NUTRITIONAL RISK ASSESSMENT AMONG DUTCH ELDERLY PEOPLE

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Nutritional Risk Assessment among Dutch Elderly People

A nationwide survey among 539 apparently healthy
65-79-year-old subjects

A survey among 44 apparently healthy
65-97-year-old vegetarian subjects

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PREFACE

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Abbreviations

BMDP	biomedical computer programs
BMI	body mass index
Ca	calcium
cm	centimeter
CV	coefficient of variation
DBP	diastolic blood pressure
EAST	erythrocyte aspartate aminotransferase
EAST-AC	erythrocyte aspartate aminotransferase activation coefficient
EGR	erythrocyte glutathion reductase
EGR-AC	erythrocyte glutathion reductase activation coefficient
en%	energy percentage
eq	equivalent
Fe	iron
fl	femtoliter
g	gram
GENSTAT	general statistical program
24-h	24 hour
HCl	hydrochloric acid
HDL	high density lipoproteins
K	potassium
kg	kilogram
L	liter
ln	natural logarithm
m	meter
mg	milligram
Mg	magnesium
min	minute
MJ	megajoule
mL	milliliter
mm	millimeter
mmol	millimole
mufa	monounsaturated fatty acids
n	number of subjects
Na	sodium
NaCl	sodiumchloride
nmol	nanomole
ns	nonsignificant in statistical test
OH	hydroxy
%	percentage
P	percentile
p	probability value
PLP	pyridoxal 5'-phosphate
pmol	picomole

P/S ratio	grams polyunsaturated fatty acids divided by grams saturated fatty acids
pufa	polyunsaturated fatty acids
r	correlation coefficient (pearson)
R^2	explained variance
RDA	recommended dietary allowances
SD	standard deviation
SE	standard error
sfa	saturated fatty acids
SBP	systolic blood pressure
TIBC	total iron binding capacity
T value	test value based on a student's t distribution
U	unit
UV	ultraviolet
µg	microgram
µmol	micromole
WHO	World Health Organization
$\bar{x}$	mean value
y	year
Zn	zinc

1. INTRODUCTION

1.1. Rationale

The number of elderly people (65 y and over) in affluent societies has increased since the turn of the century both proportionally and absolutely, and this trend is expected to continue in the near future. In The Netherlands there were about 1.7 million elderly people in 1985, accounting for about 12% of the total population (see **Figure 1.1.**). It has been predicted that by the year 2000 there will be about 2.2 million elderly people, 14-15% of the total Dutch population by then (1).

With the progressive aging of the Dutch population prevention of inadequate nutrient intake and nutritional status among the elderly is of increasing concern. In general, the elderly consume less food and hence have a lower intake of energy and nutrients than younger adults. Since their nutritional requirements are considered to be similar to those of younger adults for most nutrients, intake of particular nutrients may be inadequate at old

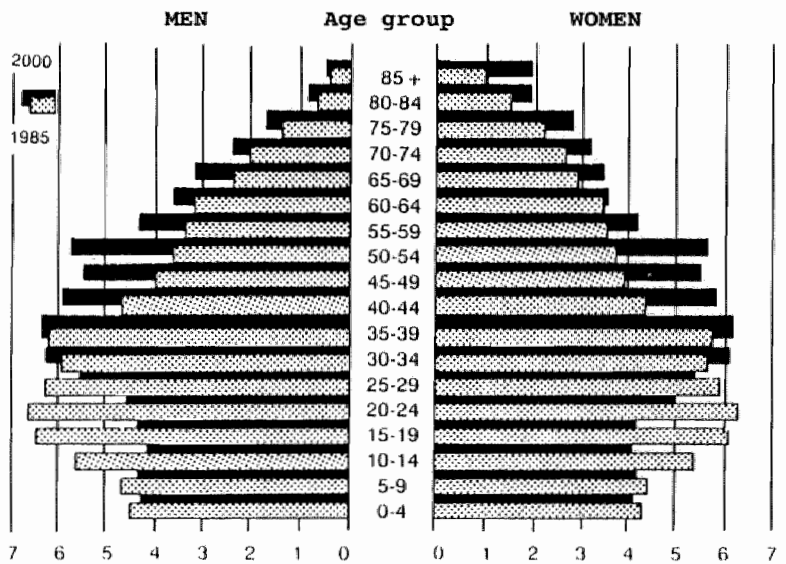

Figure 1.1. The Dutch population (in 100,000 inhabitants) according to gender and age groups in 1985 and 2000 (predicted).

Source: Centraal Bureau voor de Statistiek (1).

age (2-4). An important question is whether elderly people have an adequate supply of energy and nutrients to maintain or improve their health. If dietary intake is insufficient changes in the current diet of elderly people might be considered. Preventive measures among elderly people should not only be aimed to prolongation of life but also to maintenance of its quality (5,6). According to the World Health Organization (5), autonomy, as the state of being able to function as one wishes, is a reasonable criterion for health among elderly people. Therefore, postponement of institutionalization for as long as possible should be added to the aims of prevention. In this respect the concept of active life expectancy, defined as the years lived independently without functional limitations, may be useful (7). Although intrinsic (genetic) factors will be an important determinant of the (active) life expectancy of human beings a variety of extrinsic factors, such as lifestyle, are involved as well. According to Sauberlich (8) a poor nutritional status may contribute to or exacerbate acute and chronic diseases, delay recovery from illness, or accelerate the development of degenerative diseases associated with aging.

At higher age there is an increased prevalence of chronic diseases and disorders that may partly be of nutritional origin. The interactions between dietary factors during childhood and adult life and physiological as well as pathological processes are reflected in the health and well-being of the elderly, in which aging, nutrition and health are intimately interwoven (9). Negative health conditions such as diabetes, obesity and hypertension may result in changes in habitual lifestyle, whereas selective survival among middle-aged people (especially men) may also affect dietary intake and nutritional status of elderly people. These considerations are presented in **Figure 1.2.** (10).

1.2. Surveys

The forementioned considerations were the impetus for a national survey among elderly people oriented at nutritional risk assessment. The results of a pilot study led to the conclusion that a nationwide survey was feasible and of value (11). In a nationwide nutritional survey among 539 independently living elderly and a survey among 44 vegetarian elderly only apparently healthy elderly were selected to restrict the impact of disease(s) on dietary intake and nutritional status indicators. Both surveys were executed within the framework of the Dutch Nutrition Surveillance System (12). The primary aim of these studies was to identify the general nutritional risks among independently living,

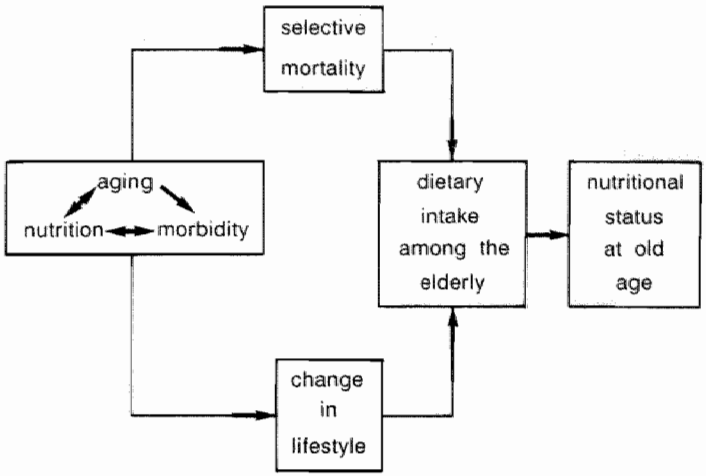

Figure 1.2. Schematic representation of the interdependent nature of nutrition, aging, and dietary intake and nutritional status at old age.
Source: Löwik et al (10).

apparently healthy Dutch elderly people. Such an identification implies a normative evaluation of dietary intake and nutritional status indicators. For food consumption data recommended dietary allowances and dietary guidelines, and for nutritional status indicators reference values obtained from healthy (younger) adults are commonly used for this purpose. However, there is a serious lack of age-specific information. Because of changes with advancing age in physiological processes, physical activity patterns and health status, an assessment based on data from healthy younger adults may be incorrect. The study into the nutritional status of elderly people with more prudent food consumption habits may contribute to an assessment of the necessity of adjustment of reference values for the nutritional status among elderly people. Dietary intake among vegetarians usually differs substantially from an omnivorous diet. A comparison between omnivorous and vegetarian elderly could provide additional information as to whether changes in nutritional status indicators with advancing age should be seen as an inevitable concomitant of aging processes. Since only one person out of the 539 in the national survey was vegetarian additional data were collected among 44 vegetarian elderly people living in a vegetarian community.

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2. NUTRITION AND AGING: DIETARY INTAKE OF "APPARENTLY HEALTHY" ELDERLY*

Michiel R.H. Löwik, Susanne Westenbrink, Karin F.A.M. Hulshof, Cor Kistemaker and Rudolf J.J. Hermus.

ABSTRACT

The dietary intake (assessed through dietary history) of 539 apparently healthy, independently living elderly aged 65-79 y, was evaluated in a nationwide random sample. Except for pyridoxine, the intake of vitamins, minerals, and water was adequate according to the Dutch recommended dietary allowances. Fat intake (40 energy%) as well as P/S ratio (0.41) was assessed as being unfavorable, whereas the intake of vitamin B-6 was marginal. The prevalence of obesity was higher among the women, while food selection was healthier as reflected in the higher nutrient density than among the men. Food consumption of elderly men (26%) and women (33%) on a dietary regimen was more prudent and nutrient density higher than among the elderly not on a diet. Our results are in accordance with previous food consumption studies among elderly people in The Netherlands, but differ substantially from dietary intake figures for American elderly. Although the intake of energy and nutrients was lower among elderly men than among younger men, we conclude that age per se is not an important determinant of dietary intake among Dutch apparently healthy elderly aged 65-79 y.

Introduction

In general, the elderly are observed to eat less and to have lower energy expenditures than younger adults (1-4). Low intake of energy mostly goes hand in hand with low intake of nutrients (5,6). Therefore, intake of some nutrients may be inadequate since most nutrient requirements of the elderly are considered to be at least equal to those of younger adults (7-9).

The elderly are a heterogeneous group with regard to health conditions and physiological age. Extrinsic factors, such as

* Subtitled with (Dutch Nutrition Surveillance System).
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nutrition, may influence the rate of functional deterioration which normally becomes more severe with advancing age. Although the current nutrition-related chronic, degenerative diseases among the elderly are mainly influenced by past (irreversible) interactions between nutrition and aging, inadequate food consumption patterns may still increase mortality and morbidity among the elderly in affluent societies (10-12).

Assessment of the prevalence of nutritional deficiencies irrespective of cause would require a random sample from the entire population of elderly people, as has been done in the United States (13), United Kingdom (14), and West Germany (15). Since many elderly suffer from chronic diseases, which may be more important than age itself in determining intake of energy and nutrients, such a sample cannot yield definitive conclusions as to the occurrence of nutritional problems. In contrast, healthy elderly are an atypical sample. Food consumption data from such a population do not allow extrapolation to general nutritional guidelines and recommendations, because health status of these elderly is probably more the result of genetic make-up and selective mortality than of extrinsic effects (such as nutrition) on aging.

To reduce the influence of diseases on the data obtained on dietary intake of the elderly, we selected apparently healthy elderly in a national nutritional survey. In our study the intake of energy and nutrients was compared with those of younger adults. We also studied changes in dietary intake with advancing age within the participating group of elderly people.

Subjects and methods

As part of the Dutch Nutritional Surveillance System (16) a nationwide nutritional survey among apparently healthy elderly has been carried out from October 1, 1984 until February 8, 1985 (with a break from December 21, to January 14, due to Christmas and New Years). The study design (n=540) consisted of a two-stage cluster sample, stratified on the basis of region (north, east, south and west), degree of urbanization (< 20,000, 20,000-400,000, and > 400,000 inhabitants), age group (65-69, 70-74, and 75-79-y-old), and gender. Entry criteria were: aged 65-79 y, independently living, Caucasian and apparently healthy. 'Apparently healthy' had been defined as not bedridden, not in a wheelchair and not suffering from a disease that would probably end life in the near future. All respondents were mentally and physically able to participate in the entire study protocol. In total, 75 of the "approached" elderly did not meet the criterion of apparently

healthy, the most important reason being (recent) hospitalization (31%). Verbal consent was obtained after the nature of the study was fully explained by letter. The study design and procedures have been tested, and approved by the external Medical Ethics Committee of the TNO-CIVO Toxicology and Nutrition Institute. Actually, 539 elderly people participated in the survey after a random selection from 18 municipal registers. The response rate was 53%, and 39% refused participation. Nonresponse bias is not likely since respondents and nonrespondents did not differ significantly in marital status and housing situation. Furthermore, the civil state (age- and gender-specific) and the percentage with a supplementary social security benefit among respondents correspond to data of The Netherlands Central Bureau for Statistics (17).

All respondents were visited twice at home. During the first visit data were collected on demographic variables, living, shopping and cooking arrangements, meal pattern, dietary regimen, smoking habits and usual food consumption pattern. Respondents were carefully instructed to collect one 24-h urine between the two visits. At the second visit, usually a few days later, a physician used structured questionnaires to obtain information on clinical condition (including current drug use), usage of nutritional supplements, activities of daily living, socioeconomic background, physical exercise, and dental status. Anthropometric and blood pressure data were recorded and a venous blood sample was obtained for hematological, biochemical and routine clinical analyses. In this manuscript only the data on dietary intake are presented. Food consumption data were obtained by 15 trained dietitians at the homes of the participants with a modified version of the dietary history method with cross-check (18). The habitual pattern of food intake, with special attention to the past two weeks, was assessed. The frequency of consumption and amounts consumed (in common household measures) for the food products included in the checklist were assessed against information on the respondent's usual intake. The reliability of the dietary history has been confirmed in a group of independently living elderly (19), whereas this method has also been validated among elderly on the basis of nitrogen excretion in the urine (20). Dietary information was converted into figures on intake of energy and nutrients with a computerized version of the Dutch Food Composition Table (21,22). The data presented on vitamin and mineral intake refer to food consumption only; intake through nutritional supplements was not taken into account.

The reference values from younger adults (18-y-old men, n=185, and 35-y-old men, n=49) were also obtained by dietary history with cross-check, whereas the procedure described above was also

followed for coding and data processing (23,24). Data on the dietary intake of younger women were not available.

Statistics

To test age dependency of dietary intake among the elderly an analysis of variance was carried out with age groups (65-69, 70-74 and 75-79 y) and gender as factors. The interaction between age category and gender was also included in the model, because changes with age may differ for men and women. The assumptions of the analysis of variance regarding the residuals, namely equality of variances and normal distribution, were checked before the actual analysis was carried out. When the distribution was skewed [as was the case for saturated fatty acids (sfa), monounsaturated fatty acids (mufa), polyunsaturated fatty acids (pufa), cholesterol, alcohol (grams and in energy %), ascorbic acid, P/S ratio, riboflavin per MJ, riboflavin per gram protein, vegetables and sweets/sweet-spread/sugar] values were transformed logarithmically. Out-of-range values were excluded from both the descriptive statistics and the analyses. Actually, all food consumption data of one man (daily use of 400 g blood pudding) and the ascorbic acid intake (374 mg/day) of one woman were regarded as being out of range and excluded.

Differences in discrete variables were examined with χ^2 tests. All statistical tests were two-tailed, and a p value of less than 0.05 was considered to be significant. Data analysis was performed with the statistical computer packages of BMDP (25).

Results

Table 2.1. summarizes some characteristics of the elderly classified according to gender. More women than men were living alone and had a low level of education (maximal 8 y), whereas more men than women had breakfast daily. In the households of the women potatoes and meat were more often prepared for 2 or more days. No significant relationships between age group on the one hand and educational level, vitamin supplement usage, and daily use of breakfast, lunch, and dinner on the other hand were observed. Although living alone increases with advancing age for both sexes, it reaches statistical significance for women only. In the household of the men 75-79 y of age potatoes are more often (13%) prepared for 2 or more days at the same time, while daily fresh preparation of vegetables decreases with age among women. About half of the elderly practice physical (sport) activities on a

Table 2.1.
Some characteristics of independently living elderly men and women

Characteristic	Men n=269	Women n=269
Mean age (y)	72.4	72.3
Living alone (%)	14	43***
Low educational level# (%)	68	77**
Regular physical activities (%)	52	46
Daily use of		
breakfast	98	93***
lunch	90	92
dinner	90	86
Daily fresh preparation of		
potatoes	92	84***
vegetables	91	86
meat	52	41**
Nutrition supplement usage		
vitamin A	5	5
vitamin B complex	8	11
vitamin C	6	5
vitamin D	5	5
folic acid	1	1
iron	1	3
calcium	1	1
Prescribed diet (restriction)		
sodium	13	18
fat/cholesterol	8	9
mono- and disaccharide	7	9
energy	3	3
remainder	2	3

Maximal 8 y; * $p < 0.05$; ** $p < 0.025$; *** $p < 0.01$.

regular basis, but this percentage decreases with age (especially among women). The lowest prevalence (6%) of a sodium-restricted dietary regimen was observed among men 65-69 y old.

In **Tables 2.2.-2.5.** the food consumption data are presented. Since no significant interactions between age and gender were observed, differences between age groups are similar for both sexes. Data are therefore presented separately for age groups and gender. In Tables 2.2.-2.4. the data are presented according to

Table 2.2.
Daily intake (mean ± SD) of energy and nutrients of elderly men and women and younger men

Nutrient	Younger adults		Elderly	
	18-y old men n=185	35-y old men n=49	Men n=269	Women n=269
Energy (MJ)	14.3	12.7	10.1 ± 2.0	7.9 ± 1.9*
Protein (g)				
vegetable	38	36	26 ± 7	21 ± 6*
animal	61	63	56 ± 14	49 ± 13*
Fat (g)				
sfa+	66	57	47 ± 15	36 ± 13*
mufa+	55	51	41 ± 12	31 ± 10*
pufa+	24	22	18 ± 9	14 ± 6*
Cholesterol (mg)	414	413	355 ± 121	290 ± 105*
Carbohydrate (g)				
mono- and disaccharides	200	140	128 ± 49	104 ± 39*
polysaccharides	204	172	123 ± 32	98 ± 26*
Dietary fiber (g)	34	31	27 ± 8	23 ± 7*
Alcohol (g)#	16	23	10	1*
Water (L)	2.59	2.82	2.15 ± 0.49	1.98 ± 0.47*
Phosphorus (g)	2.10	2.11	1.57 ± 0.36	1.35 ± 0.34*
Calcium (g)	1.39	1.40	1.13 ± 0.37	1.01 ± 0.34*
Iron (mg)				
heme	3.7	3.9	3.0 ± 1.1	2.5 ± 1.0*
nonheme	11.7	12.7	10.1 ± 2.7	8.8 ± 2.4*
Potassium (g)	5.32	4.65	3.72 ± 0.81	3.24 ± 0.76*
Retinol eq (mg)	1.22	1.22	1.07 ± 0.39	0.95 ± 0.38*
Thiamin (mg)	1.41	1.37	1.11 ± 0.24	0.93 ± 0.24*
Riboflavin (mg)	2.27	2.18	1.70 ± 0.47	1.51 ± 0.42*
Pyridoxine (mg)	1.77	1.60	1.38 ± 0.35	1.15 ± 0.30*
Ascorbic acid (mg)	112	73	94 ± 43	101 ± 43

Median (skew distribution); * $p < 0.001$ between elderly men and women; + sfa: saturated fatty acids, mufa: monounsaturated fatty acids, pufa: polyunsaturated fatty acids.

Table 2.3.
Some qualitative indicators of the dietary intake (mean ± SD) of elderly men and women

Variable	Younger adults		Elderly	
	18-y old men n=185	35-y old men n=49	Men n=269	Women n=269
Protein (% of total energy)	11.8	13.2	13.7 ± 2.3	15.1 ± 2.7**
Fat (% of total energy)	37.5	40.0	40.4 ± 5.8	39.6 ± 6.2
Carbohydrate (% of total energy)	47.8	41.4	41.6 ± 6.8	43.1 ± 6.6*
Alcohol (% of total energy)#	1.4	4.5	2.6	0.5*
P/S ratio	0.41	0.39	0.42 ± 0.23	0.40 ± 0.21
Cholesterol (mg/MJ)	29	33	35 ± 10	38 ± 12*
Dietary fiber (g/MJ)	2.3	2.5	2.7 ± 0.7	3.0 ± 0.8**
Calcium/phosphorus ratio	0.65	0.65	0.71 ± 0.11	0.74 ± 0.12**
Thiamin (mg/MJ)	0.10	0.11	0.11 ± 0.02	0.12 ± 0.02**
Riboflavin (mg/MJ)	0.16	0.17	0.17 ± 0.04	0.20 ± 0.05**
Riboflavin (µg/g protein)	22	22	21 ± 4	22 ± 4*
Pyridoxine (µg/MJ)	153	127	139 ± 29	149 ± 31**
Pyridoxine (µg/g protein)	22	16	17 ± 3	17 ± 3

Median (skew distribution); Difference between elderly men and women: * $p < 0.05$, ** $p < 0.01$.

Table 2.4.
Daily use (mean ± SD) of some food groups (in grams) by elderly men and women

Food group	Men n=269	Women n=269
Potatoes, rice, pulses, paste	205 ± 102	142 ± 64*
Bread	149 ± 57	116 ± 46*
Nonalcoholic beverages	1057 ± 389	1032 ± 384
Fresh fruits	175 ± 135	187 ± 131
Vegetables	179 ± 86	182 ± 85
Biscuits and pastry	43 ± 29	42 ± 26
Milk and milk products	362 ± 234	336 ± 216
Cheese	37 ± 26	33 ± 20
Fats and oils	52 ± 22	39 ± 18*
Sweets, sweetspread, sugar	53 ± 38	32 ± 27*
Meat and meat products	114 ± 40	96 ± 34*
Eggs	19 ± 16	15 ± 13*

* $p < 0.01$.

Table 2.5.
Age-dependent variables of the daily dietary intake (mean ± SD) of elderly according to age groups

Variable	Age group 65-69 y n=178	70-74 y n=180	75-79 y n=180
Water (L)	2.13 ± 0.53	2.07 ± 0.45	1.98 ± 0.48**
Thiamin (mg)	1.04 ± 0.27	1.03 ± 0.24	0.98 ± 0.25*
Thiamin (mg/MJ)	0.12 ± 0.02	0.12 ± 0.02	0.11 ± 0.02**
Pyridoxine (µg/MJ)	144 ± 32	146 ± 30	139 ± 28*
Nonalcoholic beverages (g)	1085 ± 408	1052 ± 343	980 ± 360**
Meat and meat products (g)	108 ± 38	108 ± 38	99 ± 38*

Differences among age groups significant at * $p < 0.05$, ** $p < 0.025$.

gender, whereas Table 2.5. shows the variables that appeared to be age-dependent. Men consume substantially more energy, protein, fat, alcohol, cholesterol, carbohydrates, dietary fiber, water, minerals and vitamins, but slightly ($p = 0.07$) less ascorbic acid than women. The nutrient density of the diet is higher among women than among men, reflecting the healthier food choice of women. Women consume somewhat more vegetables, fruit, fruit juice, and skimmed milk products, and less sugar, alcoholic beverages, coffee, soft drinks, fats, whole milk, and fat meat products than men.

