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**Nutrition and Senescence: Healthy Aging for All in the New Millennium?**

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**INTRODUCTION**

Community-dwelling, physically frail elders are a particularly vulnerable group who need special and more structured attention within the total health-care system. Early identification of deteriorating health with easily applied methods is a prerequisite for successfully implementing simple and enjoyable interventions aimed at autonomy and improved quality of life. Several issues play a role in the downward spiral of frailty and may be of particular interest in future research in the elderly and in future actions taken to prevent or slow the onset of frailty. These issues are discussed below.

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**Demography and Policy**

As researchers, we are well aware of our earth’s increasing population of elders as the result of both an increase in the absolute number of the aged (≥65 y and ≥85 y) and increased longevity. How much of this increased life expectancy is disability free and whether it can be further positively affected is the topic of future interest. Currently, Dutch 55-y-old men have on average 22.6 y to live, 14 y of which should be healthy. The corresponding number for Dutch women of the same age is 27.6 y, 16 y of which should be healthy.1

Current Western health-care policy has curtailed the development of institutional care to limit government expenditure on health care. As a result, an increasing number of elders sustain a living in the community. Home-care services, social services, and meals-on-wheels programs are of increasing value in assisting these older people. Hence, it is not surprising that, as the number of clients and total costs rise, a considerable burden is placed on these civil institutions. This burden will soon be on the total health-care system. In Europe, the number of working employees supporting pensioners in the year 2000 is 3.8; in 2050, this number will be only 1.6. It is just not feasible to maintain a high quality of
health care through economic redistribution alone. Politicians, administrators, caregivers, insurers, and researchers must place a higher priority on health-care promotion and ailment and disability prevention in the elderly to improve functional independence and quality of life. Nutritional research and intervention is called to take affirmative action.

Physically Frail Elders: Neglected Elders?

Among aging people, the independently living, physically frail elderly may be most vulnerable to nutrient deficiencies, disability, and hence a deteriorating quality of life. However, much research performed on the elderly to date has focused on either apparently healthy elderly or institutional residents, the latter having “sheltering support.” In surveys focused on less healthy, yet free-living but more socially isolated elders, the problem of refusal to participate is well known. Natural reluctance to cooperate, mild to severe disabilities, and no opportunity to discuss inner thoughts with close partners influence decisions on unascertained events. Nonetheless, nutritional problems are likely to occur in this expanding group; thus, the problems in the elderly registered thus far are prone to underestimation.

Several definitions of frailty have been postulated in the geriatric literature, but thus far we have been unable to develop a suitable definition accompanied by practical screening tools. On the one side, one finds definitions as broad as “those who are neither too well, nor too disabled”; on the other side are only slightly more specific definitions such as “those having a reduced physiologic reserve, associated with increased susceptibility to disability.” With the passage of time, a continuous downward spiral is established (Fig. 1) that leads to loss of physiologic reserves, to problems in physical, cognitive, emotional, sensory, and social functioning, and, finally, to institutionalization. Chin A Paw proposed that physical inactivity combined with involuntary weight loss should be used as a practical, inexpensive screening criterion for identifying functionally vulnerable persons. However, this criterion will be difficult to apply unless body weight is recorded. Pilot tests performed with my colleagues revealed that weight loss was either unknown or indicated elderly persons who were already too ill to participate in any intervention. Attempts in the form of the relatively rapid Mini Nutritional Assessment tool also seem to result in limited sensitivity and specificity to determine nutritional problems early.

NUTRITIONAL AND HEALTH INDICATORS THAT PLAY A ROLE IN THE DOWNWARD SPIRAL

Advancing our understanding of dietary, biochemical, and other clinical nutrition data to support our current marginal knowledge of the frail elderly is essential for developing adequate recommendations and public-health policy. Many indexes can be used to partly define nutrition status, but there is no sole key measure that indicates either nutrition or health and disease status adequately. From the onset of the discipline of human nutrition, we have been trying to distinguish malnutrition from underlying disease, but perhaps we are digging our own graves by attempting to separate these two courses. The indicators for malnutrition that we currently use all differ in responsiveness and may be affected by illness and injury; their validity to independently measure nutritional risk has yet to be proven. A combination of several indexes is often applied, but the development of other sensitive clinical nutrition indicators that are non-invasive, economical, humanistic, and suitable for defining a suboptimal state early remains a future challenge.

