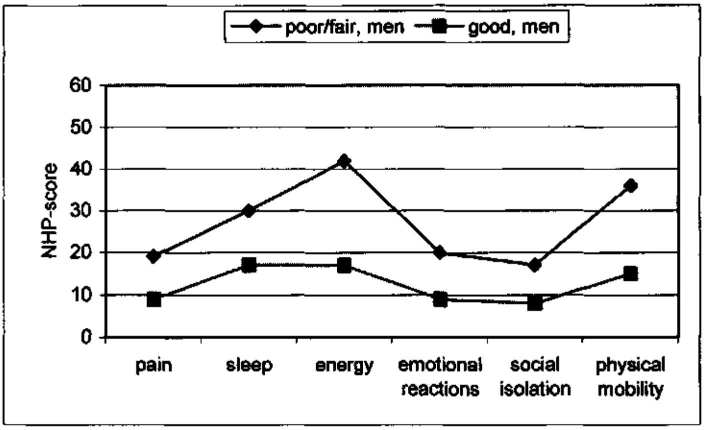
In the SENECA study, a standardised modified dietary history method was used to measure food intake (de Groot & van Staveren, 1988). This method was validated against a 3-day weighed record and energy expenditure as observed in metabolic rooms. The modified dietary history method overestimates energy intake as compared to the weighed record method (Nes et al., 1991) and underestimates energy intake as compared to 24-hour energy expenditure (Visser et al., 1995). The estimated 3-day record, used for the analyses in chapter 3 and 4, is known to underestimate energy intake as compared to the modified dietary history method (van Staveren et al., 1996). The systematic error in the measurement of energy intake of both the modified dietary history method and the estimated 3-day record may not have distorted the described association between dietary quality and health status, because intake of food groups of all SENECA participants seemed to be influenced to the same extent. In the above-mentioned validation studies, a good agreement between the estimated macro- and micronutrient intake was observed between the dietary record methods (Nes et al., 1991; van Staveren et al., 1996). Chapters 2 to 4 show the close relationship between the selected food groups and nutrient intake, and therefore the systematic error in the measurement of energy intake appears not to be related to specific food groups.

Composition of food groups

The SENECA study used a uniform coding system of daily food intake: the Eurocode. This allows for description and comparison of food intake across all SENECA towns (Arab et al., 1987). For the classification of snack foods in chapter 3 and 4, a coding system geared to snack foods was developed, based on the Dutch food composition table (NEVO, 1986). Making a new food classification system deviating from the Eurocode system is time-consuming work and is difficult to perform because of multilingualism of European food composition tables. Current developments in Europe to arrange a uniform European food composition table are very helpful in generating classification systems of specific food or snack groups.

Measurement of health indicators

Health is defined by the WHO (1948) as "a state of complete physical, mental and social well-being." Health is a multidimensional concept and can be measured at different levels (Wilson et al., 1995; Verbrugge & Jette, 1994). To meet the multidimensionality of health status, two measures of health, namely functional status and self-rated health, were included in our analyses. The simple question on self-rated health is compared to a quality of life questionnaire, the Nottingham Health Profile (NHP), for eight European countries (**Figure 1**). The NHP consists of 38 statements categorised in six domains, including pain, sleep, energy, emotional reactions, social isolation, and physical mobility. A lower NHP-score indicates a better quality of life. **Figure 1** shows that self-rated health discriminates between all dimensions of quality of life. Subjects who rated their health as "good" have better scores on the six domains of quality of life than subjects who rated their health as "fair" or "poor". The robust measurement of self-rated health encloses the multidimensional concept of health and appears to be a valid measure of overall health *in multi-centre studies.*



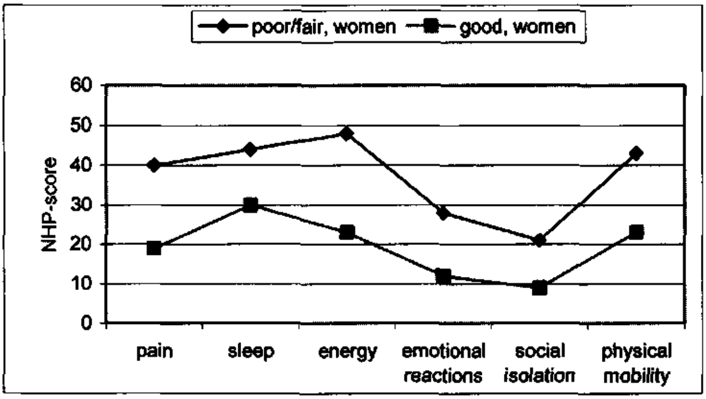


Figure 1. Self-ratings of health compared to six domains of quality of life in male and female participants, aged 80-85 year, of SENECA's finale study in 1999

Confounding

Multiple regression techniques (logistic regression and Cox's proportional hazards analysis) were used to study the association between exposure and outcome (chapter 5 and 6). The association between exposure and outcome can be distorted by confounding factors. To confound an association between exposure and outcome, a variable must be associated with both the exposure and the outcome (Hennekens & Buring, 1987). In the SENECA study, many potential confounders were measured and their relationship to the exposure (lifestyle) and outcome (health indicators) was determined. Adjustment for confounding factors is made to present estimates of associations independent of the effect of confounding factors. In chapters 5 and 6 separate analyses were performed for men and women and allowance was made for the confounders country or region, baseline age and health status in the analysis model. As the multicentre SENECA study included a wide variety of cultural and environmental factors influencing dietary patterns and lifestyle habits, adjustment for country may result in an over-correction of the true association between lifestyle factors and survival and health variables. However, with disregard of this confounder no adjustments were made for the higher valued non-diet-related differences across sites. Adjustment was made for baseline health status by using different measures of health status. Although most persons had one or more chronic diseases, the majority of the baseline population had no serious health problems. Adjustment for number of chronic diseases and adjustment for the small group with serious health problems did not change the association between lifestyle factors and mortality in chapter 5. The association between lifestyle factors and deterioration of health status was investigated in a selective sample of subjects who had a good functional status and self-rated health at baseline (chapter 6).

Cluster analysis

Cluster analysis is a technique used to divide the study population into clusters with characteristic dietary patterns with a high internal homogeneity (within-cluster) and high external heterogeneity (between-cluster). Persons in the same cluster have a food intake more comparable to each other than they have to persons in other clusters (Hair et al., 1992). **Table 1** gives an overview of studies that used cluster analysis to characterise dietary patterns. This table highlights that differences in the clustering procedure, the selection and standardisation of variables, and the selected number of clusters, influence the outcome of cluster analysis.