The intake of water, thiamin (both absolute and per MJ) and pyridoxine (per MJ) and the use of nonalcoholic beverages and meat (products) tends to decrease with advancing age (see Table 2.5.). The use of nonalcoholic beverages is strongly ($r = 0.73$; $p < 0.001$) correlated with the intake of water, whereas a somewhat weaker relationship was observed between the use of meat (products) and the intake of thiamin ($r = 0.43$; $p < 0.001$) and of pyridoxine per MJ ($r = 0.16$; $p < 0.001$). Women aged 65-69 y consume more alcohol (both in grams and in energy percentage) than women 70-79 y of age.

About 26% of the men and 33% of the women were following a diet. A sodium restriction is the most important characteristic. After exclusion of the elderly on a dietary regimen (n=151) the differences described between men and women as well as between age groups still exist. However, the lower use of white bread, alcoholic beverages, eggs, biscuits and pastry, butter, sugar, and meat (especially pork) and a higher consumption of brown bread and skimmed milk products render a more prudent food pattern and of a higher nutrient density among the elderly on a dietary regimen than that of the elderly not on a diet.

On the average, the elderly on a dietary regimen have a lower intake of energy, fat (sfa and mufa), cholesterol (both absolute and per MJ), mono- and disaccharides, and alcohol, whereas the intake of calcium and water (men only) was found to be higher among these elderly. This results in a higher nutrient density (dietary fiber, thiamin, riboflavin and pyridoxine per MJ), P/S ratio and calcium/phosphorus ratio for elderly on a diet, whereas these elderly obtain more energy from protein and polysaccharides than those not on a diet. On the average, the 24-h urine excretion of sodium among the elderly on a sodium restricted diet (men: 7.6 g NaCl; women: 5.5 g NaCl) is lower than among elderly not on such a dietary regimen (8.8 g NaCl and 7.1 g NaCl for men and women, respectively). Sodium restriction resulted also in a lower intake of fat (sfa and mufa), cholesterol (both absolute and per MJ), and retinol, but a higher P/S ratio in the diet. More energy is derived from carbohydrates and less from fat among elderly

subjects with a sodium restricted diet. In contrast, in the diet of the elderly with a mono- and disaccharide restriction more energy comes from protein (especially animal) and fat (especially sfa), and less from carbohydrates (especially mono- and disaccharides).

Compared to younger (18- and 35-y-old) men, elderly men have a low intake of energy and nutrients (see Table 2.2.). The quality of dietary intake of elderly men, as reflected by the distribution between the energy-providing nutrients, P/S ratio, and nutrient density, is roughly similar to that of the diet of 35-y-old men. However, the dietary intake of elderly men differs from that of 18-y-old men with respect to the percentage of energy derived from protein, fat and carbohydrates. Except for pyridoxine, the nutrient density is somewhat lower among 18-y-old men than among elderly men (see also Table 2.3.).

Discussion

Our results on dietary intake fairly well agree with food consumption studies (all utilizing dietary history with cross-check) among elderly people conducted in The Netherlands between 1962 and 1982 (26-30). In contrast, McGandy et al (31) observed substantially lower intakes of energy, fat, carbohydrates, and calcium among 691 apparently healthy elderly from the Greater Boston Area in the United States (using 3-day diet records), whereas the intakes of ascorbic acid, thiamin, riboflavin, retinol, and iron was found to be higher among the American elderly. The diet of the American elderly is more prudent in that more energy comes from carbohydrates and less from protein and, especially, fat; alcohol intake as a percentage of total energy equals that of the Dutch peers. The differences in intake of vitamins are most likely due to use of nutritional supplements, because 39% of the men and 50% of the women surveyed by McGandy et al (31) were using supplements and intake data referred to both food consumption and nutritional supplements. In our data intake by supplements is not included in the nutrient intake calculations, whereas the prevalence of usage is much lower (men 12%; women 17%).

In general, elderly are considered to be at risk for some degree of dehydration (32,33). Although we observed among 75-79-y-old elderly a lower intake of water as a consequence of a lower consumption of nonalcoholic beverages, mean water intake is still adequate. Under normal circumstances a daily intake of 1600-2400 mL is considered to be adequate (34); even the lowest mean intake (1870 mL) found in the group of 75-79-y-old women is within this

range. Dietary habits acquired during adulthood may counteract the impaired thirst responses in the elderly. However, the impact of the use of diuretics and the lower body water reserve of the elderly are not taken into account in the assessment of the water intake.

Nutrient intake of the elderly women studied is somewhat more favorable than that of men. Although the percentage of energy derived from fat tends to be higher among men than among women, this difference is not significant ($p = 0.13$). However, men consume more alcohol, which results in a decrease of the energy% from the other macronutrients. Furthermore, the differences in dietary intake between men and women may be masked by selective cardiovascular mortality due to, among other things, the less healthy lifestyle of men. According to Verbrugge (35), sex differences in health and mortality rates are principally the outcome of differential risks acquired from roles, stress, lifestyle (such as smoking and food consumption habits), and preventive health practices; these differences being determinants of the difference in life expectancy between the genders. In general, rates of morbidity are higher among women than among men (but their disorders are less likely to be fatal), whereas mortality rates are higher in men (35). Our finding of a somewhat healthier food choice of elderly women indicates that nutrition may be one of the components of lifestyle causing the differences mentioned with regard to morbidity and mortality.

As 6% of the elderly men and 20% of the elderly women studied have a body mass index above 30 kg/m^2, the energy intake of these elderly may be too high. According to the Dutch recommendations for a healthy diet (37,38), the intake of (saturated) fat and the P/S ratio of the diet is unfavorable. Except for pyridoxine, the mean intakes of vitamins, minerals, and water were calculated and assessed to be adequate. To improve the food pattern of elderly people the use of bread, potatoes, pasta, pulses, vegetables, fruit (juices), and skimmed milk products may be increased, and the intake of products with a high (saturated) fat content restricted. Selective restriction (e.g., fat and salt) is probably more important than a general energy restriction, because adequate amounts of essential nutrients must be maintained.

Many diseases and disorders may require special diets, meaning a change in lifestyle. A substantial part of the elderly (29%) were on a (prescribed) dietary regimen, which proved to be more favorable, and 34% had stopped smoking, indicating that common pathological processes such as hypertension resulted in a more healthy lifestyle among these elderly. Our results show that the dietary intake of elderly on a dietary regimen is more favorable with respect to nutrient density, P/S ratio, calcium/phosphorus

ratio, and the proportion between the energy-providing nutrients. This implies that the differences in dietary intake between elderly and younger adults are probably masked somewhat because of the higher prevalence of prescribed diets among elderly people.

Our anthropometric and biochemical results (Chapter 3) show that the build and composition of the body differs among the age groups studied (36). On average, body height, body weight and muscle mass (as assessed by the excretion of 3-methylhistidine and creatinine) is lower among the elderly aged 75-79 y than among the group 65-69-y-old. Furthermore, we found that the percentage of elderly practicing physical (sport) activities decreases with advancing age. Despite these differences we did not observe relevant effects of age on dietary intake of the elderly aged 65-79 y. In general, energy intake decreases with advancing age which results in a lower intake of most nutrients (3-5). Our comparison with younger adults is in accordance with that general observation. Particularly elderly in poor health, which may limit physical activities, have an impaired appetite and a depressed intake of energy and nutrients, whereas diseases and drug usage may increase nutrient requirements (14). Posner et al (39) observed a mean daily energy intake of 6.0 MJ among homebound elderly aged 66-99 y, but no significant change with age within this population. The health status of these homebound elderly also proved to be independent of age. In contrast, some elderly maintain a high level of physical activity and show only very small reductions in basal metabolic rates and little change in body composition (40).

Conclusions

We conclude that age per se is not an important determinant of the intake of energy and nutrients among apparently healthy elderly aged 65-79 y in The Netherlands. This may probably be attributed to our selection of apparently healthy elderly people. However, the intake of energy and nutrients of the elderly is lower than that of younger adults, which can be accounted by reduced physical activities as a result of changed lifestyle. Whether the nutritional recommendations should be adjusted on the basis of the observed age-dependent changes in body build and composition is questionable. Since age-related morbidity and mortality may decrease when physical activities and lean body mass are maintained in older persons, a decline in these variables cannot be considered as normal and (implicitly) harmless (41-43). A fundamental question is whether the lower intake may lead to vitamin or mineral malnutrition in some elderly, and whether a

particular state of subnutrition is associated with increased health risks. Because it is still unknown whether nutrient requirements of elderly subjects are similar to those of younger adults, our nutritional assessment may be somewhat distorted. Pyridoxine is of special importance since its intake is calculated to be marginal, indicating that elderly are a risk group with regard to this nutrient. Stimulation of physical activity is considered to be of vital importance, maintaining the energy balance on a relatively high level, which in turn ensures most likely an adequate intake of nutrients without the risk of severe obesity.

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3. NUTRITION AND AGING: NUTRITIONAL STATUS OF "APPARENTLY HEALTHY" ELDERLY*

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ABSTRACT

In a nationwide survey the nutritional status was assessed of 539 apparently healthy, independently living elderly aged 65-79 y. Anthropometric data showed no energy deficits. The prevalence of anemia was 4 and 1% among men and women, respectively. Many elderly showed a low level of 25-hydroxyvitamin D in plasma (< 31 nmol/L: men 35%; women 43%) indicating a marginal status. Although the prevalence of low blood levels of folate, pyridoxal 5'-phosphate and total carotenoids was higher among the elderly than among younger adults, clear (clinical) signs of nutritional deficiencies were not observed. Prevalence of obesity (13%), hypercholesterolemia (38%) and hypertension (63%) was found to be high, the percentages being higher for women than for men. Several indicators of the nutritional status appeared to differ among age groups. It is concluded that few differences can be considered as being due to physiological aging, which finding should be reflected in reference values for elderly people.

Introduction

Biological aging after maturity is usually marked by physiological changes in the human body. Individuals differ as to the progress of aging. Genetics, use of health care, environmental exposure and (former) lifestyle (including diet) are among the determinants of this interindividual variation.

There is a recurrent debate whether age-related changes should be attributed to aging per se and therefore must be considered as normal, and thus inevitable, concomitants of aging (1-3). If so, age-specific reference values are necessary for any assessment of the nutritional status of elderly people. This implies that a distinction must be made between changes caused by aging per se,

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and factors such as lifestyle changes, cohort effects, selective mortality and, especially, diseases. Physiological changes caused by aging are often superimposed on pathological processes. However, some large-scale nutritional surveys among randomly selected elderly people (4-6) have not excluded the elderly with serious illnesses.

The survey reported in this paper was designed to assess the nutritional status among independently living elderly in The Netherlands. To reduce the influence of diseases, we selected apparently healthy elderly only for our study. To obtain an insight into the need for age-specific reference values, the indicators of the nutritional status of the elderly were compared with those of apparently healthy younger adults. Moreover, differences among age categories in the indicators were studied within the group of participating elderly aged 65-79 y.

Study design and subjects

As part of the Dutch nutrition surveillance system (7), a nationwide nutritional survey among apparently healthy elderly has been carried out in 1984-85. The study design consisted of a two-stage cluster sample stratified for region (north, east, south, and west), degree of urbanization (< 20,000, 20,000-400,000 and > 400,000 inhabitants), age group (65-69, 70-74, and 75-79 y), and gender (men and women). The number of subjects investigated was equal in all strata. Entry criteria were: age (65-79 y), living independently, Caucasian and apparently healthy. The latter has been defined as not bedridden, not in a wheelchair, and not suffering from a disease that would probably end life in the near future. All respondents had to be mentally and physically able to participate in the entire study protocol. In total, 75 of the "approached" elderly did not meet the criterion of apparently healthy, the most important reason being (recent) hospitalization (31%). Verbal consent was obtained after the nature of the study was fully explained by letter. Study design and procedures were tested and approved by the external Medical Ethics Committee of the TNO-CIVO Toxicology and Nutrition Institute.

Actually, 539 elderly people, randomly selected from samples of 18 municipal registers, participated. The response rate was 53%. The presence of a considerable responder bias is unlikely since respondents and nonrespondents did not differ significantly in civil state and housing situation. Furthermore, the civil state (age- and gender-specific) and the percentage of respondents with a supplementary social benefit corresponded to data of the Netherlands Central Bureau for Statistics (8).

Data collection

All respondents were visited twice at home. During the first visit data were collected on lifestyle (such as food consumption) and sociodemographic variables. At the second visit, usually a few days later, a physician used structured questionnaires to obtain information on clinical condition (including current drug use), usage of nutritional supplements, activities of daily living, socioeconomic background, physical exercise and dental status. Dietary data and information on the use of nutritional supplements are presented elsewhere (9). Body weight (calibrated portable scale), body height, upper arm length, upper arm circumference (metal tape), triceps and biceps skinfold thickness (Holtain caliper), systolic (Korotkov phase I) and diastolic (Korotkov phase IV or V) blood pressure (seated) were measured according to standardized procedures. Anthropometric variables were measured for 535 elderly. Body height and weight were measured without shoes but with one layer of clothing. Due to severe senile kyphosis, the heights of one man and four women were not measured, whereas in five elderly blood pressure was not measured. Body mass index (BMI) was calculated by dividing weight (kg) by height (m) squared. Percentage of body fat was calculated from the sum of biceps and triceps skinfold thicknesses using the linear regression equations for men aged 50-72 y and for women aged 50-68 y published by Durnin and Womersley (10). At the end of the second visit, a venous blood sample was taken from 529 elderly for hematological, biochemical, and clinical chemical analyses. Urine (24-h, to which 10 mL of 1 mol/L HCl was added as a preservative) was collected between the two visits by 520 respondents. Several biochemical variables were measured in blood and urine for a random subsample (same stratification as in the main design) of 108 respondents.

All biochemical measurements, including the reference values obtained from blood donors (11) and 35-y-old men (12), were carried out in the same laboratories of the Departments of Clinical Biochemistry and Human Nutrition of TNO-CIVO Toxicology and Nutrition Institute. In order to standardize the methods as far as possible, only younger population groups that were also studied by our Institute were used for comparison purposes. **Table 3.1.** shows the biochemical analyses, methods used, mediums, and references to more detailed descriptions of the methods (13-31).

Table 3.1.
Methods of biochemical analyses conducted in blood and urine

Variable	Material	Used kit and/or method (reference for method)
Hematology	Blood	Coulter counter Sysmex-cc-180 (13)
Iron	Serum	Boehringer Mannheim kit 124222(14)
TIBC#	Serum	Boehringer Mannheim kit 124222 and 125806 (14)
Ferritin	Serum	Ramco kit (15)
Zinc	Serum	Atomic absorption spectrophotometry (16)
EGR activity*	Erythrocytes	Spectrophotometry (17)
EAST activity*	Erythrocytes	Spectrophotometry (18)
PLP+	Plasma	Radioenzymatic assay (19)
Vitamin B-12	Plasma	Simultrac kit (20)
Folate	Plasma	Simultrac kit (21)
All-trans retinol	Plasma	HPLC (22)
Total carotenoids	Plasma	Colorimetry (23)
25-OH-vitamin D	Plasma	Competitive protein-binding assay (24)
Total cholesterol	Serum	Boehringer Mannheim kit 704121
HDL-cholesterol	Serum	Boehringer Mannheim kit 704121 and 543004
Uric acid	Serum	Boehringer Mannheim kit 704156
Thyroxine	Plasma	Diagnostic products kit KT4D5
Creatinine	Serum	Boehringer Mannheim kit 704130 (25)
Creatinine	Urine	Boehringer Mannheim kit 704130 (25)
3-Methylhistidine	Urine	HPLC (26)
Hydroxyproline	Urine	Organon Teknica Hypronosticon kit
Sulfate	Urine	Colorimetry (27)
Sodium	Urine	Atomic absorption spectrophotometry (28)
Potassium	Urine	Atomic absorption spectrophotometry (28)
Calcium	Urine	Boehringer Mannheim kit 749125 (29)
Magnesium	Urine	Roche Diagnostica kit 07-1019 (30)
Iodide	Urine	HPLC (31)

TIBC: total iron binding capacity; * EGR: erythrocyte glutathion reductase, EAST: erythrocyte aspartate aminotransferase; + PLP: pyridoxal 5'-phosphate.

Statistics

To test the age dependence of the indicators of nutritional status, an analysis of variance was carried out with age groups (65-69, 70-74, and 75-79 y) and gender as factors. The interaction among age groups and gender was also included in the model. The assumptions (equality of variances and normal distribution) of the analysis of variance were checked. In case of skewed distribution (body mass index, biceps and triceps skinfold, ferritin, pyridoxal 5'-phosphate, vitamin B-12, all-trans retinol, total carotenoids, 25-hydroxyvitamin D, and iodide excretion) a transformation (natural logarithm) of each value was carried out. Out-of-range values were excluded from both the descriptive statistics and the statistical analyses. Actually, the value of the serum total cholesterol concentration of one woman (19.31 mmol/L) and four values (20.03, 25.76, 40.78, and 53.87 µmol/24-h) of iodide excretion were excluded. These outliers violated the assumptions of the analysis of variance and could therefore distort the results regarding differences between the age groups and gender. Differences in discrete variables regarding gender and age group were examined with χ^2 tests. Data analysis was performed with the BMDP statistical computer package (32). All statistical tests were two-tailed; effects with a p value of less than 0.05 were considered significant.

Results

Table 3.2. summarizes some characteristics of the elderly. More men than women were married. Only 5% of the men, but 65% of the women, had never smoked tobacco. The ability to walk outside the home without help and without resting for a period more than 40 minutes, and regular exposure to sunlight were higher among men than women. In Table 3.2. only drugs used by more than 5% of the population are presented. In general, women used more drugs. No significant differences were observed among age groups as regards percentages of respondents who had stopped smoking, were edentulous, or had problems with chewing. Except for an increase with age in the use of medicines for adrenergic/cardiac disorders (men only) and antihypertensive agents (women only), drug usage was similar for all age groups. The percentages of married women, female smokers, and women who often expose themselves to sunlight were lower at higher age, as well as the ability of women to walk outside without help and without resting.

Tables 3.3.-3.8. present data on the nutritional status (anthropometry, blood and 24-h urine biochemical analyses). No

Table 3.2.
Some characteristics of
independently living elderly men and women

Characteristic	Men n=270+	Women n=269+
Mean age (y)	72.4	72.3
Married (%)	80	50***
Smoking		
current (%)	49	12***
former (%)	46	23***
Edentulous (%)	78	83
Problems with chewing (%)	4	8
Regular exposition to sunlight (%)	68	53***
Ability to walk outside		
(> 40 min) (%)	77	60***
Drug use		
diuretics (%)	17	28***
antihypertensive agents (%)	17	22
adrenergics/cardiacs (%)	21	20
bronchodilitators (%)	15	11
analgesics (%)	8	17***
sedatives (%)	7	17***
anticoagulants (%)	12	4**
neuroleptics (%)	4	7

+ Maximum number; Difference between men and women significant at:
* $p < 0.05$, ** $p < 0.025$, *** $p < 0.01$.

significant interactions between age and gender were observed in the age-dependent parameters. This implies that differences among age groups were similar for both sexes. Therefore, we present the data separately for age groups and gender. In Tables 3.3.-3.7. the data are presented according to gender, whereas Table 3.8. shows the variables that appeared to differ among the age groups. Most indicators of nutritional status studied differ between men and women, men having mostly higher mean values than women. No significant differences among age groups were found for hemoglobin when elderly with hemoglobin values lower than 7.5 mmol/L (n=8) were excluded from the analysis. After exclusion of elderly using drugs with an antihypertensive effect systolic (but not diastolic) blood pressure increased with age.

Creatinine clearance was positively correlated ($p < 0.001$) with excretion of calcium ($r = 0.31$), potassium ($r = 0.35$), magnesium

Table 3.3.
Anthropometry and blood pressure
(mean ± SD) of 35-y-old men and elderly men and women

Variable	35-y-old men n=60	Elderly Men n=268+	Elderly Women n=267+
Body height (cm)	179	172.3 ± 6.6	160.3 ± 5.7**
Upper arm length (cm)	31.8	32.7 ± 2.2	30.6 ± 2.0**
Body weight (kg)	78.7	75.8 ± 10.5	69.6 ± 11.6**
Body mass index (kg/m²)	24.5	25.5 ± 2.9	27.1 ± 4.3**
Body fatness (%)	26.3	29.5 ± 4.9	39.9 ± 5.1**
Biceps skinfold (mm)	12.3	6.8 ± 2.4	14.5 ± 7.1**
Triceps skinfold (mm)	15.3	12.2 ± 5.2	24.9 ± 7.7**
Blood pressure			
diastolic (mmHg)	79	85 ± 11	88 ± 11**
systolic (mmHg)	134	151 ± 22	156 ± 22*

+ Maximum number; Difference between elderly men and women significant at: * $p < 0.01$; ** $p < 0.001$.

Table 3.4.
Hematology and iron and zinc status
(mean ± SD) of 35-y-old men and elderly men and women

Variable	35-y-old men n=60	Elderly Men n=268	Elderly Women n=261
Hemoglobin (mmol/L)	9.9	9.5 ± 0.9	8.8 ± 0.6**
Hematocrit (%)	46.4	43.4 ± 4.0	40.5 ± 2.9**
Red cell count (10^9/mL)	5.07	4.80 ± 0.45	4.56 ± 0.35**
MCV (fL)#	92	91 ± 5	89 ± 4**
Iron (µmol/L)+	-	17.7 ± 6.2	16.7 ± 5.1
TIBC (µmol/L)+#	-	59.2 ± 8.5	59.0 ± 10.1
Iron saturation (%)+	-	30.5 ± 11.2	28.8 ± 9.1
Ferritin (µg/L)+	83	98 ± 72	72 ± 74**
Zinc (mg/L)+	0.94	1.06 ± 0.20	1.08 ± 0.14

MCV: mean corpuscular volume, TIBC: total iron binding capacity;
+ Data refer to 54 elderly men and 54 elderly women; Difference between men and women significant at: * $p < 0.01$, ** $p < 0.001$.

Table 3.5.
Vitamin status (mean ± SD)
of elderly and younger adults according to gender

Variable	Men		Women	
	18-64 y n=91	Elderly n=268	18-64 y n=71	Elderly n=261
EGR-AC (ratio)#	1.09	1.12 ± 0.11	1.11	1.09 ± 0.10*
EAST-AC (ratio)#	1.86	1.69 ± 0.21	1.80	1.72 ± 0.21
PLP (nmol/L)+#	48	27 ± 22	43	45 ± 43**
Vitamin B-12 (pmol/L)+	302	288 ± 138	300	268 ± 143
Folate (nmol/L)+	10.0	6.6 ± 2.5	10.6	7.3 ± 2.6
All-trans retinol (µmol/L)+	2.2	1.4 ± 0.5	1.9	1.3 ± 0.4
Total carotenoids (µmol/L)+	2.0	1.5 ± 0.9	2.6	1.8 ± 0.7*
25-OH-vitamin D (nmol/L)+	71	40 ± 19	70	38 ± 16

EGR-AC: erythrocyte glutathion reductase, EAST-AC: erythrocyte aspartate aminotransferase, PLP: pyridoxal 5'-phosphate; + Data refer to 54 elderly men and 54 elderly women; Difference between elderly men and women significant at: * $p < 0.01$, ** $p < 0.001$.

Table 3.6.
Blood biochemistry (mean ± SD)
of 35-y-old men and elderly men and women

Variable	35-y-old men n=60	Elderly	
		Men n=268	Women n=261
Total cholesterol (mmol/L)	5.4	6.00 ± 1.01	6.53 ± 1.26**
HDL-cholesterol (mmol/L)+#	1.18	1.02 ± 0.26	1.35 ± 0.36**
Total/HDL-cholesterol (ratio)+#	4.8	6.13 ± 1.62	5.17 ± 1.46**
Uric acid (µmol/L)	-	340 ± 83	307 ± 71**
Creatinine (µmol/L)	-	114 ± 21	98 ± 18**
Thyroxine (nmol/L)+	-	108 ± 22	109 ± 18

+ Data refer to 54 elderly men and 54 elderly women; Difference between elderly men and women significant at: * $p < 0.01$, ** $p < 0.001$; # HDL: high density lipoprotein.