Sensory Perception and Appetite

Sensory perception is among the few stimuli that remain important until the very end of life. It is commonly known that a large part of food enjoyment is determined by taste. In turn, taste perception is largely influenced by smell perception, which is more affected by an age-related decline than taste. Almost half of the elderly population is liable to experience olfactory dysfunction. It is widely assumed that taste and smell dysfunction adversely influence food intake, nutrition status, and the occurrence of certain chronic diseases, but evidence for fundamental relations is lacking. The work of Schiffman and Warwick has indicated the effectiveness of taste enhancers as a potential intervention to improve quality of life by improving total intake and nutrition status in the elderly. This is an interesting approach that should be confirmed in other trials.

Appetite, feelings of hunger, and subjective sensory perception may or may not be decisive for final nutrition status; we have no conclusive evidence. They certainly reflect food enjoyment and quality of life: a good appetite is generally regarded as a sign of good health and a decreasing acceptance of food as an early warning of worsening health. In addition to recording weight
change, we should perhaps focus on developing sophisticated but easily applied appetite questionnaires that gatekeepers such as general practitioners could use to detect deteriorating health early. Elders with sensory disorders and appetite problems may be distressed by various social and psychosocial consequences of their disorder. Subjective feelings may explicitly reflect life satisfaction and are therefore extremely relevant for future research in this field.

**Dietary Intake**

The value of dietary intake data as an indicator of health status in an elderly population is debatable. In the general population, total dietary intake may predict actual nutrition status, although we cannot unravel the influence of other factors such as underlying disease and medication use. Dietary intake may also reflect appetite but not always in elderly persons. The elderly may eat simply because they know they have to, even if they do not feel like eating, or they may eat because the food is delivered (through a meals-on-wheels program or a central kitchen) and throwing it away would be wasteful. Correlation coefficients between intake and blood vitamin values differ disappointingly between 0.0 and 0.6 depending on the nutrient and the method of measurement. In addition to the debate on the value of dietary intake data, a controversial point is the choice of two-thirds the recommended dietary allowance (RDA) as a cutoff value for determining insufficient intake. This cutoff value was selected arbitrarily and is not based on scientific evidence. Minimum requirements are based on many determinants and, to date, no absolute figures indicating pronounced undernutrition have been agreed upon. Recently, under the supervision of the US National Academy of Sciences, four different dietary reference intakes instead of one recommendation (the RDA) were postulated. In addition to the established RDA, values of adequate intake, an estimated average requirement, and a tolerable upper intake level were proposed.

The lower energy expenditure of the elderly induces a lower dietary intake. In terms of energy, a new balance may be achieved because inactive humans need less fuel. However, bodily functions may require the same amount of nutrients or perhaps more as a result of disease and dysfunction. For example, extra protein may be needed for frequent repair of tissue, but renal function declines with age, as well, and this may affect the balance of elements whose main excretion route is through the kidneys. Therefore, supply of extra protein is also debatable. The intestinal uptake of nutrients (e.g., vitamin B12, folate, calcium, iron, and zinc are frequently mentioned) may also be changed in the elderly, but the exact modifications have yet to be determined. Special recommendations for the elderly are frequently based on extrapolations of recommendations for younger adults. This issue needs to be addressed in new and ongoing research.

**Biochemical Indexes**

Many biochemical indexes are in widespread use in clinical nutrition. There are indexes that describe nutrient status or the actual available body pool of nutrients and more functional biochemical indexes that are of less likelihood for overall health status. The body nutrient pool is dependent on nutrient intake, but also on disease state, drug–nutrient interactions, and other interfering internal factors such as functioning of the gastrointestinal tract and ability of elderly skin to synthesize vitamin D efficiently. The second category of biochemical indexes is assumed to reflect (endangered) homeostasis more specifically than nutrient levels because the functional indexes depend more strongly on non-nutritive factors such as age, illness, drug use, and internal metabolic processes. Because of the interdependence between disease states and biochemical indicators, it is often unclear whether disease causes unfavorable biochemical-indicator levels or whether the low levels cause the disease. There is still a lack of uniform and clear cutoff values because of the different techniques used to measure biochemical indicators. The development and validation of new biomarkers must progress with the exploration of the whole interdependent complex of age-, nutrition-, gene-, disease-, and metabolic-related factors.

