Dietary quality, lifestyle factors and healthy ageing in Europe: the SENECA study

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Abstract

Objective: to identify dietary and lifestyle factors that contribute to healthy ageing.
Subjects: for the analyses, data of the longitudinal SENECA study were used. The study population consisted of 1091 men and 1109 women aged 70–75 years from Belgium, France, Denmark, Italy, The Netherlands, Portugal, Spain, Switzerland, and Poland.
Methods: this European study started with baseline measurements in 1988–1989 and lasted until 30 April 1999. The study includes data on diet, lifestyle and health. The study population is followed for 10 years, and measurements were performed in 1988/1989 (baseline), 1993, and 1999. The relationships of the three lifestyle factors diet, physical activity, and smoking habits to survival and maintenance of health at old age were investigated. Finally it is discussed whether the relationships of healthy lifestyle habits to survival and health contribute to healthy ageing.
Results: the unhealthy lifestyle habits smoking, having a low-quality diet, and being physically inactive were singly related to an increased mortality risk (hazard ratios ranged from 1.2 to 2.1). In addition, inactive and smoking persons had an increased risk for a decline in health status as compared with active and non-smoking people. The net effect of a healthy lifestyle on the process of healthy ageing is likely to go together with a compressed cumulative morbidity.
Conclusions: 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. Therefore, health promotion at older ages can contribute to healthy ageing.

Keywords: *diet, lifestyle, mortality, healthy ageing, SENECA*

The question 'How do I get old healthy?' is very topical in view of the rapidly growing number of elderly people in our society nowadays. However, the philosopher Seneca already addressed this topic about 2000 years ago. At that time, he raised the question, 'You want to live? Do you know how to?', which is still a subject for debate. The European Study with the same name SENECA has given cause for discussion of the concept of healthy ageing. The objective of this longitudinal study (1988/89–1999) was to identify dietary and lifestyle factors that contribute to healthy ageing [1].

Healthy ageing

In this paragraph, healthy ageing is described by explaining first health status and subsequently by discussing

health status in relation to the ageing process. 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 [2, 3]. Wilson *et al*. [4], and Verbrugge and Jette [5] 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 health parameters, 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 reflects 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 [5–8]. High age not only goes together with physical and mental illness, but also influences a person's perception of health [9]. As people become older, they are less likely to focus on the physical aspects of their health and value qualitative aspects higher [10]. An illustration of this is given by a review by Idler and Benyamini [11]. This paper 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 chronic conditions, functioning, medication use, physician visits, and hospitalisation, implying that survey respondents' perception of health status are holistic.

Two health patterns related to ageing are distinguished by Vellas et al. [12]: 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 [13], 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. This situation is graphically represented in Figure 1 by plotting health status at different ages. In this process two stages can be distinguished: (i) a relatively long period of a few decades in which health status slowly and to a limited degree deteriorates as a result of the normal ageing process; (ii) a short period of maximally a few years prior to death with an accelerated decline in health status, mainly as a consequence of progressive illnesses or catastrophic events. The dotted line represents the situation of compression of morbidity [14, 15].

The longitudinal SENECA study

Design

In 1988, the European multi-centre SENECA (Survey in Europe on Nutrition and the Elderly: a Concerted Action) study was started to study dietary patterns and lifestyle factors affecting health and performance in Europe. The study started at that time because of the expected increase in elderly people in the coming 50 years. At baseline, 2586 elderly persons from 19 European towns participated. Follow-up measures were performed in 1993 (follow-up study) and 1999 (final study) in order to study changes in health status and lifestyle factors in a population that is moving from a rather healthy elderly population to 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
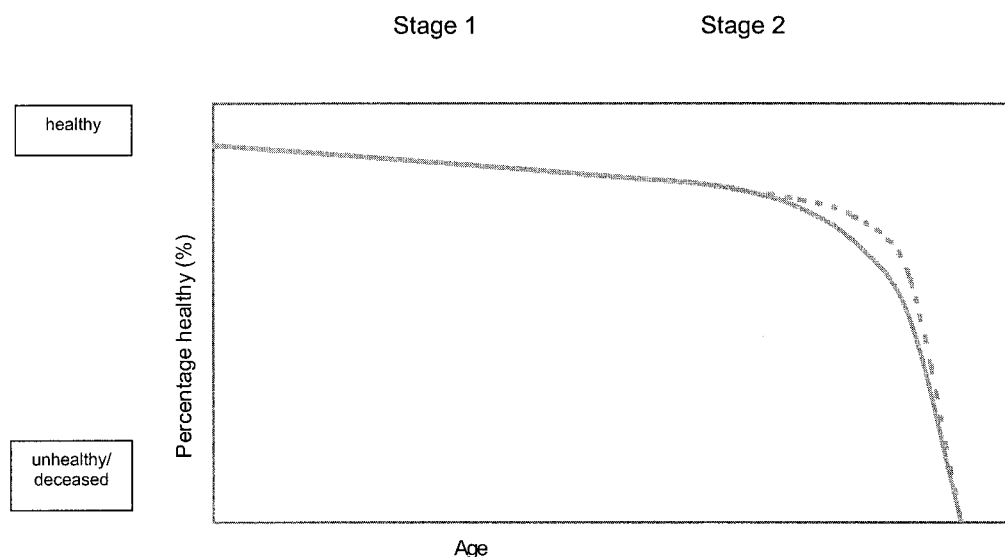