Table 3.7.
Urine biochemistry (mean ± SD) of elderly men and women

Variable	Men n=262	Women n=258
Volume 24-h urine (mL)	1554 ± 520	1524 ± 522
Density (g/L)	1016 ± 5	1014 ± 5**
Creatinine (mmol/24-h)	11.9 ± 3.2	8.3 ± 2.5**
Creatinine clearance (mL/min)	74.3 ± 21.5	60.4 ± 18.8**
Sodium (mmol/24-h)	147 ± 54	117 ± 51**
Potassium (mmol/24-h)	66 ± 20	57 ± 17**
Calcium (mmol/24-h)	3.31 ± 1.86	3.24 ± 2.08
Magnesium (mmol/24-h)	3.17 ± 1.17	2.73 ± 1.05**
Iodide (µmol/24-h)	0.96 ± 0.55	0.80 ± 0.62**
3-Methylhistidine (µmol/24-h)+	311 ± 77	218 ± 68**
Hydroxyproline (mg/24-h)+	20.0 ± 7.2	18.3 ± 6.3
Sulfate (mmol/24-h)+	17.8 ± 5.5	15.0 ± 5.8*

+ Data refer to 54 elderly men and 54 elderly women; Difference between elderly men and women significant at: * $p < 0.025$, ** $p < 0.001$.

($r = 0.23$), and iodide ($r = 0.14$, $p = 0.001$).

The anthropometric data did not indicate a marginal energy status among the elderly studied. According to the criteria of the World Health Organization (33) anemia was found among 4% of the men (hemoglobin < 8.1 mmol/L) and 1% of the women (hemoglobin < 7.5 mmol/L). Frank nutritional deficiencies were not observed. However, compared to the 2.5 percentile (P 2.5) of younger (18-64 years) adults (11), a substantial percentage of the elderly had relatively low values of folate (men 30%, women 17% below 5 nmol/L), pyridoxal 5'-phosphate (men 43%, women 13% below 19 nmol/L), basal EAST activity (men 14%, women 10% below 45 U/mmol Hb), total EAST activity (men 14%, women 7% below 80 U/mmol Hb), total carotenoids (men 22%, women 13% below 1.0 µmol/L) and 25-hydroxyvitamin D (men 35%, women 43% below 31 nmol/L). The mean 25-hydroxyvitamin D concentration was lower among elderly who stated they were rarely exposed to the sun (34 nmol/L) than among those with regular exposure to sunlight (42 nmol/L). Using a cutoff value of 0.79 µmol/24-h (34) for iodide excretion, 38% of the men had lower excretions, whereas this value was 60% for the women.

The cardiovascular risk profile among the elderly was relatively unfavorable. Hypertension (diastolic blood pressure

Table 3.8.
Age-dependent indicators of the nutritional status (mean ± SD) of the elderly according to age categories

Variable	Age group 65-69 y n=179	70-74 y n=178	75-79 y n=177
Body height (cm)	168.1 ± 8.4	166.3 ± 8.6	164.7 ± 8.6***
Body weight (kg)	74.5 ± 12.3	73.0 ± 11.6	70.6 ± 10.1***
Systolic blood pressure+ (mmHg)	149 ± 21	152 ± 21	158 ± 22***
Hemoglobin (mmol/L)	9.3 ± 0.8	9.2 ± 0.9	9.0 ± 0.9*
25-Hydroxyvitamin D (nmol/L)#	46 ± 21	40 ± 15	31 ± 13***
Total cholesterol (mmol/L)	6.43 ± 1.14	6.25 ± 1.22	6.11 ± 1.13*
Volume urine (mL/24-h)	1562 ± 507	1613 ± 530	1439 ± 512***
Creatinine clearance (mL/min)	73.7 ± 21.1	66.6 ± 22.0	61.0 ± 18.4***
Creatinine (mmol/24-h)	11.0 ± 3.4	10.0 ± 3.6	9.4 ± 2.9***
Potassium (mmol/24-h)	64 ± 20	62 ± 18	58 ± 20**
Calcium (mmol/24-h)	3.69 ± 1.92	3.26 ± 2.15	2.87 ± 1.75***
Magnesium (mmol/24-h)	3.15 ± 1.22	2.90 ± 1.12	2.79 ± 1.02**
Iodide (µmol/24-h)	0.92 ± 0.71	0.93 ± 0.62	0.78 ± 0.36**
3-Methylhistidine (µmol/24-h)#	294 ± 88	257 ± 84	242 ± 80*

+ After exclusion of elderly using antihypertensive drugs; # Data refer to 36 subjects per age group; Difference among age-groups significant at: * $p < 0.05$, ** $p < 0.025$, *** $p < 0.01$.

≥ 95 mmHg and/or systolic blood pressure ≥ 160 mmHg (35) and/or use of blood pressure-lowering drugs) was observed among 58% of the men and 68% of the women. The differences in blood pressure between men and women are masked somewhat by more use of diuretics by elderly women. Total serum cholesterol ≥ 6.5 mmol/L was found in 28% of the men and 48% of the women, whereas 6% of the men and 20% of the women were obese (BMI ≥ 30 kg/m²). The cutoff value of 6.5 mmol/L for total serum cholesterol is derived from the Dutch Consensus Conference (36); the cutoff value for obesity comes from Garrow (37). About 5% of the elderly men had never smoked; 49% were smokers; among women these percentages were 65 and 12%, respectively. A high proportion of the elderly suffered from cardiovascular diseases, as indicated by frequent use of drugs related to these diseases (Table 3.2.).

Discussion

Our survey was designed to obtain insight into the nutritional status among apparently healthy, independently living Dutch elderly. Clinical deficiencies of vitamins or minerals are rarely seen in affluent societies. This also holds true for apparently healthy elderly in The Netherlands. Chronic and intercurrent diseases and medical intervention (drugs, surgery) are usually the cause of deficiencies in the elderly, as has been shown by the survey among elderly people in the United Kingdom (4). Since we excluded people older than 79 y and the elderly suffering from severe chronic diseases (6% of the original sample) as well as people in institutions (about 10% of the Dutch population of 65 y and over), who are often confronted with illnesses and disabilities, we might have excluded elderly with a higher risk of a marginal nutritional status. For instance, as in our study, in several studies a decline of 25-hydroxyvitamin D with age, and biochemical evidence of vitamin D deficiency among elderly people was found (38). Vitamin D levels are usually lower among institutionalized elderly subjects (39).

Our comparison of the percentage of elderly in the tail (below P 2.5 or above P 97.5) of the particular distribution of younger adults show that many elderly have relatively unfavorable values of several indicators of the nutritional status. Plasma pyridoxal 5'-phosphate, total carotenoids, and folate to some extent reflect recent dietary intake, whereas the observed lower values of these indicators are in accordance with our data on dietary intake. Compared to younger men (18- and 35-y-old), elderly men appeared to have a lower intake of energy and nutrients (9). Our data on the 24-h excretion of sodium, potassium, calcium and magnesium

fairly well agree with data on other Dutch elderly men and women, but these were low in comparison with younger adults (40). Many elderly showed a low excretion of iodide in the 24-h urine. However, since the health consequences of these low levels at old age are still unkown, no conclusion can be drawn whether this indicates a marginal status among these elderly.

Among the elderly studied, some parameters of the nutritional status were found to differ among the age groups. Knowledge of the origin of age-related changes is crucial for the assessment of nutritional status. "Normal" biological changes with age have to be taken into account in age-specific reference values, since they represent unavoidable risks in an elderly population. However, differences among the age groups are not necessarily manifestations of aging in cross-sectional studies, but may also be due to intercurrent (subclinical) diseases, changes in lifestyle (such as food consumption), selective mortality, or cohort effects. It is particularly important to trace changes in lifestyle since extrinsic factors can be the foundation of preventive measures.

The differences among age groups in body height, systolic blood pressure, kidney function (assessed by creatinine clearance), and excretion of calcium, magnesium, potassium and iodide in the 24-h urine are probably partly true aging effects. Impaired renal function at old age has been described before (41). Since the 24-h excretion of calcium, potassium, magnesium and iodide was positively related with the creatinine clearance (as a marker for physiological aging of the kidney) and we did not observe an age dependence for the intake of calcium and potassium (9), the utilization of these nutrients might have been decreased as a consequence of biological aging. Moreover, a decline in kidney function may result in decreased renal synthesis of 1,25-dihydroxyvitamin D. The consequent reduced intestinal absorption of calcium may contribute to the decline in urinary excretion. In general the decline of body height with age is due to senile kyphosis, narrowing of the discs, and loss of height of the individual vertebrae (42) as well as the result of a cohort effect. The body height at 18 y (results from examination for Dutch military service) of age for men born between 1904 and 1910 was on the average 171 cm and 172 cm for men born between 1911 and 1918 due to a cohort effect (43). The observed decrease in body height with age among the elderly studied is greater than that secular change and points to an effect of aging.

We did not observe differences in hemoglobin among age groups after anemic elderly had been excluded, which implies that the decrease in hemoglobin was due to a minority of the elderly with anemia. Total iron intake of the anemic elderly did not differ

significantly from that of elderly without anemia. Anemia at old age may be the result of (recent) blood loss in the alimentary canal due to pathologic processes (4,44). Our comparison with younger adults did not confirm the often observed increase in ferritin with advancing age (45), probably as a consequence of selecting apparently healthy elderly. An increase in ferritin is usually considered as the result of pathologic processes (45).

Change in lifestyle is the most likely determinant of the decrease in volume of the 24-h urine and in 25-hydroxyvitamin D, as well as changes of body weight and body composition. Our results indicate changes in body build (decrease of body weight) and body composition (decline of excretion of creatinine and 3-methylhistidine in the 24-h urine) with advancing age due to reduced physical activity. Our data on dietary intake (9) show a decrease with age in the intake of water which is related to the lower use of nonalcoholic beverages and resulted in a lower volume of the 24-h urine among the oldest group of elderly.

Aging in middle-aged individuals in affluent societies is usually associated with an increase in nutrition-related cardiovascular risk factors (obesity, hypertension, and hypercholesterolemia). Systolic and diastolic blood pressure as well as total serum cholesterol are normally rising with advancing age, plateauing at middle or old age, and dropping afterwards (except for systolic blood pressure), probably partly due to selective mortality (46,47). Our data on the differences among age groups in the elderly as well as the results of the comparison with younger adults are in agreement with these generally observed tendencies. However, selective mortality may not be the only factor determining the observed lower mean total cholesterol at higher ages. Hershcopf et al (47) observed in their Baltimore longitudinal study of aging a drop in total serum cholesterol that could not be fully explained by changes in dietary factors.

Conclusions

Reasonable assumptions indicate that, except for hemoglobin, no clear pathologic processes can be identified as the most likely cause of differences between elderly and younger adults and of differences among age groups among the elderly studied. Therefore, our data may be used as valid reference values in the sense that they represent a "normal" nutritional risk among Dutch elderly people. Since symptoms of nutritional deficiencies were not observed and the prognostic significance regarding health consequences at a particular level of an indicator of the nutritional status is still unknown, reference values can, for the

time being, only be based on statistical grounds (for instance, $\bar{X}$ ± 2 SD, assuming a Gaussian distribution). However, since we observed a significant prevalence of "marginal" values of some indicators of the nutritional status as compared to younger adults, probably due to lifestyle changes, our results may already represent avoidable increased nutritional risks.

Cross-sectional studies, such as our nationwide nutritional survey, can indicate the most important risks and may provide suggestive evidence for the origin of these risks that have to be studied in more detail. Changes in body composition indicate some restriction of physical activity, which in turn may increase nutritional risks (severe obesity as well as malnutrition). Our results show that osteoporosis-related parameters, such as 25-hydroxyvitamin D and 24-h calcium excretion, and the risk factors for cardiovascular diseases, are of special importance among apparently healthy elderly. Also vitamin B-6 status and eventually iodide excretion infer some risks and therefore warrant further investigation.

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4. ADEQUACY OF A VEGETARIAN DIET AT OLD AGE*

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ABSTRACT

To assess the adequacy of a vegetarian diet at old age, the dietary intake (assessed through dietary history with cross-check) of 44 apparently healthy lacto-(ovo-)vegetarians, aged 65-97 y, has been evaluated. Adequacy was assessed by a comparison of nutrient intake with (Dutch) recommendations and by evaluating data on nutritional status. The results were also compared with data of elderly omnivores. In contrast to elderly omnivores, percentages of energy from protein (13%), fat (37%) and carbohydrates (50%) as well as P/S ratio (0.63) were close to or within the range of the Dutch guidelines regarding a healthy diet (percentages of energy from protein, fat and carbohydrates 10-15%, 30-35% and 55% respectively; P/S ratio 0.5-1.0). For most of the micronutrients studied intake was adequate, and nutrient density of the vegetarian diet was higher than of the omnivorous diet. However, the supply of zinc (average daily intake 8.5 and 7.6 mg for men and women respectively), iron (because of lower bioavailability of nonheme iron), vitamin B-12 (women only: intake 2.3 µg/day) and water (daily intake less than 1600 mL for 30% of the vegetarians) need special attention, considering the relatively high prevalence of a marginal status of these nutrients. In conclusion, a lacto(-ovo)-vegetarian diet can be adequate at old age, provided that it is carefully planned, especially with respect to the supply of iron, zinc and vitamin B-12.

Introduction

In recent years the number of people following a vegetarian diet has increased in affluent societies (1,2). This implies the importance of gaining more insight into the (long-term) adequacy of such a dietary regimen.

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Most studies among vegetarians conclude that nutrient intake is in general adequate (2-5) and that recommendations regarding the percentages of energy from protein, fat and carbohydrates are approximated (2,4). Therefore, a vegetarian diet is generally prudent, which may be one of the key factors in the lower mortality from cancer and cardiovascular disease among vegetarians than among omnivores (6-8). However, other nutritional risks may occur, if a vegetarian diet is not carefully designed, especially among elderly vegetarians. In general, energy intake diminishes throughout adulthood, leading to a reduced intake of nutrients at old age (9,10). Since vegetarians do not use meat, poultry and fish, which are rich sources of protein, iron, zinc, thiamin, pyridoxine and vitamin B-12, the intake of these nutrients may be inadequate among elderly on a vegetarian diet. Moreover, insufficient amounts of minerals and trace elements may be available from a vegetarian diet, since the relatively high intake of dietary fiber and phytate on such a diet may compromise absorption of minerals (1,11,12).

Dietary studies among vegetarians usually include only a few elderly if any (2-4,13). Two studies among elderly vegetarians have been directed at women only (5,14). Therefore we selected elderly vegetarian men and women for a nutritional survey to gain more insight into the food consumption habits of elderly people on a vegetarian diet.

Subjects and methods

As part of the Dutch Nutrition Surveillance System, a survey among vegetarian elderly men and women aged 65-97 y was carried out in June 1986 (15). The participants were recruited from a vegetarian community in the middle of The Netherlands. Selection criteria for the random sample were vegetarianism (not eating meat, poultry and fish), age (65 y or over), Caucasian and 'apparently healthy'. The latter was defined such that severely ill and bedridden persons, and persons in a wheelchair were excluded from the study. Since severe chronic diseases may be important determinants of dietary intake and nutritional status, we selected apparently healthy elderly to reduce the influence of diseases.

Verbal consent was obtained after the nature of the study had been fully explained by letter. The study design and investigation procedures were tested and approved by the TNO-CIVO Toxicology and Nutrition Institute's external Medical Ethics Committee.

Actually, 44 of the 66 elderly vegetarians approached participated in the survey (response 67%). No significant differences were observed between responders and nonresponders

regarding age, gender, marital status, region and degree of urbanization of the former residence nor regarding duration of living at the vegetarian centre.

The study population comprised 18 men and 26 women. Twenty-seven of them (10 men and 17 women) were living in a vegetarian home for the elderly, the remaining 17 (8 men and 9 women) were living independently close to the institution. The mean age of the institutionalized and independently living subjects was 84 and 77 y respectively. The mean age of the men was 83 y, and of the women 81 y.

Data collection and processing

Participants were visited twice at home. During the first visit by one of the two specially trained dietetic students information was obtained on demographic variables, living, shopping and cooking arrangements, meal pattern, dietary regimen and smoking habits. Food consumption data were obtained using a modified Burke dietary history method with cross-check (16). Participants were questioned about their habitual food consumption (in household measures), whereupon the dietary intake over the last two weeks was checked through a list of food items. Common household measures and the weight of foods often used were measured in order to quantify the portion sizes more accurately. For the institutionalized participants the checklist for the hot meal was replaced by the menus offered the two weeks preceding the interview, and information about ingredients and preparation practices were obtained from the staff of the central kitchen of the institution.

At the second visit, usually a few days later, a physician obtained information on health status, usage of nutritional supplements, daily activities, socioeconomic background, physical exercise and dental status by means of structured questionnaires. A blood sample was obtained, anthropometric measurements were carried out and blood pressure was measured. Urine over 24-h was collected by the participants between the two visits.

The food consumption data were encoded on standardized forms according to the Dutch Uniform Encoding System (17). The average daily intake of energy and nutrients was calculated using the computerized Dutch Nutrient Data Bank (18). Because vitamin B-12 and zinc are not included in this data bank, additional tables were composed for these nutrients. Data on vitamin B-12 and zinc contents of foodstuffs were, in order of importance, derived from analyses by Dutch research institutions, foreign food composition tables, and estimations based on calculation of recipes or comparison with similar food products. The intake of vitamin B-12

and zinc was not calculated on an individual level, but was based on the average consumption of food products for men and women respectively. The supply of vitamins and minerals through supplements was not taken into account in the presented data regarding nutrient intake.

Foodstuffs were classified into food groups. The average daily use of these groups (in grams) and their contribution (in percentages) to total energy and nutrient intake were calculated.

Adequacy of nutrient intake was assessed by comparing the mean daily intake with (Dutch) recommendations (19,20). To get insight into whether a low intake of nutrients is likely to be attributed to the vegetarian diet per se, the results were compared with those from a national survey among omnivorous elderly in The Netherlands (10). Moreover, a comprehensive set of indicators of the nutritional status was assessed among both the vegetarian and omnivorous elderly people. The results are presented in detail elsewhere (21,22), whereas in this article some results on the main nutritional risks found are evaluated within the context of dietary intake. Criteria for marginal nutritional status indicators were, among other sources, derived from the WHO (23) (hemoglobin, serum iron and iron saturation), Hershko and Konijn (24) (ferritin) and Croughs and Hemker (25) (water) or were based on the 2.5 percentile of younger adults (21) (zinc, vitamin B-12).

Data Analysis

The homogeneity of the vegetarian study population was examined by testing the relationship between dietary intake and some independent variables through multiple linear regression analysis. The independent variables were gender (dummy variable: coding for men -1, women 1), housing situation (institutionalized -1, independently living 1) and age (continuous minus the average age of 81.8 y). As a consequence of the dummy variable coding scheme, the regression coefficients tabulated represent half the differences in dietary intake between men and women, and between institutionalized and independently living participants. The assumptions of the regression analysis regarding the residuals (equality of variances and normal distribution) were examined. In case of a skewed distribution (namely retinol equivalents, P/S ratio and the food group "rice and pasta") a transformation (natural logarithm: ln) of each value was carried out. Out-of-range values were excluded from the regression analysis only. Actually, the values for intake of animal protein (76 g, 13.5% of energy intake) and total protein (110 g) of one independently living 70-y-old woman were excluded. The descriptive statistics

(mean ± standard deviation) were based on all observations. All effects were examined both bivariately and multivariately. Because the bivariate and multivariate results were mostly similar and there was a difference in age between the institutionalized and independently living elderly, only the regression coefficients (and their significance) obtained from the multivariate model are reported.

The statistics were performed with BMDP statistical software (26). All statistical tests were two-tailed, effects with a p value of less than 0.05 were considered significant.

It should be noted that percentages of subjects reported are based on a small number of persons.

Results

In **Table 4.1.** some characteristics of the food pattern of the elderly vegetarians are summarized. The majority (38 subjects) were lacto-ovo-vegetarian, while the remaining six persons were lacto-vegetarian. Of the respondents 32 had been vegetarian for more than 45 y, and three of these had practiced a vegetarian diet their entire life. Only two subjects had been vegetarian for less than five y. The most important reasons for following a vegetarian regimen were based on ethical motives (43%) and health considerations (20%). Other motives were objections to factory farming or spoilage of food, and having a vegetarian partner/family.

Only three subjects did not have a breakfast daily, whereas under normal circumstances the lunch (in the evening) and the hot meal were never missed by any of the respondents. All institutionalized subjects obtained their meals from the central kitchen and could choose among several meal components offered. All independently living subjects prepared their meals themselves.

A dietary regimen was followed by thirteen subjects (30%), eleven of which had been on that regimen for more than five y. Sodium restriction was the most important feature. Twenty subjects (4 men and 16 women) were using nutritional supplements on a regular basis. Vitamin B complex and calcium were used most frequently.

In **Tables 4.2.-4.4.** data on the intake of energy and nutrients are presented. The mean values found in our national survey among elderly omnivores are also included in these tables (10). Vegetarian men had a higher intake of energy than vegetarian women, as a result of a substantially higher intake of protein (especially vegetable protein) and total carbohydrates

Table 4.1.
Some characteristics of the food pattern of vegetarian elderly men and women#

Characteristic	Men n=18 %	Women n=26 %
Vegetarian regimen		
lacto-ovo-vegetarian	78	92
lacto-vegetarian	22	8
Duration of vegetarianism		
< 5 y	6	4
5 - 45 y	22	23
> 45 y	72	73
Dietary regimen		
total	17	38
sodium-restricted	6	15
easy to digest	6	8
mono-/disaccharides-restricted	0	8
Nutritional supplement usage		
total	22	62*
vitamin B complex	11	31
vitamin B-12	0	12
folate	6	8
vitamin A	6	8
vitamin C	6	12
iron	0	12
calcium	17	23

Chi-square test; * $p < 0.025$.

(predominantly polysaccharides) and a slightly higher intake of total fat ($p = 0.07$). Except for a higher percentage of energy from polysaccharides in the diet of men, the contribution of protein, fat and carbohydrates to total energy intake in the vegetarian diet did not differ between men and women. The institutionalized vegetarians had higher intakes of animal protein (both in grams and % of energy) and saturated fat (% of energy) than the independently living vegetarians. The intake of pyridoxine per gram protein was higher among the independently living subjects than among the institutionalized subjects. Only four vegetarians used slight amounts of alcohol (1 g per day on the average).