**Body and Bone Composition**

Changes in body and bone composition are induced by biological aging and by disease, inactivity, and inadequate dietary intake. Changes in body composition fall into three categories: wasting (unintentional loss of total weight, including fat and fat-free mass), cachexia (loss of fat-free mass but little total body weight loss), and sarcopenia (loss of skeletal muscle mass). Wasting may develop at the far end of the life spectrum, but sarcopenia and cachexia may be preexisting. Sarcopenia accounts for age-associated decreases in resting metabolic rate resulting from a decline in activity levels and in the number of active cells. Additional effects of sarcopenia resulting from disuse of muscles have been documented on muscle strength, bone density (because of a lack of a regular, substantial mechanical load), and functional capacity. Although the effects of sarcopenia seem enormous, the public-health significance of this process has not been fully appreciated.

In contrast with sarcopenia, osteoporosis is recognized as one of the most important disorders associated with aging. It is characterized by a reduction in bone mass and an alteration of bone architecture, leading to an increased susceptibility to fracture. Factors affecting bone mass and density are 1) peak bone mass, 2) nutritional factors, 3) physical activity, 4) hormones, and 5) age. Research in twins suggests that about 60–80% of peak bone mass is genetically determined. It is also assumed that several aspects of bone architecture, which in turn influence bone strength, are genetically determined. Currently, several candidate receptor genes are being investigated.

With respect to nutritional factors, calcium and vitamin D are the popular candidates designated to influence bone health in young and older people. Although more and more evidence is being amassed on the beneficial effects of these two nutrients, no absolute consensus on their effects has been established because results obtained within the first 1 or 2 y of intervention may decline even during the subsequent period of intervention. There is also no uniformity in nutritional recommendations between the United States and Europe. For vitamin D, no optimal dose has been agreed to: even small dosages may be effective in reducing the incidence of fractures. Other nutrients mentioned as having either beneficial or detrimental effects, depending in part on concentrations, are protein, phosphate, magnesium, sodium, fluoride, vitamin C, and vitamin K.

Physical activity induces a mechanical load on bones and is therefore beneficial. Hormone therapy is effective in decreasing bone loss, but the side effects of this therapy (e.g., small increases in the incidence of breast cancer and thrombosis) are a drawback. Thus far, maximizing peak bone mass, maintaining peak bone mass for as long as possible, and preventing bone loss in old age are the most important therapeutic objectives for restoring bone and preventing osteoporosis-related fractures.

Which optimal dosages of which nutrients and perhaps hormones are most effective is still a topic of research, as is the specific long-term mechanisms involved in bone restoration. Biochemical markers of individual bone loss and restoration, such as alkaline phosphatase and osteocalcin, are currently not that useful for studying the effects of treatment because the sensitivity and specificity of the markers are not satisfactory. In combination with bone densitometry, such markers may add meaningful information, but research is needed to determine their specific value.
FUTURE INTERVENTIONS

Although elderly persons are survivors, they may still benefit from interventions that extend their healthy or disability-free life expectancy. Preservation and maintenance of optimal nutrient concentrations, of muscle and bone tissue, and of other organ systems would help to establish longer-term physiologic reserves that would preserve and maintain functional ability, autonomy, and, hence, quality of life.

Given the diminished energy requirements of old age, it is difficult for many elderly individuals to maintain a balanced diet that contains adequate amounts of micronutrients. Hence, the use of nutrient-dense foods should be considered in at-risk populations. These foods should be familiar, be served in small portions, and be easy to include in daily meals. One promising way of administering such foods is to replace a normal dessert with a nutrient-dense item in a meals-on-wheels program. The frail elderly, who often have reduced appetites and nutritional intakes, are probably in need of a range of nutrients as opposed to a single isolated nutrient.52 The results of our 4-mo intervention trial suggest positive effects of multiple micronutrient-dense foods on blood concentrations of several functional nutrients and on bone health.9 However, it is essential that a long-term (5–10 y) prospective trial will be conducted, with a focus on two groups of elderly: those consuming familiar nutrient-dense items and those consuming familiar normal items (the same subjects) to investigate prescriptive effects. Physiologic doses of nutrients, based on RDAs, rather than pharmaceutical-dosed supplements may be sufficient for treating deficiencies. Nevertheless, there is limited information on the distinction between sufficient and excessive nutrient intakes.8,9 Data on nutrient–nutrient and drug–nutrient interactions may help to define the optimal supplement. Furthermore, new information based on the elderly is useful in the current debate on the sense or non-sense of functional (enriched) foods for the general public.