The selection of variables included in the cluster analysis is based on theoretical and practical considerations. In some studies a detailed classification into many food groups was made (Wirfält & Jeffrey, 1997; Greenwood et al., 2000; Millen et al., 2001), while in other studies a limited number of food/nutrient groups was used for the analysis (Hulshof et al., 1993; Huijbregts et al., 1995b; Schroll et al., 1996). **Table 1** demonstrates the impact of energy adjustment on the composition of clusters. The studies with energy adjusted food group data did not include a cluster with *Light or small eaters*, while the studies using unadjusted data did. For the analysis described in this thesis, the classification into Eurocode food groups was fixed, whereas a more detailed classification was made for snack food groups. In chapter 2, standardisation for energy intake and transformation to mean zero and unit variance of the Eurocode food groups resulted in more clear-cut clusters. The same treatment for snack foods in chapter 3 and 4 flattens out the outcome of the clustering procedure. Since snack consumption is not directly related to total daily energy intake, standardisation of snack foods for energy intake removes a great part of individual variation in snacking habits.

A frequently used clustering procedure is K-means method (**Table 1**). This method is designed for large data sets, but also commonly used in smaller data sets (Huijbregs et al., 1995b; Greenwood et al., 2000). Ward's method has a tendency to compose clusters with a minimum of internal variance and the best overall performance (SAS, 1989; Kent & Coker, 1992; Ward, 1963). For the composition of clusters in chapter 2, Ward's method and K-means method were both used. In spite of similarities in type of clusters, the Ward's method gave more clear-cut clusters, and therefore this clustering outcome is presented.

No standard, objective criteria exist for the selection of number of clusters. In chapter 3 and 4, the distances between clusters at successive steps (R-squared) are used as guideline for the selection of number of clusters. For chapter 2, the clustering procedure is performed for 2 to 10 clusters to find the most characteristic and interpretable cluster solution.

In conclusion, there is no ultimate approach to compose dietary clusters. Theoretical considerations at different stages in the process of cluster analysis have to be affirmed by a meaningful interpretation of the composed clusters. Used in this way, cluster analysis is a valuable tool to describe dietary patterns. The identified dietary patterns can be used in research on dietary quality and for example in nutrition education. In the next paragraph the validity of dietary patterns is discussed.

Table 1. Studies using cluster analysis to characterise population dietary patterns

Author	Dataset	Variables	Energy stand.	Procedure	Clusters
Akin et al., 1986	1977-78 Nationwide Food Consumption Survey, N=1756, men and women aged 65-74 y	20 food groups, based on similarity in nutrient content, standardised to mean 0 and standard deviation 1	no	FASTCLUS	1. Light eaters 2. Whole grain, fruits/vegetables 3. Alcohol 4. Salty snacks, soup 5. Animal fat products 6. Legumes 7. Sugar, sweets, sweetened milk
Boeing & Klein, 1989	Pilot study EMSIG Giessen, N=86, men and women aged 17-65 y	16 food groups, based on similarity in nutrient content	no, but stand. to weight	Relocate	1. Meat 2. Bread and beer 3. Fruit/vegetable and milk 4. Wine, sausage and cheese 5. Non-alcoholic beverages
Tucker et al., 1992	Boston-area residents, N=680, men and women aged 60 y and older	16 food groups, based on similarity in nutrient content	yes	Quick cluster, K-means method	1. Alcohol 2. Milk, cereals, and fruits 3. Bread and poultry 4. Meat and potatoes
Hulshof et al., 1993	1987-1988 Dutch National Food Consumption Survey, N=3781, men and women aged 20-85 y	6 nutrient groups (mainly macronutrients)	yes	K-means method	1. High fat/low alcohol 2. Moderate fat/low alcohol 3. High fat/high alcohol 4-8. Not labelled with names
Huijbregts et al., 1995b	Zutphen elderly study, N=518, men aged 70-89 years	9 nutrient groups (mainly macronutrients), standardised to zero mean and unit variance	yes	FASTCLUS, K-means method	1. Alcohol 2. High meat 3. Healthy diet 4. Refined sugars

Author	Dataset	Variables	Energy stand.	Procedure	Clusters
Schroll et al., 1996	SENECA study 1993, N=973, men and women aged 74-79 y	8 micronutrient groups, standardised to mean 0 and variance 1	no	FASTCLUS, K-means method	1. Lean and green eaters 2. Gourmands 3. Milk drinkers 4. Small eaters 5. Modest eating women
Wirfält & Jeffrey, 1997	3 data sets in 2 US metropolitan areas, N=526, adult men and women, age not given	38 food groups, based on similarity in nutrient content, adjustment for extreme values	yes	FASTCLUS	1. Soft drinks 2. Pastry 3. Skim milk 4. Meat 5. Meat-cheese 6. White bread
Greenwood et al., 2000	UK Women's Cohort Study, N=33968, women aged 35-69 y	74 food groups	no	K-means	1. Monotonous low-quantity omnivores 2. Health conscious 3. Traditional meat, chips and pudding eaters 4. Higher diversity, traditional omnivores 5. Conservative omnivores 6. Low diversity vegetarians 7. High diversity vegetarians
Millen et al., 2001	Exam 3 of the Framingham Offspring Cohort 1984-1988 N=1828, women aged 25-73 y	42 food groups, based on similarity in nutrient content	no	two steps: 1. VARCLUS 2. Ward	1. Heart healthy 2. Light eating 3. Wine and moderate eating 4. High fat 5. Empty calorie

DIETARY PATTERNS

The dietary pattern approach includes the total dietary intake and therefore accounts for the highly interrelated nature of dietary variables and complexity of the diet. In this respect, the dietary pattern approach has some advantages over studying individual dietary components. From the perspective of public health, this approach is useful for customised planning of dietary advises (Jacques & Tucker, 2001). Further, lack of agreement in the relationship between individual dietary components and diseases in observational and intervention studies demonstrate the limitations of studying individual dietary components (de Waart, 2000; Jacques & Tucker 2001). Although the concept of dietary patterns is attractive, in practice there are many difficulties to overcome in assessing the total diet. So far, no "golden standard" method exists to assess dietary patterns.