Table 4.2.
Daily intake (mean ± SD) of energy, macronutrients, cholesterol, dietary fiber and water by vegetarian elderly men and women

Energy and nutrient	Men n=18	Women n=26	Regression coefficients+ Inter-cept	Gender	Housing	Age
Energy (MJ)	8.23 ± 1.65 (10.13)#	7.00 ± 1.34 (7.89)	7.62	-0.62*	0.05	-0.02
Total protein (g)	59.8 ± 12.1 (82.2)	54.4 ± 16.0 (70.1)	55.3	-4.1*	-2.8	0.1
Vegetable protein (g)	31.2 ± 9.8 (25.9)	25.3 ± 7.8 (21.1)	28.7	-2.7	2.3	-0.01
Animal protein (g)	28.6 ± 9.9 (56.3)	29.1 ± 15.1 (49.0)	26.7	-1.3	-4.9**	0.1
Total fat (g)	81.1 ± 24.4 (109.5)	69.1 ± 19.7 (83.8)	74.8	-6.4	-1.6	-0.3
P/S ratio	0.65 ± 0.41 (0.42)	0.62 ± 0.44 (0.40)	-0.62	-0.03	0.16	-0.01
Total carbohydrates (g)	249.1 ± 49.5 (252.0)	207.7 ± 39.8 (202.8)	230.1	-20.0**	7.9	-0.1
Polysaccharides (g)	123.4 ± 28.4 (123.0)	90.3 ± 20.9 (97.9)	107.3	-16.6**	1.9	-0.3
Mono- and disacch. (g)	123.6 ± 34.4 (128.2)	111.9 ± 34.7 (104.3)	119.0	-5.1	6.2	0.2
Cholesterol (mg/MJ)	24.3 ± 7.1 (35.1)	30.8 ± 12.2 (37.3)	27.0	2.7	-2.7	-0.3
Dietary fiber (g/MJ)	4.1 ± 0.9 (2.7)	4.1 ± 0.9 (3.0)	4.1	0.02	0.3	0.02
Water (mL)	1769 ± 322 (2146)	1785 ± 341 (1979)	1795	11	80	-6

+ Transformation (ln) was performed for P/S ratio; * $p < 0.05$, ** $p < 0.01$; # Mean values for elderly omnivores in parenthesis.

Table 4.3.
Daily intake (mean ± SD) of minerals and vitamins by vegetarian elderly men and women

Nutrient	Men n=18	Women n=26	Regression coefficients+			
			Inter-cept	Gender	Housing	Age
Calcium (mg)	1219 ± 303 (1128)#	1141 ± 379 (1013)	1167	-43	-59	2.5
Iron (mg)	13.7 ± 4.2 (13.1)	12.2 ± 2.9 (11.4)	13.1	-0.7	0.7	-0.01
Retinol equivalents (mg)	1.27 ± 0.48 (1.07)	1.27 ± 0.50 (0.95)	0.20	0.007	0.109	-0.004
Thiamin (mg)	1.26 ± 0.54 (1.11)	1.08 ± 0.41 (0.93)	1.19	-0.08	0.12	0.01
Riboflavin (mg)	1.87 ± 0.59 (1.70)	1.70 ± 0.64 (1.51)	1.79	-0.08	0.04	0.00
Pyridoxine (µg)	1345 ± 357 (1381)	1125 ± 325 (1154)	1253	-102	86	0.2
Pyridoxine/gram protein (µg)	23 ± 4 (17)	21 ± 6 (17)	23	-0.4	2.3*	0.1
Ascorbic acid (mg)	136 ± 63 (94)	149 ± 49 (101)	146	10	17	2

+ Transformation (ln) was performed for retinol equivalents; * $p < 0.05$; # Mean values for elderly omnivores in parenthesis.

Table 4.4.
Contribution (%) of protein, fat and carbohydrates (mean ± SD) to total energy intake in the diet of vegetarian elderly men and women

Nutrient (% of energy intake)	Men n=18	Women n=26	Regression coefficients			
			Inter-cept	Gender	Housing	Age
Total protein	12.4 ± 2.2 (13.7)#	13.0 ± 2.5 (15.1)#	12.6	0.3	-0.5	-0.01
Vegetable protein	6.4 ± 1.7 (4.3)	6.1 ± 1.4 (4.5)	6.3	-0.1	0.4	0.01
Animal protein	6.0 ± 2.1 (9.4)	6.9 ± 3.2 (10.6)	6.0	0.2	-1.1*	0.01
Total fat	36.5 ± 6.8 (40.4)	36.9 ± 5.0 (39.6)	36.4	0.02	-1.2	-0.1
Saturated fat	15.0 ± 3.8 (17.3)	15.8 ± 4.1 (17.2)	15.1	0.2	-1.4*	-0.03
Monounsaturated fat	12.3 ± 3.1 (15.0)	12.2 ± 2.4 (14.6)	12.1	-0.1	-0.5	0.02
Polyunsaturated fat	8.5 ± 3.3 (6.8)	8.3 ± 3.5 (6.5)	8.5	-0.2	0.3	-0.1
Total carbohydrates	51.1 ± 5.9 (41.6)	50.0 ± 5.8 (43.1)	50.9	-0.3	1.6	0.1
Polysaccharides	25.4 ± 4.6 (20.4)	22.0 ± 5.1 (21.0)	23.8	-1.7*	0.5	0.01
Mono- and disaccharides	25.3 ± 5.0 (21.1)	26.8 ± 6.5 (22.0)	26.3	1.0	1.3	0.1

* $p < 0.05$; # Mean values for elderly omnivores in parenthesis.

Among elderly vegetarians the average daily energy intake was within the range of the Dutch recommendations (7.6-9.1 MJ and 6.5-7.8 MJ for men and women respectively, assuming a sedentary or lightly active life), and guidelines for the contributions of protein (10-15%), fat (30-35%) and carbohydrates (55%) to total energy intake were approximated (19,20). The average intake of polysaccharides and total carbohydrates was slightly lower, and the intake of fat somewhat higher than the recommendations. The Dutch guidelines for P/S ratio (0.5-1.0) and cholesterol intake (≤ 33 mg/MJ) were met. Except for pyridoxine, the mean intake of vitamins, minerals and dietary fiber exceeded the Dutch recommended dietary allowances (RDA). The mean intake of pyridoxine was 90% and 75% of the lower limit of the Dutch RDA (1500 µg/day) for the vegetarian men and women, respectively.

The average daily intake of zinc was 8.5 mg and 7.6 mg for vegetarian men and women respectively. The average vitamin B-12 intake for men and women was 2.8 and 2.3 µg per day respectively. As compared to the American RDA (27) (Dutch recommendations are not yet available) zinc intake was low for both men and women (57% and 51% of the RDA, respectively) and vitamin B-12 intake for women only (77% of the RDA). The omnivorous elderly men and women had a substantially higher mean daily intake of zinc (10.6 and 9.3 mg respectively) and vitamin B-12 (5.6 and 4.6 µg respectively).

In **Table 4.5.** the consumption of foods classified into groups is presented. Although men tended to have a higher consumption than women for most food groups, only the differences in consumption of bread and fats & oils were significant. The independently living subjects consumed more vegetables than those institutionalized. The consumption of rice and pasta was inversely associated with age.

The contribution of food groups to the intake of energy and the most relevant nutrients among elderly vegetarians is presented in **Table 4.6.** Bread, fats & oils, milk products and cheese were the food groups contributing most to energy intake. Visible fats were the most important source of fat (43% for men and 32% for women). Bread and vegetables provided about 40% of iron intake. The relatively large contribution of nonalcoholic beverages to iron intake (about 10%) is accounted for by tea and coffee. The intakes of zinc and vitamin B-6 were scattered over various food groups. Approximately 37% of dietary zinc was of animal origin. The relatively large contribution of 'miscellaneous foods' to the intake of vitamin B-6 and iron was primarily to be attributed to the consumption of yeast products and soups. Milk products and cheese provided about 87% of vitamin B-12 intake.

In **Table 4.7.** information on the status of the indicators of nutritional risks found among elderly vegetarians is presented and

Table 4.5.
Daily consumption (mean ± SD) of food groups (in grams) by vegetarian elderly men and women

Food group	Men n=18	Women n=26	Regression coefficients+ Intercept	Gender	Housing	Age
Potatoes	94 ± 42	88 ± 35	92	-1.4	6.8	0.9
Rice and pasta	20 ± 20	18 ± 18	2.38	-0.19	-0.28	-0.08*
Other cereal products	30 ± 22	25 ± 21	28	-1.9	1.9	0.3
Bread	159 ± 54	95 ± 37	128	-32.1*	3.9	-0.3
Vegetables	271 ± 125	264 ± 119	284	5.3	77.8*	1.1
Fruit (fresh and canned)	269 ± 120	229 ± 118	255	-16.5	29.1	0.7
Milk products (cheese excluded)	442 ± 202	360 ± 236	397	-38.3	-16.1	4.6
Cheese	42 ± 28	44 ± 23	42	0.7	-5.9	-0.1
Eggs	13 ± 8	16 ± 10	14	1.2	-2.6	-0.4
Fats and oils	41 ± 18	26 ± 11	33	-8.1*	-1.1	-0.3
Nonalcoholic beverages	608 ± 275	763 ± 281	699	74.8	57.9	-9.9
Cookies and cakes	37 ± 35	37 ± 18	36	-1.3	-4.9	-0.7
Sweets, sweetspread and sugar	33 ± 18	32 ± 19	33	-0.8	-0.1	-0.3

Transformation (ln) was performed for the food group "rice and pasta"; * $p < 0.01$.

Table 4.6.
Contribution (%) of food groups to the intake of energy and nutrients in the diet of elderly vegetarians

Food group	Energy	Protein	Fat	Carbohydrates	Iron	Zinc	Vit. B-6	Vit. B-12
Potatoes (potato dishes included)	4	3	1	7	3	3	15	-#
Rice, pasta and other cereal products	6	7	2	10	10	10	4	-
Bread	15	16	4	23	21	19	14	-
Vegetables	4	8	-	5	19	11	15	-
Fruit (fresh and canned)	8	2	-	15	8	1	18	-
Milk products (cheese excluded)	12	26	11	9	2	19	12	71
Cheese	9	20	18	-	-	16	2	16
Eggs	1	4	2	-	2	2	1	11
Fats and oils	14	-	37	-	-	1	-	-
Nonalcoholic beverages	4	1	-	7	10	2	3	-
Cookies and cakes	8	4	8	9	5	3	2	2
Sweets, sweetspread and sugar	6	-	1	12	6	-	1	-
Soy products and pulses	1	3	1	1	2	2	2	-
Nuts, peanut butter and seeds	4	4	10	-	3	6	3	-
Miscellaneous foods	3	3	5	2	8	4	9	1

Contribution less than 0.5%.

Table 4.7.
Prevalence of a marginal status (% below cutoff point) for some nutritional status indicators among vegetarian and omnivorous elderly men and women

		Vegetarians		Omnivores	
Indicator	Cuttoff point	men n=17 %	women n=23 %	men n=54* %	women n=54* %
Hemoglobin (mmol/L)	< 8.1	35	4#	4	1#
Serum ferritin (µg/L)	≤ 12	18	9	2	11
Serum iron (µmol/L)	< 9.0	12	13	9	0
Iron saturation (%)	< 15	12	13	11	4
Serum zinc (µmol/L)	< 11.5	29	19	4	0
Plasma vitamin B-12 (pmol/L)	< 138	35	13	4	6
Volume 24-h urine (mL)	< 800	27	4	5	6

* Number of omnivorous men and women was 268 and 261 for hemoglobin, but 262 and 258 for 24-h urine; # Cutoff point for women: 7.5 mmol/L.

compared with data on elderly omnivores. Elderly vegetarians had, on the average, higher blood concentrations for most vitamins studied, but lower average plasma vitamin B-12 and serum zinc levels, lower iron status indicators and lower volume of 24-h urine than elderly omnivores. As shown in Table 4.7. this was also reflected in the generally higher prevalence of low values (21).

Discussion

Among the elderly vegetarians food consumption tended to be higher among men than among women, which resulted in (the tendency to) a higher absolute intake of nutrients and energy among men. This is in agreement with differences in nutritional requirements between men and women as a result of differences in body build and body composition. Dietary intake proved to be virtually independent of age, probably due to our selection of only 'apparently healthy' elderly people. Generally speaking, the differences in dietary intake between institutionalized and independently living vegetarians were small. However, there was a tendency towards a higher vitamin, dietary fiber and water intake among the

independently living vegetarians. The P/S ratio and the contribution of fat and carbohydrates to total energy intake tended to be closer to the Dutch guidelines among independently living than among institutionalized vegetarians. This indicates a somewhat more favorable food choice of vegetarians preparing their own meals. Although some differences in dietary intake were observed, the vegetarians studied can, to a certain extent, be considered as a homogeneous group with respect to food consumption habits.

In spite of the generally high nutrient density of the vegetarian diet, the intake (zinc, vitamin B-6, vitamin B-12, water) and status (iron, zinc, vitamin B-12, water) (21) of some nutrients was assessed as being marginal for a substantial proportion of the vegetarians studied.

The average iron intake among elderly vegetarians (especially men) exceeded the Dutch RDA, assuming 10 percent absorption (19). However, the high prevalence of a marginal iron status among vegetarians and the iron intake and status among vegetarian elderly as compared to omnivorous elderly subjects (prevalence of a marginal iron status was somewhat higher among vegetarians; although intake was slightly higher as well) suggest an inadequate bioavailability. This is probably to be attributed to a relatively low absorption because of the absence of meat and a high content of dietary fiber and/or phytate (28-30), and perhaps owing to hypochlorhydria (31). Moreover, tea and coffee, used by about 60% of the vegetarians with breakfast and by over 30% with lunch, may have inhibited iron absorption (32,33). The contribution of tea and coffee (about 10%) to iron intake will most probably have had no beneficial effect on iron status. Since absorption of iron of vegetable origin probably increases appreciably only when meals contain at least 50 mg ascorbic acid (30), which was generally only the case for the hot meals (which were also rich in fiber), the high ascorbic acid intake will probably not have had a substantial impact on iron bioavailability. The higher prevalence of anemia among vegetarian men than among vegetarian women may be related to the lower cutoff point used for women than for men, and may be partly due to dietary factors. A higher percentage of men (33%) than women (19%) had a relatively low iron intake (< 10 mg/day). The bioavailability of iron in the diet of men was probably lower, because men derived more iron from bread and cereal (products) than women (36% versus 27%) and less from vegetables and fruit (24% versus 29%) (30,34).

The high prevalence of a relatively low zinc status among elderly vegetarians is probably due to a low intake as a result of the absence in the vegetarian diet of meat as rich source of zinc and the overall low food consumption among elderly people, as well

as to a low bioavailability of zinc in products of vegetable origin, mainly due to dietary fiber and/or phytate (35,36).

The average absolute vitamin B-6 intake among the elderly vegetarians (especially women) was considerably below the Dutch RDA. However, from a physiological point of view, pyridoxine requirement is related to protein intake. An intake of 20 µg pyridoxine per gram of protein is suggested as a basis for pyridoxine allowances (27). Departing from this ratio, the average pyridoxine intake among the vegetarians, as contrasted with the elderly omnivores, seems adequate, assuming a similar requirement for older and younger adults. In addition, the results on the vitamin B-6 status do not indicate that elderly vegetarians are at high risk of a marginal vitamin B-6 status (21).

The average intake of vitamin B-12 among vegetarian women was low as compared to the American RDA (3 µg/day) (27). Departing from a recommendation of 2 µg/day (37), the vitamin B-12 intake among both vegetarian men and women can be considered adequate. Nonetheless, six vegetarian men (35%) and three vegetarian women (13%) had relatively low plasma vitamin B-12 concentrations (< 138 pmol/L). These results suggest that a marginal vitamin B-12 status among elderly vegetarians is not only determined by dietary factors. Malabsorption of vitamin B-12 as a result of atrophic gastritis, which is more prevalent among elderly people (38), may have had a negative impact on the vitamin B-12 concentration in blood. Therefore, a higher prevalence of low plasma vitamin B-12 levels among vegetarian than among omnivorous elderly subjects is possibly partly due to (patho)physiological changes accompanying old age (vegetarian subjects were on the average older than the omnivorous elderly).

Under normal circumstances a daily water intake of 1600-2400 mL (from drinks and food together) is considered to be adequate (39). Although the average intake among the elderly vegetarians met this recommendation, about 30% of the elderly had an intake lower than 1600 mL. Moreover, elderly are considered to be at higher risk of dehydration because of a declined osmoregulation ability, a decreased thirst sensation and a decrease in total body water (40,41). A relatively low volume of 24-h urine was found among many of the vegetarian men and among men a high correlation ($r = -0.52$) between the volume of 24-h urine per kg body weight and hematocrit was found (21). Therefore, water supply may have been critical, particularly because the study was executed in a relatively hot period.

The absence of meat, poultry and fish in the vegetarian diet and the relatively low energy intake among the elderly vegetarians did not lead to a marginal intake of protein and most of the calculated micronutrients. In comparison with elderly omnivores in

The Netherlands the nutrient density of the vegetarian diet was even higher. Pyridoxine supply was more favorable among vegetarians because of the higher pyridoxine/protein ratio in the vegetarian diet. Iron intake among vegetarians was slightly higher than among omnivores, but the bioavailability in the vegetarian diet was probably lower. Intake of zinc and vitamin B-12 was lower among vegetarians. The water intake was lower among vegetarians, which may be associated with the higher mean age of the vegetarians (water intake was found to be lower at higher age in the national survey among omnivorous elderly [10]). As compared to the omnivorous diet, the vegetarian diet was more prudent (lower % of energy from fat, higher % of energy from carbohydrates, higher P/S ratio and dietary fiber intake, and lower cholesterol intake), whereas the vegetarians were found to have aged more successfully with respect to cardiovascular risk factors than their omnivorous contemporaries (21,22). However, it should be noted that vegetarian and omnivorous elderly subjects also differ in other (lifestyle) factors, such as age, physical activity, socioeconomic status, housing situation, smoking habits, nutritional supplement usage, health status and drug use, and that there was a difference in period of data collection.

In accordance with our results, several studies among (lacto-ovo-)-vegetarians conclude that the intake of most nutrients is adequate (2-5). A marginal absolute pyridoxine intake among vegetarian women has also been observed by Shultz and Leklem (2,13). Calkins et al (3) and Shultz and Leklem (2) found iron intake among vegetarian women to be considerably below the RDA. However, in both studies younger women were included, for whom iron allowances are higher. Zinc, vitamin B-12 and water intakes are not reported in most studies. Like our study, other studies conclude that the percentages of energy from protein, fat and carbohydrates in the vegetarian diet approximate the recommendations fairly well (2,4). Therefore, the diet of elderly vegetarians can be considered as favorable with respect to risk of chronic diseases such as cardiovascular disease and cancer. The relatively low prevalence of obesity, hypertension and hypercholesterolemia (21) is probably partly due to characteristics of the vegetarian diet.

Our results show that the supply of iron, zinc, water and vitamin B-12 among elderly vegetarians needs special attention. To improve the vegetarian diet a higher consumption of bread (especially for women), rice, pasta and other cereal products and milk products (especially for women) can be recommended. Because the consumption of vegetables and cheese was relatively high in the vegetarian diet, it is not realistic to advise a higher consumption of these products. To increase the bioavailability of

iron, the use of food products rich in ascorbic acid, such as fruit (juice) and vegetables, with breakfast and lunch, and the restriction of consumption of coffee and tea during these meals can be advised. Water intake can easily be increased by a higher consumption of nonalcoholic beverages. A considerably higher intake of zinc may be difficult to achieve; a limited use of supplements may be an option.

Conclusions

A vegetarian diet at old age can be considered as being prudent with respect to cardiovascular risk factors. Although the nutrient density of the vegetarian diet is generally high, the mean intake and/or status of iron, zinc, vitamin B-12 and water was marginal among the elderly vegetarians, which can only partly be attributed to the vegetarian nature of the diet. In summary, we conclude that a lacto(-ovo)-vegetarian diet can be adequate at old age, provided that it is carefully planned, especially with respect to the supply of iron, zinc and vitamin B-12.

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5. LONG-TERM EFFECTS OF A VEGETARIAN DIET ON THE NUTRITIONAL STATUS OF ELDERLY PEOPLE*

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Henk van den Berg and Michel Wedel.

ABSTRACT

The health and nutritional status (anthropometry, and blood and urine biochemistry) of 44 Dutch apparently healthy vegetarians, aged 65-97 y, refraining from meat, fish and poultry consumption was assessed for insight in long-term consequences of ovo-lacto-, or lacto-vegetarianism. The results indicate that in comparison to omnivorous elderly the vegetarian elderly (especially men) have aged successfully with respect to cardiovascular risk factors. In contrast, vegetarian elderly are at a higher risk for a marginal iron, zinc, and vitamin B-12 status. Although several vegetarian elderly showed low levels of 25-hydroxyvitamin D in plasma and many had low values of 24-h urine volume (per kg body weight), these values are not likely the result of a vegetarian diet per se. It is concluded that, although some nutrition-related risks are prevalent among vegetarian elderly, these risks can probably be prevented by lifestyle changes.

Introduction

In the past decades a vegetarian lifestyle has gained in popularity (1). Vegetarians have generally lower standardized mortality for major causes of death such as cancer and coronary heart disease (2-4), as well as being at lesser risk for several other diseases and disorders (5). Indicators of the nutritional status can provide information on the dietary factors causally associated with the state of health. However, the nutritional status cannot be assessed with a single indicator; a profile that refers to the different nutrients has to be chosen for evaluation of the nutritional status of population groups (6). Although there is information on the cardiovascular risk factors, and on the iron (Fe), zinc (Zn) and vitamin B-12 status of vegetarians (7-24),

* Subtitled with (Dutch Nutrition Surveillance System).
Submitted.

there is still inadequate information on other long-term effects of the vegetarian diet on the nutritional status. Few elderly subjects have been included in studies aiming at characterizing most aspects of the nutritional status of vegetarians (7-17); Gibson et al (25) studied hair levels of trace metals among elderly vegetarian women.

This study examines a comprehensive set of indicators of the nutritional status in a group of vegetarian elderly.

Subjects and methods

In June 1986, a nutritional survey among apparently healthy vegetarian elderly living in a "vegetarian community" in The Netherlands, was carried out within the framework of The Dutch Nutrition Surveillance System (6). Selection criteria were: age (≥ 65 y), Caucasian, apparently healthy and ovo-lacto- or lacto-vegetarian (not eating meat, fish or poultry). 'Apparently healthy' was defined as not bedridden, not in a wheelchair and not suffering from a disease that would probably end life in the near future. All respondents had to be mentally and physically able to participate in the entire study. The study design and investigation procedures were tested and approved by our Institute's external Medical Ethical Committee.

Of the 66 vegetarian elderly approached 44 (18 men and 26 women) participated in the survey. The response rate was 67%. No significant differences in age, gender, marital status, region and degree of urbanization of former residence, and duration of living at the vegetarian center were observed between responders and nonresponders. Before their move to the vegetarian community the respondents had been living all over the Netherlands, except in the south.

The procedures (including the dietary, biochemical and anthropometric methods) during the data collection were similar to those in our national survey among independently living elderly (26,27); the results on the dietary intake, nutritional supplement usage and some results on the vitamin status of the vegetarians surveyed are presented elsewhere (28,29). Body height of 3 men and 1 woman with severe senile kyphosis was not measured. A (nonfasted) venous blood sample was obtained from 40 vegetarian elderly for hematological (excepted one women), biochemical and clinical chemical analyses (Tables 5.2.-5.4.). Included in Table 5.3. are erythrocyte glutathion reductase activation coefficient (EGR-AC) and erythrocyte aspartate aminotransferase activation coefficient (EAST-AC). Urine (24-h, to which 10 mL 1 mol/L HCl was added) was collected by 36 of the participating vegetarians.

The criteria for obesity, hypertension and hypercholesterolemia were derived from Garrow (30), World Health Organization (WHO) (31) and Erkelens (32), respectively. According to the WHO (33) whole blood hemoglobin values below 8.1 (men) and 7.5 mmol/L (women) indicate anemia among adults. Ferritin levels of 12 µg/L or less indicate low storage of Fe in the body and iron deficiency (34). According to Swanson et al (35) Zn concentrations below 11 µmol/L are marginal. Values indicative of a marginal vitamin status are based on the 2.5 percentile (P 2.5) of younger (18-64 y) adults (29,36). The average daily requirement of water in the elderly is considered to be about 25-30 mL per kg body weight (37).