Figure 1. Ideal graph of healthy ageing.

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 [16]. Participation rates at baseline varied from 37% to 62% [17].

Health status measures and lifestyle indicators

Indicators of health status, vital status, dietary intake, lifestyle factors, and other measurements were collected according to a strictly standardised methodology both over time and across Europe [16].

In the SENECA study we focused on three health aspects: vital status (being alive or not), functional status, and self-rated health. Vital status is an objective indicator and has a very clear endpoint. Table 1 shows the vital status of the SENECA participants over the 10-year follow-up period. Functional status is an objective indicator of health status, specifying the level of dependence in performing activities of daily living [18]. Self-rated health is a subjective health indicator, summarising individual health aspects, weighted by personal values and preferences [19, 20]. 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 other manifestations of ageing coexist.

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 [16, 17]. Two smoking groups were composed: (i) current smokers and former smokers with 15 or fewer years of abstinence, indicated as smokers; (ii) never smokers and former smokers with more than 15 years of abstinence, indicated as non-smokers [21]. 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 constructed from data for the baseline population [22]. Two activity groups were composed: (i) an inactive group with participants from the low-activity tertile, and (ii) an active group with participants from the intermediate- and high-activity tertiles. Dietary quality groups were based on the Mediterranean Diet Score [23, 24]. The score included the following items: monounsaturated-to-saturated fat ratio; alcohol; legumes, nuts, or seeds; cereals; vegetables and fruits; meat and 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 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 the literature, we defined the intake of dairy products in between the P25 and 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 and meat products on 130 g/day [25–27]. The modified Mediterranean diet score ranged from 0 (low-quality diet) to 7 (high-quality diet). Two dietary groups were composed: (i) a low-dietary quality group with diet scores of 4 or less, and (i) a high-dietary quality group with diet scores greater than 4.

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 [28]. Work, household, sport and leisure time activity patterns vary widely among elderly Europeans [18]. Further, Schroll *et al.* [29] and Huijbregts *et al.* [30]

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	Final study 1999			Baseline 1988/89	Final 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

describe a wide variety in dietary patterns in elderly Europeans. Therefore, the European setting is especially well suited for the study of lifestyle factors in relation to survival and health status, because of substantial differences in health status, smoking, dietary, and activity patterns.

Lifestyle factors in relation to survival and health

In the SENECA study we found that diet, physical activity and smoking habits are related to survival and health status.

A high-quality diet, physical activity, and non-smoking were related to survival in elderly Europeans, aged 70–75 years (Table 2). In addition, non-smoking delayed the deterioration of health status in men. In women, the relationship of smoking to functional status and self-rated health could not be investigated, due to the very low number of smokers among elderly women. Physical activity delayed the deterioration of both health indicators in men, while in women a relationship of physical activity with physical functioning, but not with self-rated health, was found [31, 32]. Different processes of incorporating information into self-ratings of health between men and women are responsible for this [11, 33]. In line with our results, it has been found in previous studies that these single healthy lifestyle behaviours are related to survival [23, 34–38]. So far, few longitudinal studies investigated the relationship between lifestyle factors and deterioration in health status. It is found that physical activity and non-smoking delay the deterioration

of indicators of mobility [39–41]. So far, only cross-sectional studies found associations between dietary patterns and health measures as cognitive function or functional status [29, 42]. More longitudinal research in this field may reveal whether lifestyle factors delay the deterioration in different indicators of health status.