Cluster analysis and the calculation of diet scores are possible methods of evaluating the quality of dietary patterns. The primary value of cluster analysis lies in the "natural" groupings of the data themselves, and therefore this technique is valuable for identifying existing dietary pattern groups (Hair et al., 1992). Diet scores are mostly based on dietary guidelines and summarise the total diet into one variable (de Groot et al., 1996; Haines et al., 1999; Huijbregts et al., 1997a; Kennedy et al., 1995). The sum-scores range from a low-quality diet to a high-quality diet and this classification makes diet scores very useful for scientific research. While there are different measures of dietary patterns, only few measures have been validated. In contrast to American diet scores (Haines et al., 1999; Kennedy et al., 1995), the Healthy Diet Indicator (HDI) and Mediterranean Diet Score (MDS) have not yet been validated against the individual components or nutritional status indicators. Recently, Millen et al. (2001) validated the use of cluster analysis by linking dietary patterns with other health-related behaviours.

In this thesis, different methods of measuring dietary patterns are compared over different data sets, and related to nutritional status and health-related behaviours. The same type of snack clusters emerged in the Dutch population as well as in the European population (chapter 3 and 4) and persons of different research centres are represented in all dietary clusters (chapter 2 and 3). The clusters correspond to clusters described in the literature (**Table 1**). For example, clusters characterised by meat, alcohol (only in male study populations), and fruit & vegetables were also identified by Akin et al. (1986), Tucker et al. (1992), Huijbregts et al. (1995b), and Greenwood et al. (2000). Clusters characterised by sugar products were identified by Akin et al. (1986), Huijbregts et al. (1995b), and Millen et al. (2001). In addition, chapter 2 shows that dietary clusters and scores are associated with nutritional status and health-related lifestyle behaviours in a pooled analysis of SENECA and Framingham data. Together, these results affirm the existence of dietary patterns that differ in dietary quality. New scientific insights and developments may refine measures of dietary patterns. For instance, Oomen et al. (2000) recently found an inverse association between fatty fish consumption and coronary heart disease (CHD) mortality, indicating that fatty fish is protective against CHD mortality. Incorporating the group fatty fish into a diet score can improve the classification of the quality of dietary patterns in future analyses.

As the quality of the total diet can be expressed in dietary clusters and scores, many applications in public health programs and nutrition research are possible. For example, the characterisation of groups at nutritional risk are promising in making customised planning of nutritional advises. In nutrition research, separate analysis for different dietary clusters can be performed in order to study specific relationships between diet and health status.

DIETARY PATTERNS AND LIFESTYLE FACTORS IN RELATION TO SURVIVAL AND HEALTH

Chapter 5 and 6 of this thesis describe the effect of diet, physical activity and smoking habits on survival and health status. A high-quality diet, physical activity, and non-smoking were related to survival, and the latter two factors delay the deterioration of health status in elderly Europeans, aged 70-75 years (**Table 2**). The combined effect of the three healthy lifestyle behaviours is even more strongly related to survival than the effect of a single behaviour.

Table 2. Mortality risks and risks of deterioration of health status resulting from three unhealthy lifestyle behaviours of elderly men and women, born between 1913 and 1918, of the European SENECA study

	Men		
	vital status	fall in self-rated health vs stable self-rated health	become dependent vs remain independent
	n=631	n=39 vs n=104	n=35 vs n=175
	HR (95% CI)	OR (90% CI)	OR (90% CI)
Physical activity[1]	1.4 (1.1 – 1.7)	2.8 (1.3 – 6.2)	1.9 (0.9 – 3.9)
Dietary quality[2]	1.2 (0.9 – 1.7)	1.1 (0.5 – 2.3)	1.0 (0.5 – 2.2)
Smoking habits[3]	2.1 (1.6 – 2.6)	2.0 (1.0 – 4.1)	2.2 (1.1 – 4.5)
	Women		
	vital status	fall in self-rated health vs stable self-rated health	become dependent vs remain independent
	n=650	n=38 vs n=120	n=41 vs n=206
	HR (95% CI)	OR (90% CI)	OR (90% CI)
Physical activity	1.8 (1.3 – 2.4)	0.8 (0.3 – 1.7)	2.6 (1.4 – 4.9)
Dietary quality	1.3 (0.9 – 1.8)	1.4 (0.7 – 2.8)	0.9 (0.5 – 1.8)
Smoking habits	1.8 (1.1 – 2.7)	-	-

[1]Physical activity: lowest activity tertile vs intermediate and highest activity tertile. [2]Diet: low-quality diet with diet score ≤ 4 vs high-quality diet with diet score > 4. [3]Smoking: current smokers and past smokers for ≤ 15 years vs never smokers and past smokers for more than 15 years.

Dietary quality is only associated to mortality and not to the health indicators. This lack of univocal results is probably caused by three factors. First, vital status is a much stronger outcome measure than functioning and self-rated health, and consequently the relationship with vital status can be more easily established. In addition, the complexity of the diet, and the lower number of subjects in the study of chapter 6 might also have contributed to these findings. So far, only cross-sectional studies found associations between dietary patterns and health measures as cognitive function or functional status (Schroll, 1997; Huijbregts et al., 1998). More longitudinal research in this field may reveal whether dietary patterns delay the deterioration in health status. Physical activity is related to chance of survival and both health indicators in men, while in women no relationship of physical activity to self-rated health is found. Different processes of incorporating information into self-ratings of health between men and women is indicated to be responsible for this (Idler & Benyamini, 1997; Kumpusalo et al., 1992). In women, the relationship of smoking to functional status and self-rated health is not investigated, due to the very low number of smokers among elderly women.

The relationship between lifestyle factors and survival and health indicators has been described for different age groups (e.g. LaCroix et al., 1993; Ferruci et al., 1999; Stuck et al., 1999; Hu et al., 2000). In general, the strength of the association between risk factor and outcome measure decreases with increasing age (Kaplan et al., 1992). Recently, Kaplan et al. (1999) reported unique age-related patterns of associations for every combination of a lifestyle factor and outcome measure. For example, they demonstrated that the negative consequences of smoking are much earlier manifested in life than the consequences of an inactive lifestyle. They showed that in addition to age-related patterns of declining strength, also patterns of increasing strength or mixed patterns are possible. Because only few studies present age-specific data, no definitive statement about these patterns can be made. Lasheras et al. (2000) evaluated the association between a Mediterranean diet and survival for two age groups. They found that a Mediterranean diet is associated with a significant reduction in overall mortality in subjects aged < 80 years but not in subjects aged ≥ 80 years.