In our nationwide survey most nutritional status indicators differed for the genders, and several were significantly associated with age (26). In this national survey among omnivorous elderly all subjects were living independently; none was living in an institution. To obtain insight into the effects of these factors on the nutritional status indicators among the vegetarians surveyed regression analysis (with the GENSTAT statistical package) was carried out with the indicators of the nutritional status as continuous dependent variables (38). The independent factors were: gender (dummy variable; coding for men -1, women 1), housing (institutionalized -1, independently living 1) and age (continuously minus the average age of 82 y). As a consequence of the dummy variable coding scheme the regression coefficients tabulated represent half the (adjusted) differences between men and women, and (adjusted) differences between institutionalized and independently living. The assumptions of the regression analysis regarding residuals (equality of variances and normal distribution) were checked. When the distribution was skewed, values were transformed logarithmically (ln). Out-of-range values were excluded from both the descriptive statistics and the analyses. Actually, vitamin B-12 concentrations (2493, 8400 and 21445 pmol/L) of three women (receiving regularly vitamin B-12 injections), and the body mass index of one 65-y-old woman (30.8 kg/m^2) and one 97-y-old man (18.7 kg/m^2) were excluded. All effects were examined both unadjusted and adjusted for the effects of the other factors. An age-adjusted comparison between vegetarian elderly people and omnivorous elderly subjects can be obtained by making use of the presented regression equations among the vegetarians. On the average the omnivorous elderly people in our nationwide survey were 10 y younger than the vegetarian elderly people. Unadjusted descriptive statistics and correlation coefficients were calculated with the BMDP statistical computer package (39). All statistical test were two-tailed; a p value of less than 0.05 was considered as significant. When percentages (of

the number of observations available) are reported, it should be noted that these are based on a small number of subjects.

Results

The mean age (in y) of the men and women was 82.8 (range: 65-97) and 81.1 (range 65-94), respectively. Of the subjects 27 were institutionalized, and 17 were living independently; 38 were lacto-ovo-vegetarian (not eating meat, fish and poultry) and the remainder were lacto-vegetarian (not taking eggs either). Of the respondents 32 had been vegetarian for more than 45 y. 27 Vegetarians were able to walk (without any help and without resting) outdoors for 40 minutes or more. Twenty subjects (4 men and 16 women) were using nutritional supplements on a regular base. Twenty subjects were using one or more drugs; 6 used adrenergic/cardiac drugs, 4 used analgesics; diuretics, bronchodilitators and sedatives were used by 3 subjects. Thirty were under care of a physician or medical specialist. Circulatory diseases (18% of the total population), problems with eyes or ears (14%), hypertension (11%), and diseases of urogenital organs (11%) were the most frequently reported disorders. About 30% were under medical care for cardiovascular diseases (including hypertension).

Data on the nutritional status are presented in **Tables 5.1.-5.5.**, with mean values from our nationwide survey of omnivorous elderly (26). Except for HDL-cholesterol and some minerals excreted in the 24-h urine no relevant differences were found between the unadjusted and adjusted analyses. Since the institutionalized vegetarians were on the average older than those living independently, only the results of the adjusted analyses are reported. The anthropometric data show that the men were taller than the women, while generally the women were fatter than the men. The higher creatinine excretion (as crude indicator of the fat-free mass) for men was in accord with this observation as no significant differences between the genders were found regarding mean body weight and body mass index.

Among the independently living vegetarians, a higher mean plasma concentration of total carotenoids (difference about 1.0 µmol/L) and 25-hydroxyvitamin D (difference about 16 nmol/L) was observed; a higher mean EGR-AC (difference about 0.06) was found in institutionalized vegetarians. Urinary sodium excretion (difference about 26 mmol/24-h) as well as 24-h sulfate excretion was higher in the institutionalized than in the independently living group. Independently living subjects were somewhat leaner

Table 5.1.
Anthropometry and blood pressure of vegetarian elderly men and women

Variable	Men n=18	Women n=26	Regression analysis				
				Regression coefficients			
			Trans-formation	Inter-cept	Gender	Housing	Age
Body height (cm)+	172.6 ± 6.1§ (172.3)	159.0 ± 4.3 (160.3)	-	165.4	-7.1**	-1.6	-0.3*
Upper arm length (cm)	33.7 ± 2.9 (32.7)	31.3 ± 2.1 (30.6)	-	32.3	-1.4**	-0.8	-0.1
Body weight (kg)	65.6 ± 8.6 (75.8)	63.5 ± 9.6 (69.6)	-	64.0	-1.9	-2.9*	-0.8**
Body mass index (kg/m^2)‡	23.5 ± 3.4 (25.5)	24.7 ± 2.9 (27.1)	-	23.8	0.5	-1.1	-0.1
Body fatness (%)	25.9 ± 4.3 (29.5)	34.7 ± 6.2 (39.9)	ln	3.37	0.12**	-0.08*	-0.01**
Biceps skinfold (mm)	5.4 ± 2.1 (6.8)	10.4 ± 5.1 (14.5)	ln	1.90	0.26**	-0.12	-0.03*
Triceps skinfold (mm)	9.1 ± 2.9 (12.2)	17.9 ± 7.3 (24.9)	ln	2.45	0.28**	-0.18**	-0.03**
Diastolic blood pressure (mmHg)	76 ± 9 (85)	79 ± 15 (88)	-	76	0.4	-4*	-0.8*
Systolic blood pressure (mmHg)	143 ± 19 (151)	153 ± 26 (156)	-	148	5	-1	0.2

+ Values based on 15 men and 25 women; ‡ values based on 14 men and 24 women; § unadjusted mean ± SD (mean value of omnivorous elderly in parenthesis); * $p < 0.05$, ** $p < 0.01$.

Table 5.2.
Hematology and iron and zinc status of vegetarian elderly men and women

Variable	Men n=17	Women n=23+	Regression analysis				
				Regression coefficients			
			Trans-formation	Inter-cept	Gender	Housing	Age
Hemoglobin (mmol/L)	8.5 ± 1.1# (9.5)	8.5 ± 0.8 (8.8)	-	8.5	-0.1	-0.2	-0.06*
Hematocrit (%)	40.9 ± 5.2 (43.4)	41.8 ± 4.4 (40.5)	-	41.3	0.1	-0.8	-0.3**
Red cell count (10^9/mL)	4.36 ± 0.62 (4.80)	4.53 ± 0.65 (4.56)	-	4.43	0.04	-0.10	-0.04*
MCV (fL)	95 ± 6 (91)	94 ± 5 (89)	-	94	-0.5	-0.2	0.1
Iron (µmol/L)	12.9 ± 4.9 (17.7)	14.9 ± 6.5 (16.7)	ln	2.56	0.08	0.06	0.004
TIBC (µmol/L)	53.7 ± 7.7 (59.2)	55.5 ± 10.1 (59.0)	-	54.5	1.1	-0.1	0.3
Iron saturation (%)	24.6 ± 10.3 (30.5)	27.1 ± 10.2 (28.8)	ln	3.18	0.07	0.06	-0.001
Ferritin (µg/L)	32 ± 20 (98)	50 ± 48 (72)	ln	3.45	0.17	0.04	-0.01
Zinc (µmol/L)	12.2 ± 2.1 (16.2)	12.5 ± 1.5 (16.5)	-	12.5	0.2	0.3	0.002

+ Hematology based on 22 women and zinc on 21 women; # unadjusted mean ± SD (mean values of omnivorous elderly in parenthesis); * $p < 0.05$, ** $p < 0.01$.

Table 5.3.
Vitamin status of vegetarian elderly men and women

Variable	Men n=17	Women n=23+	Regression analysis: Transformation	Regression coefficients: Intercept	Gender	Housing	Age
All-*trans* retinol (µmol/L)	1.4 ± 0.3# (1.4)	1.6 ± 0.3 (1.3)	-	1.5	0.05	-0.08	-0.01
Total carotenoids (µmol/L)	2.6 ± 1.3 (1.5)	2.8 ± 1.0 (1.8)	-	2.9	0.2	0.5*	0.04
EGR-AC (ratio)	1.04 ± 0.09 (1.12)	1.01 ± 0.07 (1.09)	-	1.02	-0.02	-0.03*	-0.001
Pyridoxal 5'-phosphate (nmol/L)	49 ± 62 (27)	75 ± 65 (45)	ln	3.85	0.20	0.20	-0.01
EAST-AC (ratio)	1.67 ± 0.27 (1.69)	1.67 ± 0.29 (1.72)	-	1.66	0.001	-0.01	0.002
Folate (nmol/L)	12.7 ± 8.1 (6.6)	14.2 ± 7.3 (7.3)	ln	2.51	0.10	0.13	0.01
Vitamin B-12 (pmol/L)	235 ± 205 (288)	183 ± 71 (268)	ln	5.21	-0.05	0.07	-0.01
25-Hydroxyvitamin D (nmol/L)	45 ± 22 (40)	35 ± 16 (38)	-	42	-5*	8**	-1*

+ Number of women for all-*trans* retinol and total carotenoids was 21 and 20 for vitamin B-12; # unadjusted mean ± SD (mean values of omnivorous elderly in parenthesis);
* $p < 0.05$, ** $p < 0.01$.

Table 5.4.
Blood biochemistry of vegetarian elderly men and women

Variable	Men n=17	Women n=23	Regression analysis				
				Regression coefficients			
			Trans-formation	Inter-cept	Gender	Housing	Age
Total cholesterol (mmol/L)	4.31 ± 0.87# (6.00)	5.49 ± 1.20 (6.53)	-	4.90	0.60**	-0.01	0.01
HDL-cholesterol (mmol/L)	0.95 ± 0.22 (1.02)	1.04 ± 0.24 (1.35)	-	0.99	0.05	-0.04	0.01
Total/HDL-cholesterol (ratio)	4.83 ± 1.82 (6.13)	5.66 ± 2.10 (5.17)	-	5.33	0.41	0.30	-0.03
Uric acid (µmol/L)	336 ± 82 (340)	313 ± 71 (307)	-	326	-8	15	3
Creatinine (µmol/L)	91 ± 20 (114)	80 ± 16 (98)	-	85	-5	-0.2	0.3
Thyroxine (nmol/L)	92 ± 13 (108)	103 ± 22 (109)	-	97	5	-5	-0.2

Unadjusted mean ± SD (mean values of omnivorous elderly in parenthesis); * $p < 0.05$, ** $p < 0.01$.

Table 5.5.
Urine biochemistry of vegetarian elderly men and women

Urinary excretion	Men n=14	Women n=22+	Regression analysis: Trans-formation	Regression coefficients: Inter-cept	Gender	Housing	Age
Volume 24-h urine (mL)	1119 ± 570# (1554)	1465 ± 566 (1524)	ln	7.06	0.16*	-0.01	-0.002
Density (g/L)	1020 ± 7 (1016)	1015 ± 6 (1014)	-	1017	-3**	-2	-0.4*
Creatinine (mmol/24-h)	8.3 ± 3.0 (11.9)	6.0 ± 1.4 (8.3)	-	7.0	-1.3**	-0.8	-0.2**
Creatinine clearance (mL/min)	65.6 ± 24.0 (74.3)	53.2 ± 12.8 (60.4)	-	58.4	-7.8**	-6.3	-1.5**
Sodium (mmol/24-h)	89 ± 27 (147)	82 ± 32 (117)	-	83	-6	-13*	-2**
Potassium (mmol/24-h)	69 ± 35 (66)	64 ± 28 (57)	ln	4.13	-0.04	0.08	-0.02
Calcium (mmol/24-h)	2.24 ± 1.90 (3.31)	2.85 ± 2.03 (3.24)	ln	0.58	0.08	-0.24	-0.06**
Magnesium (mmol/24-h)	2.57 ± 0.90 (3.17)	2.81 ± 1.09 (2.73)	-	2.72	0.07	0.07	-0.04
Iodide (µmol/24-h)	6.03 ± 6.14 (0.96)	5.20 ± 5.80 (0.80)	ln	0.90	-0.26	-0.06	-0.05
Hydroxyproline (mg/24-h)	13.3 ± 4.3 (20.0)	15.3 ± 6.7 (18.3)	-	13.9	0.6	-1.7	-0.3*
Sulfate (mmol/24-h)	16.7 ± 5.2 (17.8)	15.2 ± 4.5 (15.0)	-	15.6	-1.1	-1.6	-0.3**

+ Number of observations among women was 21 for creatinine and sulfate and 20 for creatinine clearance; # unadjusted mean ± SD (mean values of omnivorous elderly in parenthesis); * $p < 0.05$, ** $p < 0.01$.

and had on the average a lower diastolic blood pressure (difference about 8 mmHg) than those living in the institution.

Body height, body weight, percent body fat (based on biceps and triceps skinfolds), hemoglobin, hematocrit, number of red cells, 25-hydroxyvitamin D, creatinine clearance, density of urine and excretion of creatinine, hydroxyproline, sulfate, sodium and calcium were lower in older subjects. Correlation coefficients between urinary excretions and creatinine clearance are presented in **Table 5.6.**. Some excretions in the 24-h urine were positively related with creatinine clearance, especially those inversely associated with age. Slightly higher correlations were found after logarithmic transformation.

Table 5.7. summarizes the cardiovascular risk profile for men and women, which in general showed the prevalence of these risk factors (especially among men) to be relatively low. Hypertension, defined as systolic blood pressure ≥ 160 mmHg and/or diastolic blood pressure ≥ 95 mmHg and/or usage of antihypertensive drugs, occurred in 29% of the men and 43% of the women. Among omnivorous elderly subjects these percentages were 58 and 68 for men and women, respectively (26).

Six men and three women had vitamin B-12 concentrations below 138 pmol/L (P 2.5 of blood donors). Among women there was an inverse association between vitamin B-12 concentration and mean corpuscular volume (MCV), which indicates a marginal status for this vitamin (29). Since most subjects (88% of the men and 96% of the women) had MCV values below 100 fL, frank megaloblastic anemia

Table 5.6.
Correlation coefficients between urinary excretions and creatinine clearance among vegetarian elderly men and women

	Creatinine clearance	
Urinary excretion	Men n=14	Women n=20
Density of urine	0.60*	0.40
Sodium	0.54*	0.39
Potassium	-0.07	0.46*
Calcium	0.82***	0.66**
Magnesium	0.17	0.56*
Iodide	0.01	-0.06
Hydroxyproline	0.40	0.36
Sulfate	0.58*	0.49*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5.7.
Prevalence of cardiovascular risk factors among vegetarian men and women

Risk factor	Vegetarians				Omnivores			
	Men		Women		Men		Women	
	%	(n)+	%	(n)+	%	(n)+	%	(n)+
Body mass index (≥ 30 kg/m²)	7	(15)	12	(25)	6	(267)	20	(262)
Blood pressure								
SBP# (≥ 160 mmHg)	17	(18)	38	(26)	34	(266)	45	(264)
DBP# (≥ 95 mmHg)	0	(18)	20	(26)	18	(266)	28	(264)
Total cholesterol (≥ 6.5 mmol/L)	0	(17)	17	(23)	28	(269)	48	(263)
Smoking								
current	0	(18)	0	(26)	49	(270)	12	(269)
former	44	(18)	8	(26)	46	(270)	23	(269)

+ Total number of observations; # SBP: systolic blood pressure, DBP: diastolic blood pressure.

was not usual. The storage of Fe (ferritin) was low for most subjects; 3 men and 2 women had values ≤ 12 µg/L. According to the WHO cutoff values 6 men and 1 woman were anemic. About 24% of the vegetarians had relatively low (< P 2.5 of younger adults) Zn levels, and three men and one woman had marginal (< 11.0 µmol/L) Zn concentrations. Although June 1986 was very sunny, the 25-hydroxyvitamin D concentration in plasma was low (< 31 nmol/L; P 2.5 of blood donors) in three men and eight women (29). About 71% of the vegetarian men and 64% of the vegetarian women had urinary output below 25 mL per kg body weight per 24-h (assuming complete collection). Based on habitual water intake (assessed through dietary histories) 47% of the men and 35% of the women ingested less than 25 mL per kg body weight daily. Although for men the hematocrit tended to be lower at higher water intake ($r = -0.48$) and excretions ($r = -0.52$) per kg body weight, these associations did not reach significance ($p = 0.06$) probably due to the small number of observations. Similar correlations were found after logarithmic transformation. Among men, urine excretion per kg body weight was positively ($r = 0.82$; $p < 0.001$) correlated with water intake per kg body weight; among women there was a much lower correlation ($r = 0.22$; $p = 0.32$).

Analysis of variance (BMDP) with gender, dietary style and their interaction as factors indicated that, except for body

height, systolic blood pressure, hematocrit, EAST-AC, 25-hydroxyvitamin D, uric acid, total/HDL cholesterol, potassium and sulfate excretion, the mean values differed significantly ($p < 0.05$) between vegetarian and omnivorous elderly people.

Discussion

In general, differences found between vegetarian men and women were in accordance with those observed between omnivorous Dutch elderly men and women (26). On average similar results were observed for independently living and institutionalized vegetarians. Exceptions were some anthropometric variables (particularly body weight), diastolic blood pressure, total carotenoids concentration, EGR-AC, 25-hydroxyvitamin D concentration and sodium excretion in the urine. These findings are most likely due to differences in physical activity (anthropometry and 25-hydroxyvitamin D), and dietary intake and preparation practices (sodium, carotenoids, and EGR-AC). Several indicators of the nutritional status were significantly associated with age. Age dependencies were mainly found with respect to body build and body composition, blood pressure, hematology, 25-hydroxyvitamin D, and excretions in the 24-h urine. The excretions of sodium, calcium, and sulfate as well as the density of the urine were found to be positively correlated with the creatinine clearance, indicating a vital role of the kidney function in these age dependencies. Therefore, the lower urinary excretions at higher age, especially calcium with the highest correlation with creatinine clearance, are not likely to be solely the result of dietary factors. Moreover, except for the consumption of rice and pasta none of the dietary intake variables studied were found to be associated with age among the vegetarian elderly subjects surveyed. Most of the indicators of the nutritional status that were significantly associated with age among vegetarians, were also found to be related with age (in the same direction) in our national survey among omnivorous elderly people (26).

In accord with other studies (10,18-23), we observed a favorable cardiovascular risk profile among vegetarians, which indicates that an unfavorable profile is not a "normal" concomitant of aging in affluent societies. The differences between vegetarian and omnivorous elderly people found in their dietary intake (28) provide suggestive evidence that the differences in cardiovascular risk profile are partly of nutritional origin; they are in accordance with present concepts on the role of diet in the etiology of cardiovascular diseases.

However, 30% were under medical care for cardiovascular diseases which indicates that a vegetarian diet does not necessarily prevent these diseases at old age.

Our findings regarding the status of vitamin B-6, vitamin B-12, Fe and Zn fairly well agree with other studies among vegetarians (10-17,24), and indicate that vegetarian elderly are at risk for a marginal status of Zn, Fe and vitamin B-12.

Plasma 25-hydroxyvitamin D levels were lower at higher ages, whereas a higher mean concentration was found for the independently living elderly than for those institutionalized. These results are in accordance with previous studies among (omnivorous) elderly people (26,40) and are therefore not a typical long-term risk of a vegetarian diet. Limited exposure to sunlight as a consequence of restriction of activities outdoors is the most likely cause which is also suggested by the lower body weight and urinary creatinine excretion at higher age.

Our results show that water intake of the vegetarian elderly was marginal. This is not typical of vegetarian diets. The relatively high correlations of the volume of 24-h urine and daily water intake per kg per body weight with hematocrit among the men may even point to some degree of dehydration.

In comparison with a similar survey among omnivorous elderly in The Netherlands (26,29), the vegetarian elderly had higher mean values for vitamins except for vitamin B-12, 25-hydroxyvitamin D, EAST-AC and EGR-AC. They had higher MCV, iodide excretion and density of the urine (men), but lower mean values for most indicators of Fe status (especially men), serum Zn, 24-h urine volume (especially men), and for excretion of sodium, calcium (especially men) and magnesium (men). Although nutrition is the most salient feature of the lifestyle of vegetarians, our comparison is distorted due to differences in age (mean and range among omnivorous elderly was 72 and 65-79 y, respectively), physical activity, socioeconomic status, smoking habits, nutritional supplement usage, health status, drug use, and periods of data collection. Age-adjusted comparisons can be made by using the regression equations presented in the Tables. However, such a comparison does not isolate the effect of dietary factors from that of confounders. For instance, the differences in blood pressure are probably masked because of the higher use of diuretics (22 versus 7%) and other antihypertensive agents (20 versus 4%) among omnivores than among vegetarian elderly people. Absence of selective mortality, which has likely been higher in omnivores, would probably have resulted in more pronounced differences in the cardiovascular risk factors. Due to the large number of potential confounders that are likely to be of greater importance than age, lack of adequate information on these

confounders and their effects, and the small sample size of the vegetarians studied it was decided not to present an age-matched comparison between omnivorous and vegetarian elderly people. Vegetarians are also reported to differ markedly from omnivores with respect to attitudes, beliefs and behavior concerning health (41-43). Therefore, our study cannot provide definitive information on the long-term effects of vegetarianism on the nutritional status. Since vegetarians and nonvegetarians differ substantially with respect to dietary intake and nutritional status, etiologically oriented studies should be careful with conclusions that only one dietary factor of a vegetarian diet causes different morbidity and mortality risks among (non)vegetarians. In general, the differences between vegetarian and omnivorous elderly are in accord with results from other studies (10-14,18-23). Most differences were more pronounced in our comparison, which is most likely the result of the long history of vegetarianism (73% for more than 45 y) among our elderly subjects.

The use of nonfasted blood for the biochemical analyses may have distorted our nutritional assessment among vegetarian elderly people. For nutritional status indicators that are influenced by the short-term dietary intake, like folate and total carotenoids, higher values may have been found than in a fasting condition. However, most indicators studied are considered to reflect and integrate the intake over a relatively long period of time before sampling and/or are used as nutrition-related risk factors. Our comparisons with omnivorous elderly subjects and with younger adults (blood donors) are probably not invalidated by the use of nonfasted blood since in all three groups blood from nonfasting subjects was obtained.

In summary, we conclude that vegetarian elderly are at risk for a marginal Fe, Zn, vitamin B-12, and vitamin D status, and dehydration. The last two risks are not likely to be related to vegetarianism. On the other hand, since they had a more favorable cardiovascular risk profile greater cardiovascular risk should not be considered normal for elderly people in affluent societies. The nutrition-related risks found among the vegetarian elderly can probably be corrected by lifestyle changes.

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6. NUTRITION AND BLOOD PRESSURE AMONG ELDERLY MEN AND WOMEN*

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ABSTRACT

Associations between blood pressure and nutrition-related variables (body mass index, dietary intake, and 24-h excretion of sodium, potassium, magnesium and calcium in the urine) were investigated in men (n=138) and women (n=117) 65-79-y-old, not using drugs known to affect blood pressure and not on a diet. Among men body mass index was positively and creatinine clearance was inversely associated with systolic blood pressure, whereas body mass index and urinary sodium:potassium ratio were positively associated with diastolic blood pressure. Among women both age and urinary calcium:creatinine ratio were positively associated with systolic as well as diastolic blood pressure. Coffee consumption was positively correlated with blood pressure and urinary calcium:creatinine ratio among the women. From the results it appears that, besides "normal" weight, potassium may exert a protective effect among elderly men against hypertension when sodium exposure is relatively high. The positive association between urinary calcium:creatinine ratio and blood pressure among the women may be partly due to coffee consumption.