Reactivating or maintaining substantial activity levels by mobilizing the less-healthy elderly and regaining or maintaining an acceptable performance level are other important but difficult and time-consuming tasks. The long-term protective effects of exercise on the maintenance of body tissues and functions are worth considering, however, as our own 4-mo trial suggests regarding muscle mass, physical fitness, and functioning.8,9

Interventions that include personal attention and guidance, that have a low threshold, that are easily accessible, and that are inexpensive should be successfully implemented, and should open promising pathways for reducing health-care costs, reducing the stress placed on the health-care system, and, most importantly, improving quality of life. Scientific monitoring of proposed interventions with health outcomes such as life satisfaction rather than “surrogate” endpoints or outcomes such as morbidity and mortality must be realized.

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SENECA’s Accomplishments and Challenges

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In the European community, the major causes of mortality at old age are due to diseases in which lifestyle plays an important role.1,2 Internationally, cardiovascular disease is the leading cause of death in people older than 65 y, with deaths from cancer ranking a close second. At the age of 65 y, men and women in developed countries have a life expectancy of 15–20 y. The evidence to date suggests that improvements in nutrition, in addition to changes in other lifestyle factors, make these years healthier, more active, and less dependent on others.1,2 In this respect, nutrition, physical activity, and the use of medicines are among the major modifiable lifestyle factors of concern. These factors are influenced by societal and cultural factors that have led to a large diversity in food patterns and, consequently, in health patterns among elderly Europeans.3,4 Some 10 y ago, it was acknowledged that, to obtain information on how to age in good health, this diversity should receive due research attention before Europe reaches a situation with much less variability in food intakes and more uniform lifestyles. Therefore, in 1988, a major, longitudinal European multicenter study, the Survey in Europe on Nutrition and the Elderly: a Concerted Action (SENECA), was initiated to study cross-cultural differences in nutritional issues and lifestyle factors affecting health and performance of elderly people in Europe.

SENECA

Suitably, SENECA was also the name of a philosopher whose work reflects wisdom. It was this philosopher who stated in one of his letters to Lucilius, Non est quod compares inter se dissimilia, ‘Do not compare the incomparable.’ According to a strictly standardized methodology both over time and across Europe, this statement was challenged in the SENECA surveys in 1989 (baseline), in 1993 (follow-up), and in SENECA’s final survey in 1999. In these surveys, data were collected in a uniform way and thus became comparable. Methodologies included diet, anthropometrics, blood biochemistries, lifestyle, health, and performance assessments, and a search for possible selectivity in participation by approaching non-responders. At baseline, these methodologies were applied to 2586 randomly chosen elderly people from 19 towns in 12 European countries, who were 70–75 y old at the start of the study. The towns selected then were Hamme, in Belgium; Roskilde, in Denmark; Chateau Renault-Amboise, Hauguenau, and Romans, in France; Anogia-Archanes and Markopoulo, in Greece; Monor, in Hungary; Padua and Fara Sabina-Magliano Sabina-Poggio Mirteo, in Italy; Culemborg, in The Netherlands; Elverum, in Norway; Marki, in Poland; Coimbra and Vila Franca de Xira, in Portugal; Bentanzos, in Spain; and Yverdon, Burgdorf, and Bellinzona, in Switzerland. In 1993, 1170 subjects from the 9 towns shown in italic type were reexamined at age 74 to 79 y. A final assessment in the 9 “longitudinal” towns of health, survival, and cause of death for those who did not survive to 1999 will conclude the SENECA study.

SOME ACCOMPLISHMENTS

Results from the comparative cross-sectional phase of the study showed that, in general, the variability from site to site was great for many of the parameters studied.3 Although participation was somewhat selective in that the most healthy and active subjects were more willing to continue their involvement, 4-y changes in diet and indicators of nutritional status and health were all in an unfavorable direction.4 Nutritional concerns emerged for several of the nutritional parameters studied, e.g., for vitamins D and B12. Regardless of geographic location, elderly Europeans were at great risk of having inadequate vitamin D during winter. Unexpectedly, in general, lower median 25(OH)D concentrations in serum were observed in southern Europe than in northern Europe. These low 25(OH)D concentrations could generally be explained by reduced sunlight exposure and by indicators of physical-health status.5 Such a tendency of reduced sun exposure accompanied by a reduced capacity to synthesize provitamin D3 in skin and to hydroxylate vitamin D3 in kidneys in old age must lead to reduced “endogenous” vitamin D supply. Further, because Western diets generally provide 25–50% of the current recommended vitamin D intake, supplementation at old age would appear to be necessary according to SENECA, especially during winter. However, additional information is needed on the amount of vitamin D required to prevent bone demineralization. Moreover, an important issue for future research is the broader function of vitamin D.