Understanding the age-related patterns of associations between lifestyle factors and outcome measures requires knowledge of biological changes with ageing and consequences of methodological issues. Biological characteristics influence the impact of lifestyle factors on disease initiation and progression (Kaplan et al., 1999). In this paragraph I will go more deeply into two methodological issues: sample selection and selective survival. At baseline, the SENECA study included subjects of the small age range 70-75 years who were generally in good health (de Groot et al., 1991). As a result, it is assumed that lifestyle factors at baseline reflect mainly the lifestyle of preceding years (chapter 5 and 6). In research populations including people with a worse health status, for example institutionalised persons or persons older than 75 years, lifestyle factors can be more easily affected by a recent health decline. This misclassification of levels of lifelong lifestyle factors can dilute the size of the association between lifestyle factor and health status in institutionalised or older age groups. Another issue is selective survival that might influence the association between risk factor and outcome. In chapter 6 it is shown that the deceased group had a worse health status and worse health behaviours as compared to the full participants. These data indicate a progressive elimination of less healthy subjects from the group with unhealthy lifestyle habits, making this group more and more alike the group with a healthy lifestyle with respect to their health status. This selective survival results in a weakening of the association between lifestyle and health indicators with increasing age.

In conclusion, finding 'true' associations between lifestyle factors and survival and lifestyle factors and health indicators, requires a large healthy population at baseline. The relationship of the lifestyle factors to survival and health indicators, as described in this thesis, is specific for the age group of 70-75 years and is expected to be stronger in the general population of this age, because of the selective baseline population in the SENECA study.

HEALTHY AGEING

Previous chapters showed that healthy lifestyle behaviours are not only related to a higher chance of survival, but also to a delay in the deterioration of health status as compared to unhealthy lifestyle behaviours. The important question arises whether these two relationships contribute to healthy ageing. Campion (1998) described the ideal situation of healthy ageing as the situation in which people survive to an advanced age with their vigour and functional independence maintained, and morbidity and disability compressed into a relatively short period before death. This situation is graphically represented in **Figure 2** by plotting health status at different ages. In this process two stages can be distinguished: 1) a relatively long period of a few decades in which health status slowly and to a limited degree deteriorates; 2) a short period of maximal a few years prior to death with an accelerated decline in health status (cf. Deeg, 1988).

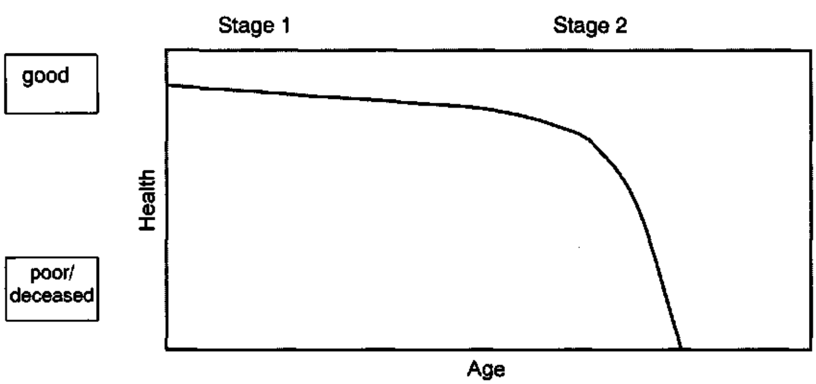


Figure 2. Ideal graph of healthy ageing

In this section, the contribution of healthy lifestyle behaviours to the process of healthy ageing is discussed. The effect of healthy lifestyle behaviours on life expectancy and health status is schematically drawn in **Figure 3.** In this figure the health status of survivors of the birth cohorts 1913-1918 with a healthy and unhealthy lifestyle are presented as the two graphs between 72.5 and 82.5 years, and hypothetical extrapolations are made from the age of 82.5 years. Graph '1' presents the survivor group with an unhealthy lifestyle and graph '2' presents the group with a healthy lifestyle. The healthy lifestyle group had a lower decline in health status during the 10-year follow-up period than the survivors with an unhealthy lifestyle.

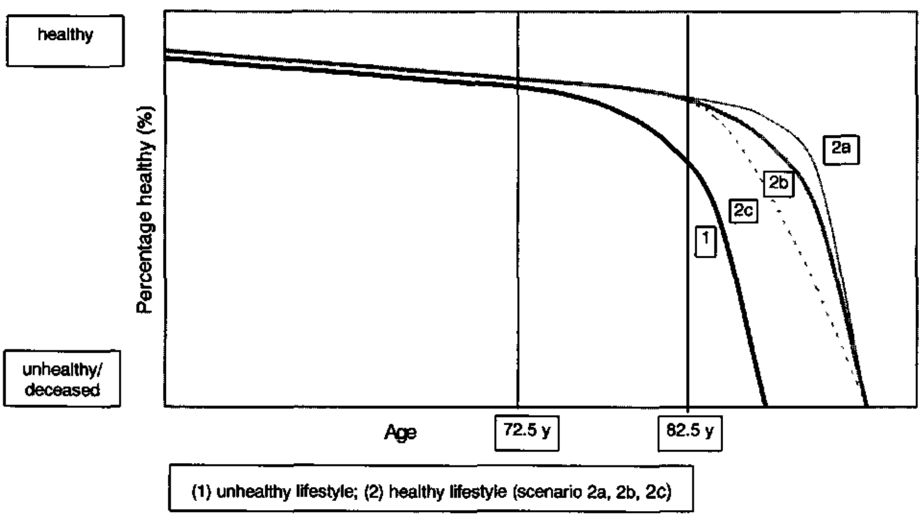


Figure 3. Lifestyle factors and healthy ageing: three scenarios

It is expected that the survivors with a healthy lifestyle live longer than survivors with an unhealthy lifestyle (Kaplan et al., 1999). Three scenarios of the development of health status in the additional years of life are described for the survivors with a healthy lifestyle (cf. Fries, 1992):

Graph '2a': the average age of onset of morbidity increases more than life expectancy, resulting in a net-effect of a lower cumulative amount of morbidity (compression of morbidity);

Graph '2b': the average age of onset of morbidity increases by the same amount as life expectancy, resulting in a net-effect of the same cumulative amount of morbidity as in graph '1', but at a later age (constant morbidity);

Graph '2c': the average age of onset of morbidity increases less than life expectancy, resulting in a net-effect of a higher cumulative amount of morbidity (expansion of morbidity).