Introduction

Both systolic (SBP) and diastolic blood pressure (DBP) increase with age, more rapidly for women than for men (1). Despite selective mortality hypertension is still associated with cardiovascular morbidity and mortality among elderly people (2,3). Although clinical trials have demonstrated the benefits of antihypertensive drugs, potential side-effects and high costs may outweigh the advantages (1). Nonpharmacologic therapy (such as weight reduction and dietary changes) does not have these overt or hidden side-effects (4). Obesity and intake of sodium, potassium, calcium, magnesium, dietary fiber, fat, alcohol and coffee may act

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as determinants of blood pressure in genetically susceptible individuals (3-8). However, most studies on the diet-blood pressure relationship refer to middle-aged adults and a serious lack of information on elderly people exists.

To investigate the associations between nutrition-related variables and blood pressure we selected elderly men and women, not using drugs known to affect blood pressure and not on a dietary regimen, from a national survey.

Materials and methods

In 1984-1985, a nationwide survey among 539 apparently healthy elderly was conducted within the framework of the Dutch Nutrition Surveillance System (9). All subjects were independently living apparently healthy Caucasians. The study design and procedures have been described in detail (10,11).

DBP (Korotkov phase V or - when the disappearance of the tone was undetectable - phase IV) and SBP (Korotkov phase I) of 530 elderly were measured in duplicate by a physician at the right arm using a standard mercury sphygmomanometer (cuff with inflatable section 12 x 23 cm) after the subject had been seated quietly for at least 5 minutes. When the readings differed by more than 10%, blood pressure was measured again in duplicate. For data analysis, the mean of the two readings was used. Body height and weight were measured of subjects standing without shoes and with one layer of upper clothes. Body mass index (BMI) was calculated (weight/height^2) and expressed in kg/m^2. Food consumption data reflecting the habitual pattern of intake were obtained by 15 dietitians with a modified version of the dietary history method with cross-check (12). The calculation of the intake of energy and nutrients was based on the 1984 version of the Dutch Food Composition Table (13). The standardized interview by a physician included questions on current drug use. Subjects were carefully (orally by a dietitian and through a written instruction) instructed how to collect one 24-h urine sample. This sample was analyzed for sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and creatinine by routine methods (14-17). Creatinine concentration was measured in serum (17). Creatinine clearance was calculated and expressed in mL/min.

Since we were interested in the association between blood pressure and habitual diet, subjects using drugs known to affect blood pressure and those on a diet were excluded from statistical analyses. The following nutrition-related variables, which have frequently been reported to be associated with level of blood pressure (3-8), were included in our study: BMI, sodium (urine),

potassium (urine and diet), calcium (urine and diet), magnesium (urine), fat (diet), alcohol (diet), dietary fiber (diet) and coffee (diet). Since the level of the creatinine clearance can represent both cause and result of high blood pressure (18), the association of both SBP and DBP with creatinine clearance was also studied.

Statistical evaluation was done in three different ways. The first evaluation comprised a regression analysis for each nutrition-related variable with blood pressure (SBP or DBP) as dependent variable. The effects of the nutrition-related variables were adjusted for age and BMI, and for age, BMI and educational level by multiple linear regression. In the second evaluation, the mean SBP and DBP were calculated for the elderly classified into three groups (tertiles) according to the distribution of the nutrition-relation variable in question. Thereafter, differences between these groups in mean blood pressure were tested both unadjusted (analysis of variance), adjusted (regression analysis) for age and BMI, and adjusted for age, BMI and level of education. Although this type of evaluation causes loss of information, the use of categorical instead of continuous variables was chosen because of the probability of nonlinear associations and to reduce the impact of high ratios of within-person to between-person variation, since the analyses are based on groups rather than individuals (19). Finally, in the third evaluation the strongest correlates of blood pressure were assessed by "all possible subsets regression analysis" with SBP or DBP as dependent variable and the nutrition-related variables as independent variables. The model with all independent variables significant and with the highest percentage of variance explained (R^2) was considered as the best fitting model. When appropriate, logarithmic (K intake, Na:creatinine ratio, K:creatinine ratio and Mg:creatinine ratio) or square root (coffee consumption and Ca:creatinine ratio) transformations were made before regression analyses to normalize the distributions. The data of one man with an energy intake of 20.9 MJ/day and of another man with a creatinine clearance of 180 mL/min were excluded from regression analyses. All analyses were performed separately for men and women using the BMDP statistical computer package (20). A p value of less than 0.05 was considered significant in the two-tailed tests.

Results

The prevalence of hypertension, defined as SBP ≥ 160 mmHg and/or DBP ≥ 95 mmHg (21) and/or usage of antihypertensive drugs among the original sample of 530 elderly, was 58% for men and 68% for

women. After exclusion of the 227 elderly using drugs known to affect blood pressure, the prevalence of hypertension was 38% for men and 51% for women. Finally, the exclusion of 48 elderly not using drugs known to affect blood pressure but on a diet resulted in prevalences of hypertension of 38% and 48% for men and women, respectively.

In **Table 6.1.** data (mean ± SD) on relevant variables are presented according to gender. The average intake of energy, fat, Ca, K, coffee and alcohol, 24-h excretion of cations (except calcium) in the urine, creatinine excretion, and creatinine clearance were higher for men than for women, whereas mean BMI and excretion of cations per mmol creatinine were higher for women. Among men a number of variables (coffee: $r = -0.18$; K excretion: $r = -0.22$; Na:K ratio: $r = 0.19$; creatinine clearance: $r = -0.26$) were significantly correlated with age. In women BMI ($r = 0.23$), SBP ($r = 0.40$), DBP ($r = 0.29$), creatinine clearance ($r = -0.22$), and Ca excretion ($r = -0.22$) were associated with age.

Tables 6.2. and 6.3. present the variables that were found to be significant in the regression analyses with SBP and DBP as dependent variables. SBP appeared to be (positively) related with age, urinary K:creatinine and Ca:creatinine ratios and use of coffee among women. DBP was found to be positively associated with age, Ca excretion, Ca:creatinine ratio and use of coffee among women. Among men both SBP and DBP were positively associated with BMI, whereas DBP was significantly and positively related with urinary Na:K ratio and inversely with urinary K:creatinine and Mg:creatinine ratio. After adjustment for age and BMI the association between DBP and Mg:creatinine ratio among men was not significant, but inverse associations of DBP with K intake as well as K excretion (borderline: $p = 0.06$) emerged among men. After adjustment for age and BMI the creatinine clearance was = 0.07; inversely (regression coefficient = -0.14; SE = 0.07; $p = 0.05$) associated with SBP among men. In women DBP was significantly (positively) associated with K excretion when adjusted for age and BMI. In these multivariate models BMI was consistently positively correlated with SBP ($p < 0.01$) and DBP ($p < 0.03$) among men, whereas among women age was positively correlated with SBP ($p < 0.001$) and DBP ($p < 0.01$) in all models. From the analyses with the nutrition-related variables as categorical factor (tertiles) similar results as presented in Table 2 and 3 were found for age, BMI, Na:K ratio, Ca:creatinine ratio, coffee intake (adjusted for age and BMI) and K intake. SBP and DBP (after adjustment for age and BMI) were relatively low at higher creatinine clearance values among men, whereas DBP tended to be lower at higher K excretions after adjustment for age and BMI.

The mean SBP and DBP values were not significantly influenced

Table 6.1.
Selected variables (mean ± SD) of elderly men and women not using medication known to affect blood pressure and not on a diet

Variable	Men n=138	Women n=117
Age (y)	71.9 ± 4.4	71.7 ± 4.5
SBP# (mmHg)	149 ± 22	154 ± 21
DBP# (mmHg)	86 ± 11	89 ± 11
Body weight (kg)	76.4 ± 10.3	67.6 ± 9.3**
Body mass index (kg/m²)	25.5 ± 3.0	26.3 ± 3.4
Energy intake (MJ/day)	10.6 ± 2.2	8.3 ± 1.9**
Fat intake (g/day)	115 ± 32	89 ± 26**
Calcium intake (g/day)	1.10 ± 0.32	0.99 ± 0.33**
Potassium intake (g/day)	3.75 ± 0.79	3.28 ± 0.80**
Dietary fiber (g/day)	27.6 ± 8.6	23.7 ± 7.4**
Alcohol intake (g/day)+	14 ± 13	9 ± 13**
Coffee intake (mL/day)	417 ± 244	347 ± 271*
Sodium excretion (mmol/24-h)	149 ± 45	125 ± 45**
Sodium:creatinine ratio	12.4 ± 4.3	15.3 ± 6.9**
Potassium excretion (mmol/24-h)	66 ± 19	57 ± 17**
Potassium:creatinine ratio	5.5 ± 1.8	7.1 ± 3.0**
Sodium:potassium ratio	2.36 ± 0.75	2.26 ± 0.80
Calcium excretion (mmol/24-h)	3.37 ± 1.66	3.61 ± 1.87
Calcium:creatinine ratio	0.28 ± 0.14	0.43 ± 0.21**
Magnesium excretion (mmol/24-h)	3.08 ± 1.19	2.72 ± 0.90**
Magnesium:creatinine ratio	0.26 ± 0.12	0.33 ± 0.16**
Creatinine excretion (mmol/24-h)	12.4 ± 3.4	8.7 ± 2.4**
Serum creatinine (µmol/L)	110 ± 15	94 ± 13**
Creatinine clearance (mL/min)	79.7 ± 21.5	64.6 ± 18.8**

* $p < 0.05$, ** $p < 0.01$; # SBP: systolic blood pressure, DBP: diastolic blood pressure; + Difference between men and women tested after transformation (logarithm of alcohol intake + 1 and logarithm of alcohol intake of users only).

by smoking habits, socioeconomic status or physical activity, but women with a higher educational level had a higher mean DBP (92 mmHg) than those with lower education (87 mmHg). Since the results (both in the categorical and continuous analyses, and both for men and women) did not change when educational level was included in

Table 6.2.
Regression coefficients (standard error) of the variables significantly associated with systolic blood pressure among elderly men and women

Variable	Men		Women	
	bivariate	multivariate#	bivariate	multivariate#
Age	0.68 (0.45)	-	1.82 (0.41)***	-
Body mass index	1.86 (0.62)**	-	0.83 (0.57)	-
Ln(Potassium:creatinine ratio)	-9.18 (6.51)	-6.96 (6.34)	10.39 (5.07)*	10.30 (4.61)*
Calcium excretion	-1.77 (1.16)	-1.99 (1.14)	1.38 (1.03)	2.52 (0.96)**
(Calcium:creatinine ratio)½	-23.37 (14.01)	-21.06 (13.56)	26.40 (12.03)*	32.04 (11.20)**
(Coffee consumption)½	0.06 (0.29)	0.09 (0.29)	0.54 (0.25)*	0.55 (0.23)*

adjusted for age and body mass index; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6.3.
Regression coefficients (standard error) of the variables significantly associated with diastolic blood pressure among elderly men and women

Variable	Men		Women	
	bivariate	multivariate#	bivariate	multivariate#
Age	0.03 (0.23)	-	0.69 (0.22)**	-
Body mass index	0.84 (0.32)**	-	0.31 (0.29)	-
Ln(Potassium intake)	-8.92 (5.03)	-10.88 (5.01)*	4.25 (3.91)	5.53 (3.81)
(Coffee consumption)$^{1/2}$	-0.10 (0.15)	-0.12 (0.15)	0.27 (0.13)*	0.27 (0.13)*
Potassium excretion	-0.07 (0.05)	-0.10 (0.05)	0.10 (0.06)	0.11 (0.05)*
Ln(Potassium:creatinine ratio)	-7.70 (3.20)*	-6.86 (3.27)*	3.51 (2.68)	3.14 (2.52)
Sodium:potassium ratio	3.90 (1.26)**	3.97 (1.28)**	-0.39 (1.25)	-0.30 (1.21)
Calcium excretion	0.01 (0.60)	-0.17 (0.60)	1.11 (0.52)*	1.50 (0.50)**
Ln(Calcium:creatinine ratio)	-2.10 (7.26)	-1.65 (7.16)	16.01 (6.04)**	20.35 (5.96)***
Ln(Magnesium:creatinine ratio)	-5.37 (2.46)*	-4.27 (2.57)	0.74 (2.51)	1.09 (2.42)

adjusted for age and body mass index; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

the model, only data unadjusted for education are reported.

In **Table 6.4.** the results of the "all possible subsets regression analysis" are shown. Among men BMI was positively associated with both SBP and DBP, whereas creatinine clearance was inversely associated with SBP, and urinary Na:K ratio positively with DBP. Among women age and Ca:creatinine ratio were positively associated with both SBP and DBP.

Table 6.4.
Models obtained by all possible subset regression analysis with systolic or diastolic blood pressure as dependent variable

Independent variables	Regression coefficient	T-value	R^2
Systolic blood pressure			
Men			
Intercept	110.50		
Body mass index	2.22	3.49**	
Creatinine clearance	-0.16	-2.33*	0.10
Women			
Intercept	-15.96		
Age	2.06	5.21**	
(Calcium:creatinine ratio)$^{1/2}$	36.03	3.29**	0.24
Diastolic blood pressure			
Men			
Intercept	56.70		
Body mass index	0.79	2.50*	
Sodium:potassium ratio	3.88	3.11**	0.11
Women			
Intercept	18.16		
Age	0.81	3.88**	
(Calcium:creatinine ratio)$^{1/2}$	19.80	3.44**	0.18

* $p < 0.05$, ** $p < 0.01$.

Discussion

Our findings show that BMI and Na:K ratio in the 24-h urine were consistently associated with DBP among elderly men, whereas age, Ca excretion (especially the Ca:creatinine ratio) and coffee (less consistently) were associated with both SBP and DBP among women. BMI was positively and creatinine clearance (less consistently) inversely associated with SBP among men. An age-adjusted regression analysis with blood pressure (normo- and hypertension; classification according to the WHO [21]) as categorical independent variable showed that the hypertensive men had a higher mean Na:K ratio in the urine than the normotensive men. Ca excretion and Ca:creatinine ratio in the urine was found to be higher for hypertensive women than for normotensive women (22), and so was coffee consumption.

In many studies both age and BMI are reported to be related to SBP and DBP (23,24). In our study, absence of one of these associations among men (age) and women (BMI) might be related to old age and a narrow age range (15 y), and to selective mortality, body fatness and body fat distribution which differ between men and women. Among younger adults the effect of age on blood pressure has been found to be more important than relative weight among women, but the reverse among men (24). Among non-obese adults DBP has been found to be associated with the trunk:extremity subcutaneous fat ratio in men, but not in women (25).

According to Kaplan (4), excess dietary sodium is a necessary, but not a sufficient condition in the pathogenesis of hypertension. In general, the association between dietary Na:K ratio and blood pressure is strongest in populations with moderate (100-350 mmol/day) to high (> 350 mmol/day) sodium intake (26). The elderly men and women studied had average Na excretions within the moderate range. Since the urinary Na:K ratio was more strongly associated with DBP than were K excretion and K intake our data partly (for men only) support the hypothesis that a moderate Na exposure may mitigate the effect of K. Other studies also indicate the importance of the Na:K ratio for blood pressure (6,23,27,28). In the First National Health and Nutrition Examination Survey in the United States the influence of the dietary Na:K ratio on blood pressure is found to be stronger in older than in younger men (6).

The positive association of both SBP and DBP with Ca excretion (especially per mmol creatinine) among elderly women is in line with other studies (29-31). In contrast to previous cross-sectional studies among middle-aged Dutch people (32,33), but in accordance with a study among post-menopausal women (34), we did not find a consistent association between blood pressure and Ca

intake among elderly people. Besides differences in age and period of time of data collection, our exclusion of the elderly using antihypertensive medication and the elderly on a prescribed diet may have contributed to the absence of an association between Ca intake and blood pressure. Moreover, the excluded elderly may have included more people sensitive to this dietary factor (26,35), whereas selective mortality may also have had such an effect on the population studied (especially men). Among the women the urinary Ca:creatinine ratio was positively correlated with intake of coffee ($r = 0.30$) and the 24-h urinary excretion of Na ($r = 0.19$), K ($r = 0.22$) and Mg ($r = 0.22$). A higher Na intake increases the urinary Ca:creatinine ratio (36), whereas caffeine increases the urinary excretion of Ca, Na and Mg (37). Among women coffee consumption was positively associated with SBP and DBP. Ca intake was not significantly correlated with Ca:creatinine ratio in our study. Urinary Ca excretion represents a small proportion of Ca intake and depends, among other things, on the 1,25-dihydroxyvitamin D level in plasma which, in turn, depends on synthesis in the kidney. A positive association between 1,25-dihydroxyvitamin D and blood pressure (both SBP and DBP) has been found for women aged 20-80 y (38). In our study, 24-h Ca excretion appeared to be associated to creatinine clearance (especially among hypertensive elderly), which indicates a vital role of the kidney function in urinary Ca excretion (22). Moreover, hypertensive people excrete more calcium, both under normal circumstances and during a calcium infusion (39). These findings might suggest a higher bioavailability and/or an increased urinary loss of calcium with higher blood pressure.

Since we studied several variables in relation to blood pressure some significant effects may have occurred by chance. However, different statistical approaches as well as multivariate analyses, in which only the strongest correlates of blood pressure were included, have been performed. Only consistent associations are given the credit of being real.

In summary, our results indicate that K may exert a protective effect among elderly men against hypertension when Na exposure is relatively high. Among elderly men obesity may be a risk factor for hypertension. The positive association between urinary Ca:creatinine ratio and blood pressure among women, probably partly due to coffee consumption, deserves further study and might be a consequence or a cause of hypertension. Practical guidelines cannot be indicated yet, since our findings were derived from a cross-sectional survey which is not appropriate for drawing definitive conclusions about causal inferences. Moreover, the elderly using antihypertensive drugs and the elderly on a diet were excluded from the analyses. Finally, among men the percentage

of variance explained in DBP in the bivariate analyses by Na:K ratio and BMI was 7 and 5 respectively, and the Ca:creatinine ratio among women explained 4 and 6% of the variance in SBP and DBP, respectively. Although the predictive power of the nutrition-related variables might become higher if repeated measurements had been performed, these variables are probably not the panacea for the control of blood pressure at old age.

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7. NUTRITION AND SERUM CHOLESTEROL LEVELS AMONG ELDERLY MEN AND WOMEN*

Michiel R.H. Löwik, Michel Wedel, Frans J. Kok, Jacobus Odink, Susanne Westenbrink and Joanna F. Meulmeester.

ABSTRACT

Associations of serum cholesterol with relevant dietary intake variables (assessed with the dietary history method) and body mass index were investigated in elderly men (n=199) and women (n=180) 65-79-y-old. All subjects were apparently healthy, nondiabetic and not on a dietary regimen. The associations were studied separately for men and women using linear regression analysis and all possible subsets regression analysis. Among men body mass index (kg/m^2) and intake of monounsaturated fat and of alcohol were positively and consistently associated with serum total cholesterol. Among women intake of alcohol and of saturated fat were positively and intake of polysaccharides was inversely associated with serum total cholesterol. The intake of monounsaturated fatty acids was highly ($r > 0.60$) positively correlated with the intake of total fat and saturated fatty acids, and inversely with carbohydrates. HDL-cholesterol was positively associated with alcohol intake (significant for men only), and inversely with body mass index (women). The results indicate that the effect of dietary factors on serum cholesterol levels is probably not age-limited. Elderly people may potentially benefit from weight reduction or control, moderate alcohol consumption and avoidance of too much dietary fat. These suggestions are fairly well in agreement with the general guidelines for a healthy diet.

Introduction

A number of studies indicate that, despite selective mortality, a high serum total cholesterol concentration still constitutes a risk factor for morbidity and mortality at old age (1-3); the relationship has been suggested to be J-shaped (4,5). Serum total cholesterol levels rise with age and appear to peak at an age of

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* Subtitled with (Dutch Nutrition Surveillance System). Submitted.

approximately 50-60 in men and 60-70 in women; after menopause cholesterol levels are often somewhat higher in women than in men (6,7). Variation in cholesterol levels is associated with dietary factors. Dietary treatment is considered first-line therapy for moderately hypercholesterolemic individuals to reduce their risk of cardiovascular disease. This has been extensively studied in young adults but not among the elderly. Therefore, it is important to know whether dietary factors can modulate serum cholesterol levels at old age and, if so, which these factors are. Since many elderly people have changed their habitual food consumption pattern as a consequence of chronic diseases, especially cardiovascular disease, we studied the diet-serum cholesterol association among apparently healthy nondiabetic elderly not on a dietary regimen and not using cholesterol-lowering drugs.

Materials and methods

In 1984-1985, a nationwide nutritional survey among 539 apparently healthy elderly (aged 65-79 y) has been carried out within the framework of the Dutch Nutrition Surveillance System (8). Consent was obtained after the nature of the study had been fully explained by letter. The study protocol was approved by the external Medical-Ethical Committee of the TNO-CIVO Toxicology and Nutrition Institute.

Food consumption data reflecting the habitual pattern of intake were obtained by 15 dietitians with a modified version of the dietary history method with cross-check (9). The calculation of the intake of energy and nutrients was based on the 1984 version of the Dutch Food Composition Table (10). Information on clinical condition (including current drug use) was obtained by a physician through structured questionnaires. Body height and body weight of subjects standing without shoes and with indoor clothing only were measured. Body mass index was calculated (weight/height^2) and expressed in kg/m^2. A venous blood sample (nonfasting) was obtained for hematological and biochemical analyses. Total cholesterol level in serum was measured in all 533 available blood samples and HDL-cholesterol concentration was determined in serum samples from a random (same stratification as original sample) subsample of 108 respondents. Cholesterol in serum was measured by enzymic procedures using the Boehringer Mannheim Kits # 704121 and, for HDL-cholesterol, # 543004. Sampling design, investigation procedures, biochemical methods and general results have been described previously in more detail (11,12).

For the purpose of the present study data of subjects using cholesterol-lowering drugs, of subjects with overt diabetes as

evidenced by antidiabetic medication, and of subjects on a dietary regimen were excluded from the statistical analyses leaving 199 men and 180 women for analyses.

Analysis of variance was used to test whether the mean value of relevant continuous variables differed between men and women. The data were analyzed separately for men and women. Linear (multiple) regression was used for studying the associations between dietary factors and serum cholesterol. All possible subsets regression analysis with dietary intake and anthropometric measures as independent variables was used to obtain the "best" predicting model of serum total cholesterol. Two analyses were carried out; the dietary variables were expressed in absolute amounts in the first analysis, and the intake of macronutrients were expressed as a percentage of total energy intake (en%) and the intake of dietary fiber as g/MJ in the second analysis. In both analyses age and body mass index were among the independent variables. The model with all significant ($p < 0.05$) independent variables and with the highest percentage of variance explained (R^2) was considered as the best fitting model. Models with a similar number of variables but with a lower R^2 are also presented. Only models in which the correlation coefficients between the independent variables (except for energy intake) were lower than 0.71 (percentage of variance explained < 50%) are presented. High correlations among independently variables gives rise to multicollinearity and may impede the identification of the contribution of each variable separately and the estimated coefficients (even its sign) may be affected for purely statistical reasons. An exception was made for energy to allow adjustment for the quantity of the dietary intake. All possible subsets regression analyses were not executed for HDL-cholesterol because of the number of observations available for this variable was small. Dietary variables included in the analysis were energy, protein (vegetable, animal, total), saturated (sfa), mono-unsaturated (mufa), polyunsaturated fatty acids (pufa), total fat, P/S ratio, mono- and disaccharides, polysaccharides, total carbohydrates, alcohol, cholesterol, dietary fiber and coffee. The association with body mass index was also studied. The assumptions of the regression analysis regarding residuals were checked. No transformations were necessary. Out-of-range values were excluded from the analyses. Actually, one man with a daily use of 400 g blood pudding and one woman with a serum cholesterol concentration of 19.31 mmol/L were excluded. Data analyses were performed with the BMDP statistical computer package (13). All statistical tests were two-tailed. Differences and associations with a p value of less than 0.05 were considered as being statistically significant.