The relationship between lifestyle factors and survival and health indicators has been described for different age groups [40, 43–46]. In general, the strength of the association between risk factor and outcome measure decreases with increasing age [47]. Recently, Kaplan et al. [48] 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. Because only few studies present age-specific data, no definitive statement about these patterns can be made.

Age-related patterns of associations between lifestyle factors and outcome measures are influenced by methodological issues such as sample selection and selective survival. At baseline, the SENECA study included subjects of the small age range of 70–75 years who were generally in good health [49]. As a result, it is assumed that lifestyle factors at baseline reflect mainly the lifestyle of preceding years. 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.

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 $n=631$ HR (95% CI)[4]	Fall in self-rated health vs stable self-rated health $n=39$ vs $n=104$ OR (90% CI)[5]	Become dependent vs remain independent $n=35$ vs $n=175$ 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 $n=650$ HR (95% CI)	Fall in self-rated health vs stable self-rated health $n=38$ vs $n=120$ OR (90% CI)	Become dependent vs remain independent $n=41$ vs $n=206$ 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.

[4]HR (95% CI) = Hazard Ratio and 95% confidence interval.

[5]OR (90% CI) = Odds Ratio and 90% confidence interval.

Another issue is selective survival that might influence the association between risk factor and outcome. The deceased group had a worse health status and worse health behaviours as compared to the full participants [32]. These data indicate a progressive elimination of less healthy subjects from the group with unhealthy lifestyle habits, making this group more and more like 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 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.

A conceptual model of healthy ageing

The previous section 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 as is described by Fries [14] and Campion [13]. The effect of healthy lifestyle behaviours on life expectancy and health status is schematically drawn in Figure 2.

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.

It is expected that the survivors with a healthy lifestyle live longer than survivors with an unhealthy lifestyle [48]. 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, 50]:

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 [51]. They performed a longitudinal study to determine whether persons aged 63–72 years with lower modifiable health risks (like smoking and exercise) have more or less cumulative disability. Seven surveys were performed between 1986 and 1994. In the survivor group
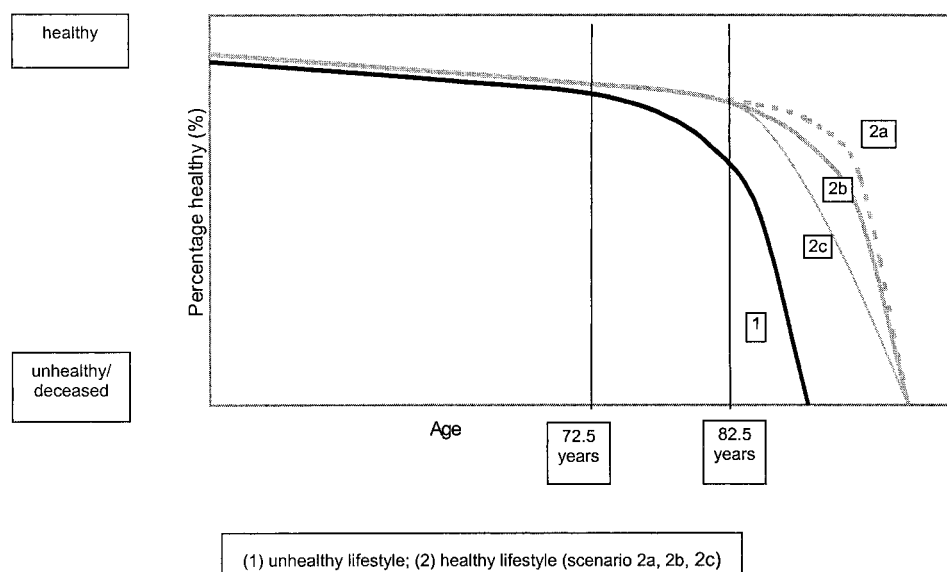

Figure 2. Lifestyle factors and healthy ageing: three scenarios.

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 [52]. But changes towards a healthy lifestyle at older ages is also effective [53–57]. 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. [58]. 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 programmes should focus on the adoption of healthy lifestyle behaviours in elderly people. The adoption of multiple lifestyle behaviours is favourable, but in practice realisable customised advice 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 programmes in young and elderly subjects.

Key points
- A healthy lifestyle at older ages is positively related to a reduced mortality risk, and to a delay in the deterioration in health status.
- A lifestyle characterised by non-smoking, physical activity, and a high-quality diet contributes to healthy ageing.
- Our results underscore the importance of a healthy lifestyle, including multiple lifestyle factors, and the maintenance of it with advancing age.

Acknowledgements

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