Ideally, studies that measure health status of elderly subjects until death at short time-intervals will provide the vital information to conclude which scenario is present. These studies are difficult to perform and so far only one study investigated health status at short time-intervals (Vita et al., 1998). They performed a longitudinal study to determine whether persons, aged 63-72 years, with lower modifiable health risks have more or less cumulative disability. Seven surveys were performed between 1986 and 1994. In the survivor group as well as in the deceased group, the high-risk group had a higher cumulative disability than the low-risk group. This study suggests that lower health risks will result, on average, in less lifetime disability.

In conclusion, healthy lifestyle behaviours increase the chance of survival, and delay the onset of deterioration of health. Although the net-effect of these two relationships on the process of healthy ageing could not be determined in the SENECA study, the postponement of the onset of major morbidity is likely to go together with a compressed cumulative morbidity.

IMPLICATIONS FOR HEALTH PROMOTION

As healthy lifestyle behaviours are related to survival and health at the age of 70-75 years, and are likely to contribute to healthy ageing, improvement of unhealthy lifestyle behaviours and maintenance of healthy lifestyle behaviours are matters of concern. Improvements in lifestyle habits or in conditions to preserve healthy lifestyle habits can be made at different stages in life, and can be directed at the general population or at specific target groups. In general, a change towards a healthy lifestyle made early in life and continued to older ages is most effective for the prevention of diseases and disability (Kennedy & Offutt, 2000). The impact of changes towards a healthy lifestyle at older ages on health is discussed in this section.

Longitudinal studies on changes in physical activity pattern in elderly men show that taking up light or moderate physical activity reduces mortality (Bijnen et al., 1999; Wannamethee et al., 1998). Intervention studies in elderly persons also demonstrate beneficial health effects of exercise training (Chin a Paw, 1999; Schuit, 1997). Smoking cessation reduces mortality risk and has beneficial health effects, such as a reduced risk of repeated surgery (Kawachi et al., 1993; Paganini-Hill & Hsu, 1994; van Domburg et al., 2000). Compared to smoking and physical activity, diet is a very complex lifestyle factor, as it consists of many different food items. Dietary patterns can be changed by means of changes in food habits or by consumption of particular (enriched) food products or supplements. Changing food habits of elderly people, however, is rather drastic and difficult to realise, because nutritional behaviour in elderly people includes not only nutritional but also symbolic and traditional aspects of specific food items (Schlettwein-Gsell, 1992). So far, dietary changes by means of changes in food habits have hardly been investigated. Intervention studies in vulnerable elderly people show, however, that supplementing diet with additional enriched food products increases weight (Gray-Donald et al., 1995; Fiatarone Singh et al., 2000) and improves bone parameters and blood vitamins (de Jong, 1999). A beneficial effect on health and functional status indicators could not be established, probably due to the short intervention period (Gray-Donald et al., 1995; de Jong, 1999; Fiatarone Singh et al., 2000). Since addition of enriched food products improves health-related body parameters, it may be expected that changed food habits have an analogous effect. Therefore, a change in food habits at higher ages can probably contribute to a better health status.

Besides the effects of change of individual lifestyle factors on health, there is a possible combined effect of change of multiple lifestyle factors, as implied in a recent study by Tuomilehto et al. (2001). Middle-aged overweight subjects at risk of type 2 diabetes received individualised counselling aimed at reducing weight and total intake of (saturated) fat, and increasing fibre intake and physical activity. They concluded that changes in lifestyles of high-risk subjects can prevent type 2 diabetes.

Public health programs should focus on the adoption of healthy lifestyle behaviours in elderly people. The adoption of multiple lifestyle behaviours is favourable, but in practice realizable customised advises should be given. An unhealthy lifestyle is determined by many factors, e.g. personal characteristics, social and environmental circumstances. The identification of people with unhealthy lifestyle habits, and finding ways to improve lifestyle habits of specific target groups is the challenge of future prevention programs in young and elderly subjects.

GENERAL CONCLUSION

The overall objective of this thesis to identify dietary and lifestyle factors that contribute to healthy ageing was investigated in three steps. First, the Mediterranean Diet Score (MDS), Healthy Diet Indicator (HDI), and cluster analysis were validated as measures of quality of dietary patterns. Cluster analysis and diet scores showed strong similarities in the classification of persons into dietary quality groups. High-quality diets were associated with nutritional status and health-related indicators. It is concluded that dietary quality can be assessed using diet scores as well as cluster analysis, the approaches being complementary. Second, a high-quality diet, physical activity and non-smoking are positively related to survival. The latter two factors also delay the deterioration in health status in the survivor population. The relationship of these healthy lifestyle behaviours to survival and health indicators are specific for the age group of 70-75 years and are expected to be stronger in the general population of this age. Although the net-effect of a healthy lifestyle on healthy ageing could not be investigated in the SENECA study, it is likely that a healthy lifestyle compresses morbidity and contributes to healthy ageing.

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SUMMARY

In Europe, increased life expectancy and decreased birth rate in the last century have resulted in a growing share of elderly people in the population. A strong increase of the share of elderly people aged 65 and over is expected for the coming decades. The sharp rise in the ageing population goes together with an increasing amount of health problems. Therefore, it is of great importance to reduce health problems related to the ageing population. This thesis aimed to identify dietary and lifestyle factors that contribute to healthy ageing.

For the analyses, data of the longitudinal SENECA study were used. This study includes data on diet, lifestyle and health of elderly Europeans, born between 1913 and 1918. The study population is followed for 10 years, and measurements were performed in 1988/89 (baseline), 1993, and 1999. Besides data of Europeans, we used data of American elderly participants of the Framingham study for the analyses in chapter 2.