Results

In **Table 7.1.** relevant descriptive (mean and pooled SD) data on dietary intake, body build, body composition, and serum cholesterol level are summarized.

In **Table 7.2.** the results of the bivariate analyses with total serum cholesterol level as dependent variable are presented separately for men and women. Among the men total cholesterol levels in serum appeared to be positively associated with body mass index, and intake of sfa (in en%), mufa (in en%), total fat (in %) and alcohol (both in g and in en%), but inversely with intake of mono- and disaccharides (in en%), polysaccharides (in en%), and dietary fiber (in g). Among the women inverse

Table 7.1.
Selected variables among elderly men and women

Variable	Men n=199	Women n=180	Pooled SD
Age (y)	72.2	72.1	4.3
Total cholesterol (mmol/L)	6.01	6.51	1.18**
HDL-cholesterol (mmol/L)#	1.03	1.39	0.37**
Total/HDL-cholesterol (ratio)#	5.99	5.08	1.61*
Body weight (kg)	75.9	69.1	10.9**
Body mass index (kg/m²)	25.4	27.0	3.4**
Dietary intake			
Energy (MJ)	10.4	8.1	2.3**
Intake in % of total energy intake:			
Vegetable protein	4.2	4.4	0.8**
Animal protein	9.1	10.1	2.2**
Saturated fatty acids	17.5	17.5	3.4
Monounsaturated fatty acids	15.2	14.9	2.7
Polyunsaturated fatty acids	6.5	6.2	2.7
Mono- and disaccharides	21.5	22.3	6.1
Polysaccharides	20.0	20.5	3.7
Alcohol	4.3	2.4	4.2**
Cholesterol (mg/MJ)	36.3	38.0	11.2
Dietary fiber (g/MJ)	2.6	2.9	0.8**
P/S ratio	0.40	0.38	0.20
Coffee (mL)	415	334	241**

Data refer to 39 men and 40 women; * $p < 0.05$, ** $p < 0.025$ for the difference between men and women.

Table 7.2.
Regression coefficients (standard error) of the variables significantly associated with serum total cholesterol in the bivariate regression analysis

Variable	Men n=199	Women n=180
Body mass index (kg/m²)	0.068 (0.024)***	-0.051 (0.024)*
Dietary intake (per day)		
Energy (MJ)	-0.026 (0.034)	0.096 (0.048)*
Saturated fat (g)	0.004 (0.005)	0.018 (0.007)***
Monounsaturated fat (g)	0.010 (0.006)	0.019 (0.009)*
Total fat (g)	0.002 (0.002)	0.008 (0.003)*
Cholesterol (g)	0.086 (0.592)	1.761 (0.812)*
Mono- and disaccharides (g)	-0.005 (0.001)***	0.001 (0.002)
Polysaccharides (g)	-0.005 (0.002)*	-0.001 (0.003)
Total carbohydrates (g)	-0.004 (0.001)***	0.001 (0.002)
Alcohol (g)	0.014 (0.004)***	0.022 (0.008)***
Dietary fiber (g)	-0.019 (0.009)*	0.013 (0.014)
Intake as % of total energy intake		
saturated fat	0.048 (0.022)*	0.044 (0.026)
monounsaturated fat	0.091 (0.025)***	0.021 (0.036)
total fat	0.031 (0.012)**	0.016 (0.015)
mono- and disaccharides	-0.042 (0.012)***	-0.009 (0.016)
polysaccharides	-0.042 (0.019)*	-0.080 (0.025)***
total carbohydrates	-0.047 (0.010)***	-0.030 (0.014)*
alcohol	0.051 (0.016)***	0.069 (0.025)***

* $p < 0.05$; ** $p < 0.025$; *** $p < 0.01$.

associations between serum total cholesterol and body mass index and intake of polysaccharides (in en%) and total carbohydrates were observed, whereas the intake of energy, sfa (in g), mufa (in g), total fat (g), cholesterol (in g) and alcohol (in g and in en%) were found to be positively correlated with serum total cholesterol. After adjustment for age as well as after adjustment for age and body mass index similar results (regression coefficients as well as statistical significance level) were observed.

In **Table 7.3.** the results of the bivariate regression analyses with HDL-cholesterol as dependent variable are presented. Among

Table 7.3.
Regression coefficients (standard error) of the variables significantly associated with serum HDL-cholesterol in the bivariate regression analysis

Variable	Men n=39	Women n=40
Body mass index (kg/m²)	-0.0078 (0.0153)	-0.0415 (0.0116)***
Cholesterol (g)	0.1785 (0.3389)	-1.0809 (0.4586)**
Cholesterol (g/MJ)	0.0449 (0.2147)	-0.5029 (0.2251)*
Mono- and disacch. (g)	-0.0022 (0.0011)*	-0.0001 (0.0016)
Mono- and disacch. (en%)	-0.0163 (0.0067)**	0.0083 (0.0079)
Alcohol (g)	0.0067 (0.0022)***	0.0079 (0.0054)
Alcohol (en%)	0.0253 (0.0081)***	0.0218 (0.0142)

* $p < 0.05$; ** $p < 0.025$; *** $p < 0.01$.

men HDL-cholesterol was correlated inversely with the intake of mono- and disaccharides (in g as well as in en%), but positively with alcohol intake (both in g and in en%). Among women HDL-cholesterol was inversely associated with body mass index and with intake of cholesterol (both in g and in en%).

In **Table 7.4.** the results of the all possible subsets regression analysis with total serum cholesterol as dependent variable are shown. Total serum cholesterol was positively associated with body mass index, intake of mufa and intake of alcohol expressed in relative terms (in en% and adjusted for energy intake) among the men. Among the women the absolute intake of sfa and alcohol was positively associated with serum total cholesterol, whereas polysaccharides (inverse) and alcohol (positive) were associated with serum total cholesterol when dietary intake was related to energy intake.

In **Table 7.5.** the models that also met the criteria but with a lower R^2 are presented. Among men a positive association between body mass index and serum total cholesterol was selected in all models. When the intake of mufa was selected a positive association and for mono- and disaccharides as well as polysaccharides an inverse association was found. In the model without mufa energy intake was selected instead. Dietary fiber was inversely associated with serum total cholesterol in the model without polysaccharides. Among women the intake of polysaccharides was inversely correlated with serum total cholesterol when

Table 7.4.
Best fitting models obtained
by all possible subsets regression analysis
with serum total cholesterol as dependent variable

Independent variables	Regression coefficient	T-value	R^2
Absolute amounts			
MEN			
Intercept	4.9185		
Body mass index (kg/m²)	0.0597	2.65	
Energy (MJ)	-0.2024	-3.91	
Monounsaturated fatty acids (g)	0.0345	3.87	
Alcohol (g)	0.0148	3.40	0.15
WOMEN			
Intercept	5.6922		
Saturated fatty acids (g)	0.0166	2.42	
Alcohol (g)	0.0219	2.73	0.08
Relative contribution			
MEN			
Intercept	2.9204		
Body mass index (kg/m²)	0.0586	2.60	
Monounsaturated fatty acids (en%)	0.0905	3.74	
Alcohol (en%)	0.0518	3.39	0.15
WOMEN			
Intercept	7.5434		
Polysaccharides (en%)	-0.0587	-2.30	
Alcohol (en%)	0.0553	2.25	0.08

adjusted for energy intake. Expressed in en% among women sfa (with a positive association) was included instead of polysaccharides (with an inverse association) in the best fitting model presented in Table 7.4. The difference in R^2 between these two models was only 0.002.

Diuretics did not affect serum total cholesterol levels. The impact of diuretics on HDL-cholesterol and total/HDL-cholesterol could not be studied because of the low number of observations. Total, HDL-, and total/HDL-cholesterol were not significantly associated with age, (former) level of education, region, degree of urbanization nor with physical activity.

Table 7.5.
Second best models obtained by all possible subsets regression analysis with serum total cholesterol as dependent variable

Independent variables	Regression coefficient	T-value	R^2
Absolute amounts			
MEN			
Intercept	4.8502		
Body mass index (kg/m²)	0.0602	2.61	
Mono- and disaccharides (g)	-0.0039	-2.54	
Alcohol (g)	0.0096	2.10	0.11
Intercept	4.9531		
Body mass index (kg/m²)	0.0627	2.73	
Monounsaturated fatty acids (g)	0.0165	2.85	
Mono- and disaccharides (g)	-0.0053	-3.54	
Dietary fiber (g)	-0.0195	-2.27	0.14
Intercept	4.9589		
Body mass index (kg/m²)	0.0613	2.67	
Monounsaturated fatty acids (g)	0.0184	3.10	
Mono- and disaccharides (g)	-0.0050	-3.25	
Polysaccharides (g)	-0.0050	-2.21	0.14
Intercept	4.7717		
Body mass index (kg/m²)	0.0640	2.79	
Energy (MJ)	0.1557	3.02	
Mono- and disaccharides (g)	-0.0069	-3.89	
Polysaccharides (g)	-0.0087	-3.07	0.14
WOMEN			
Intercept	5.8723		
Energy (MJ)	0.2430	3.32	
Polysaccharides (g)	-0.0139	-2.68	0.06
Relative contribution			
MEN			
Intercept	6.3394		
Body mass index (kg/m²)	0.0608	2.67	
Carbohydrates (en%)	-0.0449	-4.46	0.13
WOMEN			
Intercept	5.3198		
Saturated fatty acids (en%)	0.0551	2.23	
Alcohol (en%)	0.0773	3.31	0.08

Discussion

In our cross-sectional survey several dietary factors were significantly associated with serum cholesterol. Studies in similar populations generally fail to show convincing associations between estimates of dietary intake and individual serum cholesterol levels. Absence of high-order correlations may be attributed, among other things, to an inaccurate estimate of individual dietary intake which refers to a short period of time (14,15). Although we assessed the habitual intake by means of the dietary history method with cross-check, only low-order correlations were found in our survey. Since genetic and metabolic factors influence the susceptibility to diet it is not very reasonable to expect high correlations of dietary factors with individual serum cholesterol levels, especially regarding the intake of cholesterol and the P/S ratio of the diet (16). Elderly people on a dietary regimen were excluded, whereby those responsive to high-cholesterol diets may have been under-represented in the analyses. Moreover, selective mortality might also have contributed to low-order correlations between dietary factors and serum cholesterol among those surviving. However, the results of our survey reflect real-life situations where there are differences among subjects with regard to heterogeneous response of serum cholesterol to similar diets, and where there exist interactions between various dietary components and between diet and other environmental factors.

Among men body mass index, and intake of monounsaturated fatty acids and alcohol were consistently positively associated with serum total cholesterol. Among women sfa and alcohol were positively associated with serum total cholesterol, whereas polysaccharides were inversely associated with serum total cholesterol. Since a diet consists of a complex set of inter-related nutrients (17) a major problem in the interpretation of the results is related to the assessment of relative importance of different significant correlates of serum cholesterol. The all possible subsets regression analysis used provides information on the strongest correlates of serum cholesterol levels. However, it cannot identify interdependencies among dietary factors that may actually be responsible for the observed associations. Important variables that are highly correlated with the variables in the model may not have been identified. We presented not only the model with the highest percentage of variance explained. The models selected indicated an interdependency between sfa and polysaccharides among women. In the models either sfa (with a positive association) or polysaccharides (with an inverse association) was included. Among men mufa (with a positive

association) was often included in a model in which mono- and disaccharides as well as polysaccharides had an inverse association with serum total cholesterol. Therefore, from our results the intake of fat and of carbohydrates cannot be identified as separate determinants of serum total cholesterol.

The positive association of the intake of mufa with total serum cholesterol among men is surprising since it contradics with recent findings that substitution of sfa by mufa appears to lower blood cholesterol (18,19). However, diets of independently living individuals include fats from a variety of sources which vary in fatty acid composition and may be assumed to vary in metabolic and nutritional properties as well (20,21). Therefore, we suggest that monounsaturated fatty acids should be subclassified in future epidemiological studies. Another explanation and perhaps a more important one for the positive association of mufa with serum total cholesterol observed is that our data refer to steady-state responses of dietary interrelationships and not to the situation in which energy-providing nutrients are exchanged as is the case in short-term controlled experiments.

Among men the energy derived from mufa was highly correlated with the en% of total fat (0.82), sfa (0.64), and total carbohydrates (-0.66), but not with protein (-0.08) or alcohol (-0.04). Comparable correlations were found for the women. The greatest difference between the genders was found for alcohol, i.e., a correlation coefficient of -0.10 between the energy derived from mufa and energy from alcohol among the women. The bivariate regression analyses are in accordance with these interdependencies since among men serum total cholesterol was found to be positively associated with sfa and total fat and inversely with total carbohydrates.

Obesity is accompanied by increases in cholesterol whole body synthesis, whereas weight reduction can reduce it to normal levels (16,22). Serum total cholesterol is somewhat less dependent on fatness in women than in men, both for younger and older adults (23). Our results are in accordance with this observation since body mass index was positively associated with total serum cholesterol among the men. Body mass index was inversely associated with serum total cholesterol in the bivariate analysis among the women which can most likely be attributed to changes in HDL-cholesterol. Therefore, our data suggest that obese elderly men and women may benefit from weight reduction with respect to serum (HDL-) cholesterol levels.

Our different observations for men and women may be due to selective survival, prevalence of morbidity, body fatness and body fat distribution, level of serum (HDL-)cholesterol and physiological and lifestyle factors (24,26). For instance, the

positive association of alcohol intake with HDL-cholesterol was significant among men but not among women, which may be due to the lower alcohol intake among women. Furthermore, the risks associated with different lipoproteins are not similar for men and women (27). Among women the cardiovascular risk of a higher LDL-cholesterol level is less consistent and less striking than that of HDL. Since atherosclerotic cardiovascular disease in the elderly is the result of several decades of cholesterol accretion, the reversal of cholesterol accumulation, in which HDL-cholesterol plays an important role, is of special importance at old age (7). Therefore, a reduction in total cholesterol should not be accompanied by a reduction in HDL-cholesterol. Our data on HDL-cholesterol indicate a positive association with alcohol (significant for men only) but an inverse one with body mass index (women) and the intake of mono- and disaccharides (men) and of cholesterol (women).

In conclusion, our results suggest that the effect of dietary factors is not age-limited, whereby elderly people may possibly benefit from lifestyle changes. The data presented indicate that a potential benefit can be accrued by weight reduction or control, moderate alcohol consumption and avoidance of too much dietary fat and cholesterol in the diet. These suggestions are in fair accordance with the guidelines given by the Netherlands Nutrition Council (28) and by the Surgeon General (29) for the population as a whole. However, since our study was cross-sectional it remains to be proven by prospective and intervention studies that elderly people actually benefit from dietary changes with respect to longevity and quality of life.

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8. DOSE-RESPONSE RELATIONSHIPS REGARDING VITAMIN B-6 IN ELDERLY PEOPLE: A NATIONWIDE NUTRITIONAL SURVEY*

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ABSTRACT

The dietary intake and biochemical status of vitamin B-6 in 476 apparently healthy Dutch elderly people (aged 65-79 y), who were not using drugs known to affect vitamin B-6 metabolism, were evaluated. Intake of vitamin B-6 per gram protein was related to biochemical data, namely plasma pyridoxal 5'-phosphate (PLP) and cofactor stimulation of aspartate aminotransferase in erythrocytes (EAST-AC). Based on a cutoff point of 2.02 for EAST-AC, about 9% of the elderly people not using vitamin B-6 supplements had a marginal vitamin B-6 status. About 7% were using vitamin B-6 supplements. Dietary intake of vitamin B-6 per gram protein was negatively related to EAST-AC. Vitamin B-6 intakes per gram protein higher than 0.020 mg were necessary to ensure an EAST-AC value < 2.02. At high PLP values EAST-AC hardly varied. The results seem to indicate a higher requirement of vitamin B-6 in elderly people than in younger adults.

Introduction

With the progressive aging of populations in industrialized societies, prevention of a marginal nutrient intake and subclinical deficiency among elderly people is of increasing concern. Recommended Dietary Allowances (RDA) are essential and often the only available standards used for assessment of the adequacy of dietary intake. However, there is a serious lack of age-specific information, implying that the current allowances for elderly people are largely based on extrapolation of data from healthy young adults (1,2). Because of changes with advancing age in physiological processes (such as an age-associated increase in serum alkaline phosphatase (3) and hormonal changes owing to menopause in women), in physical activity patterns and in health

* Subtitled with (Dutch Nutritional Surveillance System). Am J Clin Nutr 1989;50:391-399.

status, this extrapolation may be incorrect.

Plasma pyridoxal 5'-phosphate (PLP), as an indicator of recent dietary intake and circulating store of vitamin B-6, has been shown to decrease with advancing age (4-9). Biochemical vitamin B-6 deficiency is fairly widespread in elderly people. In most cases vitamin B-6 supplements could correct the adverse situation in elderly people (4,6,7,10-12). Several authors postulated a difference in vitamin B-6 metabolism as an explanation of the higher prevalence of suboptimal vitamin B-6 status in elderly people in comparison with younger adults (6,7,13). However, subclinical deficiencies among elderly people are often conditional to chronic diseases and medical interventions (14). Most studies, in which dietary intake and/or status of vitamin B-6 of elderly people has been evaluated, have disregarded intercurrent or chronic diseases and drug use (5,6,10,14). Garry et al (15) studied healthy elderly volunteers who were not using drugs but this study was directed only at the intake of vitamin B-6.

According to Schneider et al (2) cross-sectional studies can provide useful information on the effects of age on nutritional intake required to achieve specified plasma or tissue levels. A cross-sectional survey provides a basis for studying the steady-state responses of nutrient intakes over a wide range of intake levels that are currently prevalent in the habitual food consumption patterns of elderly people.

To evaluate the adequacy of the estimated vitamin B-6 intake per gram protein in elderly people, we studied dose-response relationships among apparently healthy elderly people in a cross-sectional design. Special attention was given to elderly people who were using vitamin B-6 supplements.

Subjects and methods

As part of the Dutch Nutritional Surveillance System, a nationwide nutritional survey among apparently healthy elderly has been carried out from October 1, 1984 until February 8, 1985 (with a break from December 21 to January 14). The sampling design (n=540) consisted of a two-stage cluster sample stratified for region (north, east, south, west), degree of urbanization (< 20,000, 20,000-400,000, and > 400,000 inhabitants), age (65-69, 70-74, and 75-79 y), and gender. Entry criteria were as follows: aged 65-79 y, independently living, Caucasian, and apparently healthy (based on a clinical evaluation by a physician). Apparently healthy was defined as not bedridden, not in a wheelchair, and not suffering from a disease that would probably end life in the near future.

All respondents were mentally and physically able to participate in the entire study.

The study protocol was approved by the external Medical-Ethical Committee of the TNO-CIVO Toxicology and Nutrition Institute. Informed consent was verbally obtained after the nature of the study was fully explained by letter.

About 6% of the elderly people were considered not apparently healthy and excluded from the survey. The response rate was 53%. Actually, 539 elderly people participated in the survey after a random selection from 18 municipal registers. A relevant responder bias is not likely because respondents and nonrespondents did not differ significantly in marital status and housing situation. Moreover, in the final sample of 539 elderly people, the distribution of the civil status (age- and gender-specific) and the percentage with a supplementary social benefit correspond to the data of the Netherlands Central Bureau for Statistics (16).

All respondents were visited twice at home. During the first visit data were collected on demographic variables, lifestyle, and food consumption. At the second visit, usually a few days later, a physician used structured questionnaires to obtain information on clinical condition, including current drug use, and use of nutritional supplements. At the end of the second visit a venous blood sample (nonfasting) was obtained for hematological, biochemical and routine clinical chemical analyses. Basal aspartate aminotransferase (EAST) activity and EAST activation coefficient in the erythrocytes (EAST-AC) were measured in all available blood samples, and pyridoxal 5'-phosphate (PLP) concentrations were determined in plasma samples from a random subsample of 108 respondents.

Food consumption data were obtained at the homes of the participants by 15 trained registered dietitians with a modified version of the dietary history method with cross-check (17). The habitual pattern of food intake with special attention to the preceding 2 weeks was assessed. The frequency of consumption and amounts consumed (in common household measures) of the food products from a checklist were assessed against the information about the usual intake. Conversion of the dietary information to the intake of energy and nutrients was established with a computerized version (1984) of the Dutch Food Composition Table (18). The vitamin B-6 content (according to McCance and Widdowson [19] of advokaat (a kind of eggnog) and beer was added to this version. Vitamin B-6 losses owing to normal household food preparation practices are accounted for in the Dutch table. The data presented on vitamin B-6 intake refer only to intake through consumption of foods (without nutritional supplements).

For the purpose of the present study, all elderly people (n=57) using drugs known to affect potentially the vitamin B-6 requirement, metabolism, and/or status were excluded from the analysis. These drugs were phenobarbital, phenytoin, cycloserine, pyrazinamide, isoniazid, (thio)semicarbazide, hydracarbazine, hydramitrazine, phenelzine, carbidopa, levodopa, hydralazine, steroids, and penicillamine (20,21). Furthermore, six elderly people with frank anemia (hemoglobin < 7.5 mmol/L) were also excluded. After exclusion of these persons data on 239 men and 237 women remained for analyses. Because vitamin B-6 requirements are related to level of protein intake (22), we considered only the relative (per gram protein) intake of vitamin B-6 in relation to EAST-AC. As no sex differences were observed in both vitamin B-6 intake per gram protein and EAST-AC, men and women were combined, but separated for vitamin B-6 supplement users and nonusers. No information was available on daily dosage of supplements. However, because the vitamin B-6 supplements used by the Dutch elderly people mostly contain ≥ 1 mg vitamin B-6 (range 0.2-20.0 mg) and the bioavailability of synthetic vitamin B-6 is probably substantially higher than that of food vitamin B-6 (1), a much higher intake among elderly people using vitamin B-6 supplements can validly be assumed.

Reference values were obtained from 162 blood donors, aged 18-65 y (all volunteers and healthy according to the criteria used by the Dutch Red Cross) and 60 healthy 35-y-old men (23,24).

The evaluation of the vitamin B-6 status was based on the biochemical measurement of plasma PLP and activity of EAST before and after in vitro stimulation with PLP (at the cellular level; EAST-AC). The EAST activity with and without added PLP was measured in duplicate with a kinetic assay on a Hitachi 705 automatic analyzer. The intraassay and interassay CVs for the basal activity were 6.8% and 9.0%, respectively, and the CVs for EAST-AC were 8.3% and 9.2%, respectively (H. van den Berg, unpublished observation, 1986). The concentration of PLP in plasma was measured by radioenzymatic assay with tyrosine decarboxylase apoenzyme (singular extraction, assay in duplicate). The intraassay CV of this measurement was 5.6% and the interassay CV 7.5% (H. van den Berg, unpublished observation, 1986). All biochemical measurements including the reference values obtained from blood donors and 35-y-old men were carried out in the same laboratories of the TNO-CIVO Toxicology and Nutrition Institute.