First a valid method to assess the quality of dietary patterns had to be found. Dietary pattern is difficult to assess, because it includes multiple dietary variables. Since no "golden standard" method exists to assess the quality of dietary patterns, two approaches, namely cluster analysis and diet scores, were validated by performing analyses in different data sets and linking dietary patterns with nutritional status and health-related indicators. Chapters 2 to 4 describe dietary and snack patterns of elderly people using cluster analysis and dietary scores. In chapter 2, the total daily food intake of European and American elderly is summarised in dietary scores (Healthy Diet Indicator and Mediterranean Diet Score), and in five dietary clusters characterised by *Sugar & sugar products*; *Fish & grain*; *Meat & fat*; *Milk & fruit*; and *Alcohol*. The *Meat & fat pattern* had the lowest average diet scores, indicating a low-quality diet. The *Fish & grain pattern* had the highest average Mediterranean diet score, indicating a high-quality diet. Both cluster analysis and diet scores showed strong similarities in the classification of persons into dietary quality groups. Furthermore, high-quality diets were associated with less body fatness, non-smoking, and a greater physical activity. Chapters 3 and 4 of this thesis focus more specifically on snack patterns. In both studies the same type of snack clusters could be identified: *Light snackers*; *Dairy snackers*; *Fruit & vegetable snackers*; *(Sweet) Drinkers*; and *Alcohol drinkers*. Like dietary patterns, snack patterns were associated with nutritional status and health indicators. The similarity in classification of clusters of dietary patterns and snack patterns, and the association with nutritional status and health(-related) indicators, show that dietary quality could be meaningfully assessed with cluster analysis as well as diet scores.

Secondly, we investigated dietary and lifestyle factors important for survival and maintenance of health at old age. This objective is limited to the three modifiable lifestyle factors diet, physical activity, and smoking. In chapter 5 the relationship between these three lifestyle factors, separately and combined, and 10-year mortality is investigated.

Single unhealthy lifestyle behaviours were related to an increased mortality risk. For men, the mortality risk for a low-quality diet was 1.2 (95 percent confidence interval (CI): 0.9, 1.7), for inactivity 1.4 (95% CI: 1.1, 1.7), and for smoking 2.1 (95% CI: 1.6, 2.6). In women, the mortality risk for smoking was 1.8 (95% CI: 1.1, 2.7), for inactivity 1.8 (95% CI: 1.3, 2.4), and for a low-quality diet 1.3 (95% CI: 0.9, 1.8). Mortality risk was increased for all combinations of two unhealthy lifestyle behaviours. Men and women with three unhealthy lifestyle behaviours had a three to four-fold increase in mortality risk. For the group of survivors that participated in the three measurement periods during the 10-year follow-up period, the same lifestyle factors were related to indicators of health status. As health status has many dimensions and can be measured in different ways, two overall measurements of health status, functional status and self-rated health, were selected for the analyses. Self-rated health and functional status both declined in men and women with healthy and unhealthy lifestyle habits over the 10-year follow-up period, but the deterioration in health was delayed by the healthy lifestyle behaviours non-smoking and physical activity. Inactive men had a 2.8 (90% CI: 1.3, 6.2) times increased risk for a decrease in self-rated health and a 1.9 (90% CI: 0.9, 3.9) times increased risk to become dependent. Smoking men had a two-fold increased risk (90% CI: 1.0, 4.1) for a decrease in self-rated health and a 2.2 (90% CI: 1.1, 4.5) times increased risk to become dependent. In women, inactivity was related to 2.6 (90%CI: 1.4, 4.9) times increased risk to become dependent. The relationship of these healthy lifestyle behaviours to survival and health indicators are specific for the age group of 70-75 y and are expected to be stronger in the general population of this age.

Finally, it is discussed whether the relationships of healthy lifestyle habits to survival and health contribute to healthy ageing. The findings of this thesis are summarised in **Figure 1**.

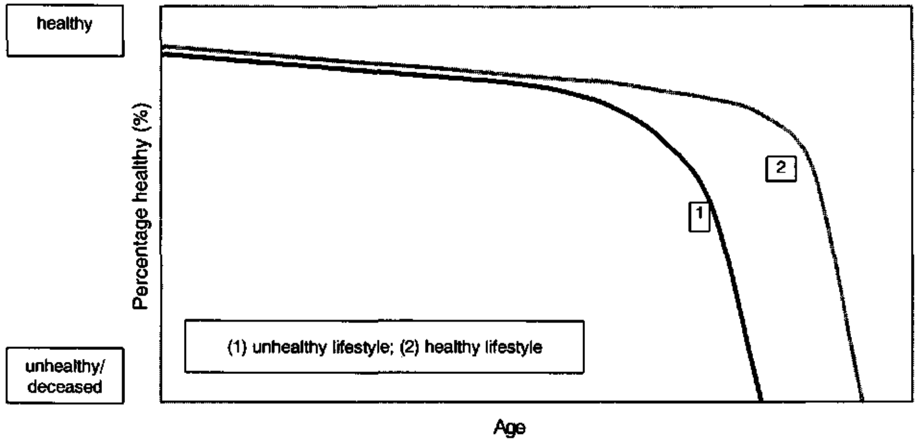


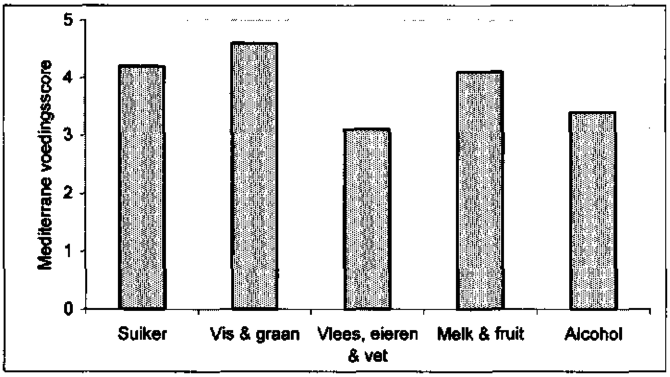
Figure 1. Lifestyle factors and healthy ageing

A healthy lifestyle was related to a higher chance of survival. Further, a healthy lifestyle delayed the deterioration in health status (graph 2). The net-effect of a healthy lifestyle on the process of healthy ageing could not be determined in the SENECA study. However, from the discussion in chapter 7 it is concluded that a healthy lifestyle is likely to go together with a compressed cumulative morbidity. In **Figure 1**, this compression of morbidity is reflected in a rectangularisation of graph 2, in comparison to graph 1. It is concluded that a lifestyle characterised by non-smoking, physical activity, and a high-quality diet contributes to healthy ageing.

SAMENVATTING

Een stijging van de gemiddelde levensverwachting in combinatie met een daling van het geboortecijfer hebben in Europa geleid tot een stijging van het aantal en het aandeel ouderen in de samenleving. Naar verwachting zal het aantal ouderen de komende 40 jaar nog verder sterk toenemen. Deze stijging gaat gepaard met meer gezondheidsproblemen en een grotere druk op de gezondheidszorg. Het is daarom van groot belang om de gezondheidsproblemen die samenhangen met een verouderende bevolking terug te dringen. In dit proefschrift wordt de betekenis van leefstijl voor het gezond ouder worden (*healthy ageing*) onderzocht.
Voor de analyses is gebruik gemaakt van gegevens van de longitudinale SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action)-studie. Deze dataset bevat gegevens over gezondheid, voeding en andere leefstijlfactoren van oudere Europeanen die geboren zijn tussen 1913 en 1918. De onderzoekspopulatie is 10 jaar lang gevolgd en in deze periode vonden meetrondes plaats in 1988/89, 1993 en 1999. Naast gegevens van de SENECA-studie zijn ter vergelijking gegevens van Amerikaanse ouderen van de Framingham-studie gebruikt voor de analyses in hoofdstuk 2.

Om de betekenis van voeding en andere leefstijlfactoren voor het gezond ouder worden te onderzoeken is als eerste een methode gezocht om de kwaliteit van het dagelijks voedingspatroon te bepalen. De kwaliteit van voedingspatronen is moeilijk vast te stellen, omdat de totale dagelijkse voedselinname uit veel verschillende componenten is opgebouwd. Deze componenten samen bepalen de kwaliteit van het voedingspatroon. Er is geen methode waarmee je de kwaliteit van het voedingspatroon precies kunt bepalen. In dit proefschrift zijn twee methodes die het totale voedingspatroon meten, namelijk clusteranalyse en voedingsscores, gebruikt om de kwaliteit van het voedingspatroon vast te stellen. Deze methodes zijn met elkaar vergeleken en gerelateerd aan indicatoren van de voedings- en gezondheidstoestand. In hoofdstuk 2 is de totale dagelijkse voedselinname van Europese en Amerikaanse ouderen samengevat met behulp van twee voedingsscores: de Healthy Diet Indicator en de Mediterranean Diet Score. Met behulp van clusteranalyse zijn vijf verschillende voedingspatronen onderscheiden. De personen in één cluster consumeren globaal eenzelfde combinatie van voedingsmiddelen. De clusters zijn benoemd naar de meest kenmerkende voedingsmiddelen: *Suiker & suikerproducten*, *Vis & graan*, *Vlees & vet*, *Melk & fruit* en *Alcohol* (**Figuur 1**).



Figuur 1. Gemiddelde Mediterrane voedingsscore weergegeven per voedingspatroon

In **Figuur 1** is de uitkomst van de clusterindeling vergeleken met de Mediterrane voedingsscore; hoe hoger de Mediterrane voedingsscore, hoe beter de kwaliteit van het betreffende voedingspatroon. Deze figuur laat zien dat het *Vlees & vet-cluster* de laagste Mediterrane voedingsscore had, terwijl het *Vis & graan-cluster* de hoogste score had. Personen met een hoogwaardig voedingspatroon hadden ook in andere opzichten een gezondere leefstijl dan personen met een kwalitatief minder voedingspatroon. Zo rookten ze minder vaak, waren vaker lichamelijk actief en hadden een lagere vetmassa. Hoofdstuk 3 en 4 van dit proefschrift zijn gericht op voedingspatronen die gebaseerd zijn op de consumptie van tussendoortjes (*snacks*). In plaats van de totale dagelijkse voeding is alleen gekeken naar voedingsmiddelen die tussen de hoofdmaaltijden ontbijt, lunch en avondmaaltijd werden genuttigd. Ook in de consumptie van tussendoortjes bleken karakteristieke patronen te zitten. In zowel de Europese als de Nederlandse onderzoekspopulatie konden dezelfde type snackers worden onderscheiden, namelijk *Matige snackers*, *Zuivelsnackers*, *Groente & fruitsnackers*, *Vochtsnackers* en *Alcoholdrinkers*. Deze typen voedingspatronen waren geassocieerd met indicatoren van de voedings- en gezondheidstoestand. De hoofdstukken 2 tot 4 laten zien dat de dagelijkse inname van de voeding kan worden samengevat met behulp van clusteranalyse en voedingsscores. De indeling in type voedingspatronen en de scores van de Healthy Diet Indicator en de Mediterranean Diet Score geven de kwaliteit van het voedingspatroon weer. Geconcludeerd wordt dat de kwaliteit van voedingspatronen betekenisvol kan worden bepaald met clusteranalyse en voedingsscores.

Vervolgens hebben we onderzocht of bij de ouderen van de SENECA-studie, voedings- en leefstijlfactoren van invloed zijn op de lengte van leven (overlevingsduur) en het handhaven van een goede gezondheidstoestand. Dit proefschrift concentreerde zich op drie leefstijlfactoren voeding, beweging en roken, die ook op oudere leeftijd nog kunnen worden aangepast. In hoofdstuk 5 zijn individuele en gecombineerde leefstijlfactoren onderzocht in relatie tot overlevingsduur. In de onderzoeksgroep van 70 tot 75-jarigen waren de afzonderlijke leefstijlfactoren roken, inactiviteit en een ongezond voedingspatroon gerelateerd aan een verhoogd sterfterisico. Vervolgens is een leefstijlscore samengesteld waarmee het effect van de drie leefstijlfactoren gezamenlijk op overlevingsduur is onderzocht. De overlevingscurven laten duidelijk zien dat zowel bij mannen als vrouwen een leefstijl bestaand uit roken èn inactiviteit èn een ongezond voedingspatroon, is gerelateerd aan een veel hoger sterftepercentage gedurende 10 jaar follow-up. In getallen uitgedrukt hebben mannen en vrouwen een 3 tot 4 keer verhoogd sterfterisico in vergelijking met personen met een leefstijl gekenmerkt door niet roken èn lichamelijk activiteit èn een gezond voedingspatroon.

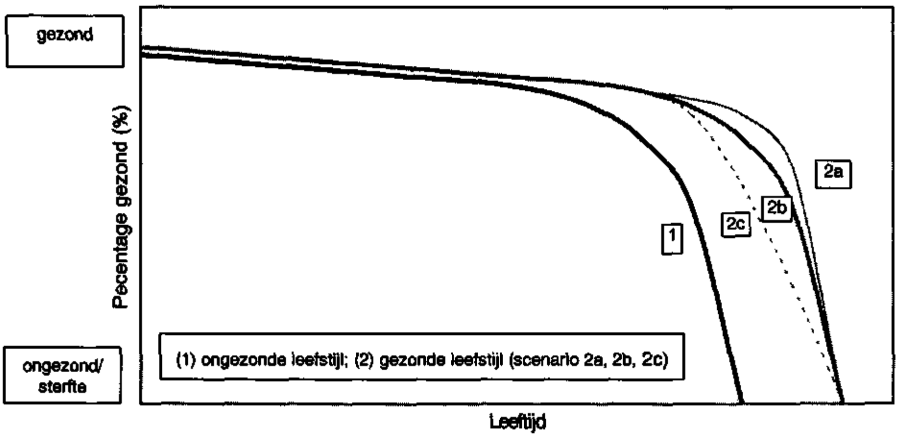
In hoofdstuk 6 is onderzocht of een gezonde leefstijl ook bijdraagt aan de handhaving van de gezondheidstoestand. Hiervoor is in de groep overlevenden die aan alle drie meetrondes van het SENECA-onderzoek hebben meegedaan, gekeken naar de leefstijl bij aanvang van de studie in 1988/89 en het verloop van de gezondheidstoestand gedurende de 10 jaar follow-up. Aangezien gezondheid een breed begrip is en in veel verschillende termen is uit te drukken, is gezondheid op twee manieren geoperationaliseerd, namelijk in termen van subjectieve gezondheidstoestand en in termen van functioneren (wassen, aankleden etc.). De subjectieve beoordeling van de gezondheidstoestand en het functioneren bleken achteruit te gaan gedurende 10 jaar follow-up, zowel bij ouderen met een gezonde leefstijl als bij ouderen met een ongezonde leefstijl. De achteruitgang in gezondheidstoestand ging gemiddeld langzamer achteruit bij ouderen die niet rookten of lichamelijk actief waren. Inactieve mannen hadden een 2,8 keer verhoogd risico op een achteruitgang in subjectieve gezondheidstoestand en een 1,9 keer verhoogd risico op een achteruitgang in functioneren. Rokende mannen hadden een verdubbeld risico op een achteruitgang in subjectieve gezondheidstoestand en een 2,2 keer verhoogd risico op een achteruitgang in functioneren. Bij vrouwen was alleen inactiviteit gerelateerd aan een verhoogd risico op achteruitgang in functioneren.

Als laatste ga ik in op de vraag of de hierboven beschreven relaties ook bijdragen aan gezond ouder worden. In **Figuur 2** wordt het effect van leefstijl op het gezond ouder worden samengevat. Een verschil in leefstijl kan tot uitdrukking komen in de lengte van leven en in het moment waarop ernstige ziekte intreedt. Scenario 2a, 2b en 2c beschrijven de drie manieren waarop dit proces kan verlopen.

Scenario 2a: de gemiddelde leeftijd waarop ernstige ziekte intreedt neemt sterker toe dan de gemiddelde levensverwachting, zodat sprake is van verkorting van de periode van ernstige ziekte (*compression of morbidity*);

Scenario 2b: de gemiddelde leeftijd waarop ernstige ziekte intreedt neemt evenveel toe als de gemiddelde levensverwachting, zodat de periode van ernstige ziekte hetzelfde blijft maar later optreedt;

Scenario 2c: de gemiddelde leeftijd waarop ernstige ziekte intreedt neemt minder sterk toe dan de gemiddelde levensverwachting, zodat sprake is van een verlenging van de periode van ernstige ziekte.



Figuur 2. Leefstijl en gezond ouder worden: 3 scenario's

Gezond ouder worden wordt gekenmerkt door een toename van de levensverwachting in combinatie met een compressie van de periode van ernstige ziekte in een relatief korte periode voorafgaand aan het overlijden (scenario 2a). Het netto-effect van een gezonde leefstijl op het proces van gezond ouder worden kon niet worden onderzocht met de gegevens van de SENECA-studie. Deze studie bevat namelijk geen gegevens van de achteruitgang van gezondheidstoestand in de laatste jaren voor het overlijden, zodat het totale proces van gezond ouder worden niet kon worden bestudeerd. Wel blijkt uit de discussie in hoofdstuk 7 dat het aannemelijk is dat een gezonde leefstijl gepaard gaat met een verkorting van de periode van ernstige ziekte. Geconcludeerd wordt dat een gezonde leefstijl op oudere leeftijd gerelateerd is aan een verlaagd sterfterisico, de aanvang van ernstige ziekte en beperkingen uitstelt en waarschijnlijk samengaat met een compressie van totale ziekteduur. Dit proefschrift is een eerste stap om het totale proces van gezond ouder worden in kaart te brengen en vervolgonderzoek is vereist naar de verschillende processen die een rol spelen bij het gezond ouder worden.

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Annemien

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Annemien Nies was born on February 12, 1972, in Lippenhuizen, The Netherlands. In 1990, she passed secondary school atheneum B, at the 'Ichthus College' in Drachten and started in the same year the study 'Human Nutrition' at what is now called Wageningen University. As part of that study she conducted a research project on energy expenditure and body composition of elderly women, a project on energy intake and energy expenditure in psycho-geriatric nursing home 'Mariahoeve', The Hague (Department of Human Nutrition, Wageningen), and a project on health education at the Dairy Foundation on Nutrition and Health (Department of Communication and Innovation Studies, Wageningen). In January 1996 she obtained the MSc degree. From December 1995 to June 1997 she worked as an associate investigator on the SENECA study at the Division of Human Nutrition and Epidemiology at Wageningen University. Main topics of interest were vitamin D and fractures, and snack patterns. From August 1997 to June 1998 she worked as an epidemiologist at Regional Health Services in Doetinchem and Zeist, mainly on the topic 'health care, living situation and health care facilities of independently living elderly people'. In July 1998 she started as a PhD-fellow at the Division of Human Nutrition & Epidemiology at Wageningen University and combined the co-ordinating work for the longitudinal SENECA study with the writing of this thesis. She joined the education programme of the Graduate School VLAG (advanced courses in Food Technology, Agrobiotechnology, Nutrition and Health Sciences) and participated in the Erasmus Epidemiology Summer Course in Rotterdam where she joined several courses as 'Health status measurement', 'Survival analysis', and 'Design, conduct and analysis of multi-centre studies'. In 1999, the Council of the Netherlands Epidemiological Society registered her as Master of Science in Epidemiology. During her PhD appointment she gained a scholarship from the Haak Bastiaanse-Kuneman Foundation for a two-months stay at Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University, Boston, USA. Since September 2001, she is working at the National Institute of Public Health and the Environment in Bilthoven on the follow-up of the SENECA study, the HALE project. Annemien lives in Zetten and is married to Rense Haveman.

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