The data were analyzed with chi-square tests, analysis of variance, linear regression, and logistic regression. The statistical analyses were performed with the statistical computer package of BMDP (25). All statistical tests were two-tailed. Effects were considered significant if $p < 0.05$.

Results

Tables 8.1.-8.4. present some characteristics of elderly people according to gender and vitamin B-6 supplement use. Of the elderly people, 7% took vitamin B-6 supplements in the form of vitamin B complexes regularly. No significant differences between users and nonusers of vitamin B-6 supplements for both sexes were observed with regard to mean age, food preparation habits, hemoglobin (Hb), hematocrit, mean corpuscular volume (MCV), leucocytes, thrombocytes, body mass index, blood pressure, and total serum cholesterol. Although many elderly people prepared potatoes, vegetables, and especially meat for ≥ 2 days at a time, this preparation appeared not to have an impact (adjusted for vitamin B-6 intake per gram protein) on the vitamin B-6 status. Elderly people using vitamin B-6 supplements also used significantly more often other vitamin supplements. The dietary intake of both vitamin B-6 and protein was similar for users and nonusers of vitamin B-6 supplements. In general, elderly people consume more fat and less carbohydrates than is recommended (26). The mean

Table 8.1.
General characteristics
according to gender and vitamin B-6 supplement usage

	Men		Women	
Characteristic	B-6 supplement n=14	No supplement n=225	B-6 supplement n=20	No supplement n=217
Mean age (years)	74.3	72.2	71.5	72.1
Use of supplements				
vitamin A (%)	50	2*	30	3*
folacin (%)	29	0*	15	1*
vitamin C (%)	57	3*	25	3*
vitamin D (%)	43	2*	30	3*
Daily fresh preparation of				
potatoes (%)	92	92	79	87
vegetables (%)	100	90	85	86
meat (%)	54	50	22	44

* $p < 0.001$ difference between supplemented and nonsupplemented elderly people separately for men and women.

Table 8.2.
Hematological indices and cardiovascular risk profile according to gender and vitamin B-6 supplement use*

Variable	Men		Women		F-test (p value)	
	supplement n=14	no supplement n=223	supplement n=20	no supplement n=213	Gender	supplement
Hemoglobin (mmol/L)	9.3 ± 0.6	9.6 ± 0.7	8.8 ± 0.6	8.8 ± 0.6	< 0.001	ns
Hematocrit	0.424 ± 0.028	0.437 ± 0.036	0.402 ± 0.027	0.405 ± 0.029	< 0.001	ns
MCV# (fL)	93 ± 3	91 ± 4	88 ± 3	89 ± 4	< 0.001	ns
Leucocytes (x 10^9 per L)	6.6 ± 2.1	6.7 ± 1.7	5.8 ± 1.4	6.2 ± 1.5	< 0.05	ns
Thrombocytes (x 10^9 per L)	220 ± 34	210 ± 57	229 ± 50	240 ± 60	ns	ns
Body mass index (kg/m^2)	24.8 ± 2.4	25.6 ± 2.8	26.3 ± 3.6	27.3 ± 4.3	< 0.025	ns
Blood pressure (mmHg)						
diastolic	87 ± 9	85 ± 10	91 ± 10	88 ± 11	< 0.05	ns
systolic	153 ± 29	150 ± 21	159 ± 17	156 ± 22	ns	ns
Total cholesterol (mmol/L)	5.64 ± 0.73	6.04 ± 1.01	6.34 ± 1.56	6.59 ± 1.20	< 0.01	ns

* $\bar{X}$ ± SD; # Mean corpuscular volume.

Table 8.3.
Some indices of food consumption according to gender and vitamin B-6 supplement use*

		Men		Women			
		supplement	no supplement	supplement	no supplement	F-test (p value)	
Energy and nutrient	DRDA#	n=14	n=225	n=20	n=217	Gender	Supplement
Energy (kcal)	-	2,318 ± 298	2,424 ± 492	2,150 ± 483	1,876 ± 447	<0.001	ns
Total protein (g)	-	84 ± 18	82 ± 17	75 ± 15	70 ± 16	<0.001	ns
Protein (% of total energy)	10-15	14.4 ± 2.6	13.7 ± 2.3	14.1 ± 2.3	15.1 ± 2.7	ns	ns
Total fat (g)	-	93 ± 21	110 ± 30	93 ± 33	84 ± 25	<0.01	ns
Fat (% of total energy)	30-35	36.0 ± 5.9	40.7 ± 5.7	38.1 ± 7.9	40.0 ± 6.2	ns	<0.01
Total carbohydrates (g)	-	270 ± 46	251 ± 66	242 ± 60	200 ± 54	<0.001	<0.01
Carbohydrates (% of total energy)	55	46.8 ± 6.8	41.3 ± 6.6	45.6 ± 8.5	42.8 ± 6.6	ns	<0.001
Alcohol (g)$^{\bar{\bar{+}}}$	-	3	10	3	1		
Alcohol (% of total energy)$^{\bar{\bar{+}}}$	-	0.8	2.7	1.1	0.5		
Dietary fiber (g)	-	30 ± 4	27 ± 8	26 ± 5	23 ± 7	<0.01	<0.02
Dietary fiber (g/1000 kcal)	12.6	13.1 ± 2.0	11.2 ± 3.0	12.5 ± 3.1	12.4 ± 3.3	ns	ns
Vitamin B-6§							
(mg)	1.50-2.00	1.42 ± 0.30	1.39 ± 0.35	1.28 ± 0.21	1.14 ± 0.31	<0.01	ns
(mg/1000 kcal)	-	0.62 ± 0.14	0.58 ± 0.12	0.61 ± 0.11	0.62 ± 0.13	ns	ns
(mg/g protein)	-	0.017 ± 0.003	0.017 ± 0.003	0.018 ± 0.004	0.016 ± 0.003	ns	ns

* $\bar{X}$ ± SD; # Dutch recommended daily allowance; $\bar{\bar{+}}$ Skew distribution, only the median is presented;
§ Not including nutritional supplements.

Table 8.4.
Vitamin B-6 status according to gender and vitamin B-6 supplement use*

Variable	Men		Women		F-test (p value)	
	supplement n=14	no supplement n=221	supplement n=18	no supplement n=206	Gender	Supplement
EAST# activity						
Basal (U/mmol Hb)	77 ± 24	57 ± 14	81 ± 15	60 ± 13	ns	<0.001
Total (U/mmol Hb)	117 ± 24	97 ± 18	118 ± 18	102 ± 16	ns	<0.001
EAST-AC	1.57 ± 0.21	1.71 ± 0.21	1.47 ± 0.12	1.75 ± 0.21	ns	<0.001
PLP (nmol/L)	111 ± 79	24 ± 11	156 ± 51	33 ± 17	<0.025	<0.001
[number of subjects]	[2]	[47]	[4]	[42]		

* $\bar{X}$ ± SD; # EAST: erythrocyte aspartate aminotransferase.

vitamin B-6 intake in the elderly people studied is slightly below the Dutch RDA (27).

There is a marked difference in vitamin B-6 status between elderly people with vitamin B-6 supplementation and those not taking such a supplement (Table 8.4.). The mean EAST-AC is lower, and the mean basal EAST activity, total EAST activity, and PLP concentration are significantly higher for vitamin B-6 users.

Table 8.5. shows the calculated contribution of different food groups to the total intake of both vitamin B-6 and protein. Most of the vitamin B-6 originates from potatoes, meat (products), bread, vegetables, fruit and milk (products). Because meat (products) and milk (products) are also rich in protein, the amount of vitamin B-6 per gram of protein in these foodstuffs is lower than in potatoes, vegetables, and fruit.

In **Figure 8.1.** the vitamin B-6 intake per gram protein by elderly people not using vitamin B-6 supplements is plotted against EAST-AC. When a linear relationship is assumed, EAST-AC is

Table 8.5.
Contribution of food products to the total protein and vitamin B-6 intake of elderly men and women

Food product	Men		Women	
	Vitamin B-6	Protein	Vitamin B-6	Protein
	%	%	%	%
Potatoes	24	4	20	3
Meat (products)	18	33	19	33
Bread	14	14	13	13
Vegetables	11	4	14	4
Milk (products)	11	16	11	18
Fruit	10	<0.5	11	<0.5
Biscuits and pastry	2	3	2	3
Cheese	2	12	2	12
Pulses	1	1	1	1
Nuts,seeds,peanut butter	1	1	1	1
Flour, bran, oatmeal	1	1	1	<0.5
Fish	1	3	1	3
Egg	1	3	1	3
Nonalcoholic beverages	1	<0.5	1	<0.5
Snacks	<0.5	1	<0.5	1
Rice and paste	<0.5	1	<0.5	1
Remainder	3	2	4	4

negatively correlated ($r = -0.14$; $p < 0.01$) with intake. However, Figure 8.1. shows that the upper range of EAST-AC is lower as the intake of vitamin B-6 per gram protein is higher. The interindividual variation in EAST-AC values decreases with increasing intake while the average approaches the mean EAST-AC value of about 1.5 for supplemented elderly people. The number of nonsupplemented subjects with a high intake of vitamin B-6 per gram protein is relatively low. Therefore, the concentration of PLP in plasma is plotted against EAST-AC for both supplemented and nonsupplemented elderly people (**Figure 8.2.**). At higher plasma PLP levels there seems to be no further decrease in EAST-AC. The five highest PLP values refer to elderly people using a vitamin B-6 supplement on a regular basis. Because no significant difference was observed regarding the dietary intake of vitamin B-6 between supplemented and nonsupplemented elderly people, a higher total intake may plausibly be assumed among the supplemented elderly people. Plasma PLP levels higher than about 100 nmol/L were associated with a plateau in EAST-AC in the erythrocytes.

Clinical symptoms of vitamin B-6 deficiency were not observed. Compared with 35-y-old men ($\bar{X}$ PLP: 48 nmol/L) and blood donors aged 18-65 y ($\bar{X}$ PLP: 46 nmol/L), PLP levels are low among elderly people not using vitamin B-6 supplements and high in elderly people who use supplements. Among elderly people not taking a vitamin B-6 supplement the mean basal and total EAST activities were lower than among younger adults (blood donors: mean basal EAST activity 66 U/mmol Hb; mean total EAST activity 119 U/mmol Hb), and more elderly people were in the lower range (< 2.5 percentile [P 2.5] of blood donors) of the distribution (32% for PLP, 11% for basal EAST activity, and 13% for total EAST activity). The P 2.5 of these younger adults is 20 nmol/L for PLP, 44 U/mmol Hb for basal EAST activity, and 82 U/mmol Hb for total EAST activity, respectively. In our study a cutoff point of 2.02 (maximum among the 32 supplemented elderly people) for EAST-AC classified 9% of the elderly people not using a vitamin B-6 supplement as having a marginal vitamin B-6 status.

The intake of vitamin B-6 (in mg, per 1000 kcal as well as per gram protein) and the vitamin B-6 status (basal and total EAST activity, EAST-AC, and PLP) did not change with advancing age among the elderly people not using vitamin B-6 supplements.

Discussion

We found a marginal vitamin B-6 status among 9% of the elderly people not taking a vitamin B-6 supplement. Compared with the RDA the intake of vitamin B-6 among elderly subjects is relatively low

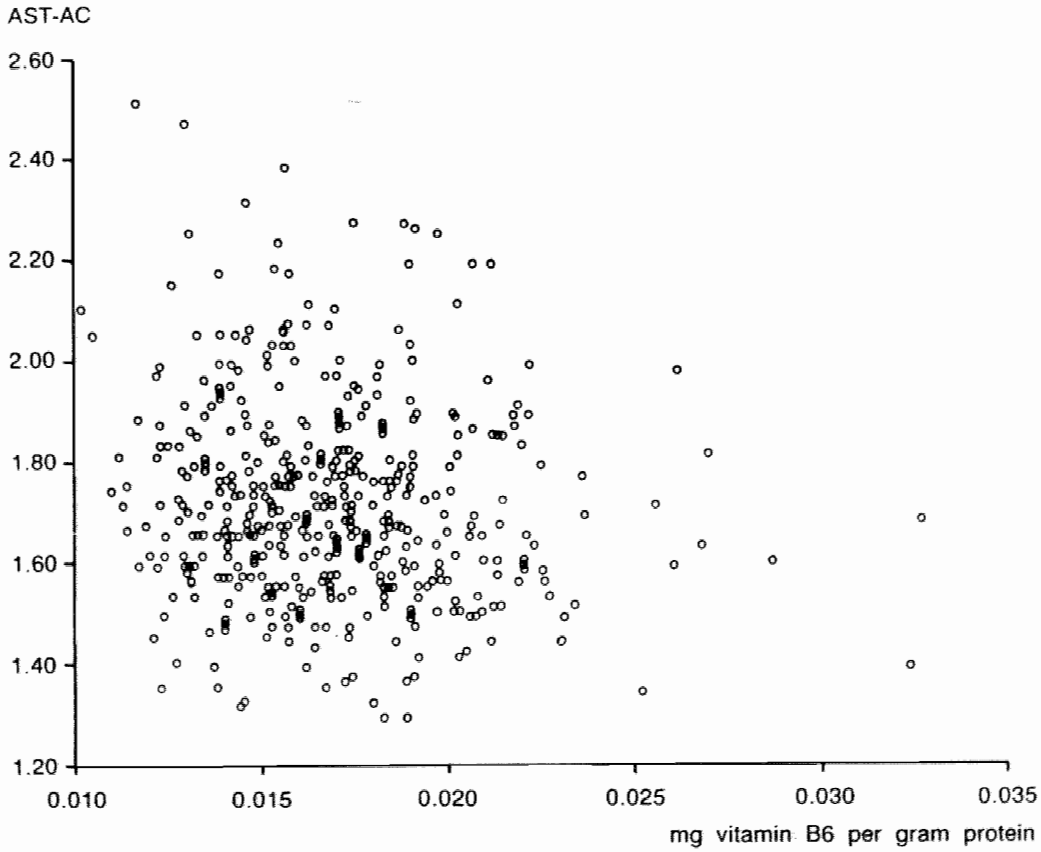

Figure 8.1. Values of aspartate aminotransferase in erythrocytes (EAST-AC) in apparently healthy elderly people plotted against vitamin B-6 intake per gram protein.

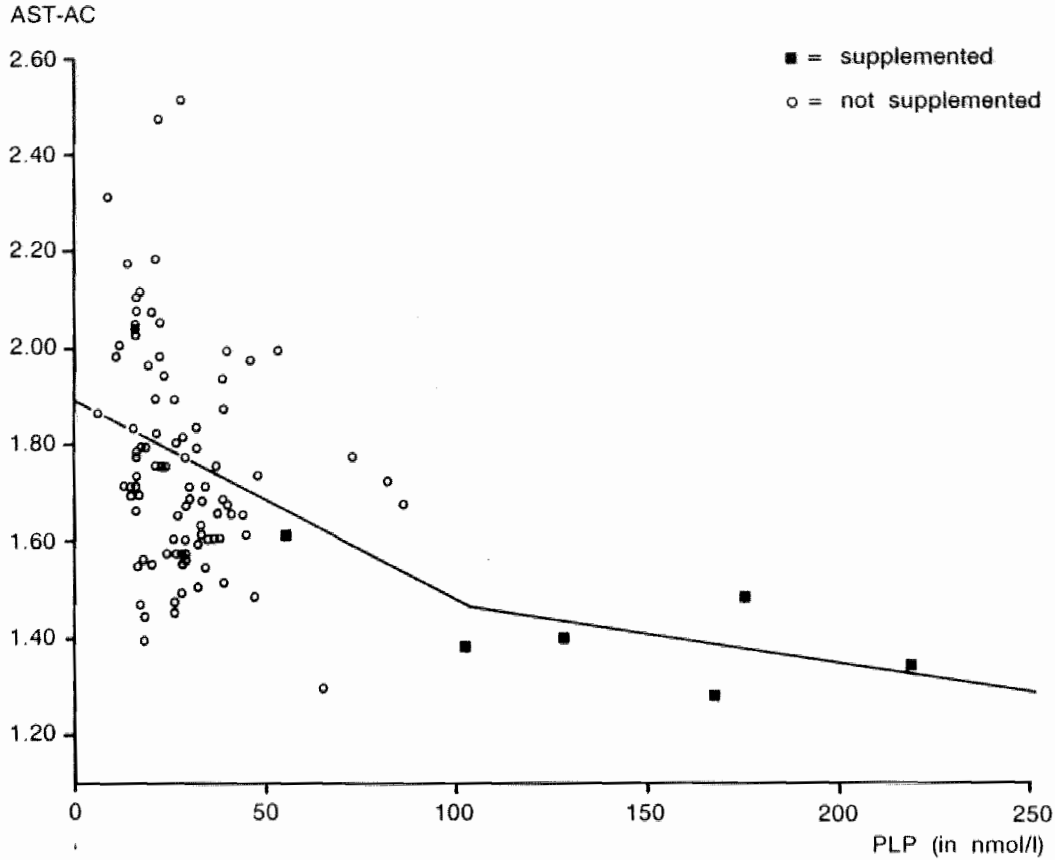

Figure 8.2. Values of aspartate aminotransferase in erythrocytes (EAST-AC) in apparently healthy elderly people plotted against pyridoxal 5'-phosphate (PLP).

which has also been observed in other studies (6,10,14). However, all the elderly people studied were living independently and were apparently healthy. We excluded elderly people suffering from severe chronic diseases (6% of the original sample), those with anemia, those using drugs affecting vitamin B-6 metabolism (12%), those living in institutions (about 10% of the Dutch population aged ≥ 65 y), and those aged > 79 y. Because the vitamin B-6 requirement of these groups of elderly people may differ from those being included in our survey, the prevalence of biochemical vitamin B-6 deficiency may actually be much higher among elderly people in the Netherlands than found in our study.

On the basis of P 97.5 of EAST-AC of blood donors, i.e., 2.28, only 1% of the elderly people not using vitamin B-6 supplements have relatively high EAST-AC values. Because no significant relationship exists between plasma PLP and EAST-AC among blood donors (24) and the mean basal and total EAST activity is lower among elderly people a cutoff value of 2.28 may underestimate the prevalence of a marginal vitamin B-6 status among elderly people. The relationship between PLP and EAST-AC may be age-dependent whereas the blood donors and the elderly people studied may differ with respect to dietary intake, vitamin B-6 supplement usage, etc. It has been suggested that in the early stages of deficiency, lack of cofactor (PLP) leads to lower basal EAST activity. Chronic marginal intake of vitamin B-6 results in reduced synthesis of the apoenzyme, implying lower values of total EAST activity (10,28). Our results indicate a more chronic situation of a marginal vitamin B-6 status among elderly people, because more plasma PLP and basal and total EAST activity values are in the lower range of the distribution whereas this is not found among elderly people using vitamin B-6 supplements.

Dietary supplement usage is much lower among elderly people in The Netherlands than among elderly people in the United States (15,29,30). Our results regarding the higher level of plasma PLP among supplemented persons, which appeared to be associated with a lower mean EAST-AC, are in accordance with other studies (5,6,10,31). Our data on supplemented elderly people theoretically refer to a more adequate functioning vitamin B-6-dependent enzyme system, i.e., the variation in the biochemical values is mainly the result of genetic makeup. The maximum value of EAST-AC among vitamin B-6-supplemented elderly people is 2.02, which corresponds to the often used cutoff value of 2.00 (5,6,9,32). Higher values would indicate (risk for) vitamin B-6 deficiency. A small response (EAST-AC) to cofactor stimulation (PLP) is taken to indicate a good supply and status of vitamin B-6 (32).

Although the nonsupplemented elderly people in our study had somewhat lower mean values of PLP and basal and total EAST

activity values than did younger adults, we observed no change in the indicators of vitamin B-6 status with advancing age (65-79 y). No statistically significant age-related change was observed regarding the intake of vitamin B-6 (in relative as well as absolute terms). Although in other studies the vitamin B-6 status was shown to be age-dependent, these studies did not account for diseases and drug use (4-6,33,34), did not present data on intake (4,5,8,33,34), and/or studied a much wider age range (including younger adults) (4-8,33,34).

In several studies no close association is observed between intake of vitamin B-6 and biochemical indices in cross-sectional studies among elderly people (6,10). Our results may partly explain why such a relationship is often not observed. A relationship is only found at low intakes of vitamin B-6, whereas usage of nutritional supplements is relatively high among elderly people (15,29,30). Another reason might be that most studies calculated the intake of vitamin B-6 (mostly not expressed per gram protein) on data of just a few days, which may not correspond to habitual food consumption patterns. Finally, intake data are mostly based on food composition tables whereas the Food and Nutrition Board in the United States (13) stated that data on the vitamin B-6 content of foods are insufficient and that information on the bioavailability of this vitamin is lacking. This implies that our results are somewhat distorted by the imperfect quantification of the vitamin B-6 intake.

Among other things requirements can be based on the level of intake that prevents a marginal vitamin B-6 status. In general, RDAs are considered to represent the needs of approximately 97.5% ($\bar{X}$ plus 2 SD in a Gaussian distribution) in a healthy population group to take interindividual variability into account. The calculation (logistic regression) of the level of intake corresponding with a probability of 97.5% that an elderly person has an EAST-AC value < 2.02 resulted in 0.026 mg vitamin B-6/g protein. This value suggests a higher vitamin B-6 requirement among apparently healthy elderly people because a ratio of 0.020 mg vitamin B-6/g protein is recommended for adults in the United States and West Germany and 0.015 for adults in Canada (1,13,35). Moreover, Van Poppel (unpublished observation, 1988) did not find an association between EAST-AC and usual vitamin B-6 intake per gram protein among 35-y-old men in The Netherlands who were not using vitamin B-6 supplements. Because the intake of vitamin B-6 per gram protein of these middle aged men was similar to the mean intake of the elderly people in our study, the dose-response relationship in the elderly people might suggest also a higher requirement of vitamin B-6 among elderly people. A higher

requirement of vitamin B-6 implies that more vitamin B-6 per gram protein is needed to reach a particular level of enzyme activity.

Frank vitamin B-6 deficiencies (symptoms are only observed in an advanced state of deficiency) are rare in affluent societies like The Netherlands. However, subclinical vitamin B-6 deficiencies may influence the rate of mental and physical functional deterioration that normally becomes more severe with advancing age. Vitamin B-6 may be associated with cardiovascular diseases (36) and may contribute to some neurological disorders such as depression and electroencephalographic abnormalities because PLP plays an essential role in the formation of aminergic neurotransmitters (28). Biochemical evidence points to an altered metabolism of vitamin B-6 or compounds utilizing vitamin B-6 enzymes in a variety of mental disorders (37). Vitamin B-6 deficiency may also be accompanied by impaired immune function (38,39). These findings indicate the importance of prevention of a marginal vitamin B-6 intake and biochemical deficiencies.

In contrast to Guilland et al (6), but in accord with the American Dietetic Association Task Force (40), we conclude that it is not necessary to recommend the use of artifical vitamin B-6 supplements for elderly people as a group. Most elderly people not taking vitamin B-6 supplements have adequate EAST-AC values (< 2.02) whereas high EAST-AC values are associated with a low intake of vitamin B-6 per gram protein. A higher ratio of vitamin B-6 to protein will most likely prevent high values of EAST-AC among all apparently healthy elderly people, implying some changes in the current food consumption habits. The consumption of cheese, meat, and milk (products) could be restricted somewhat because they have a relatively unfavorable ratio of vitamin B-6 to protein. However, these products usually furnish other essential nutrients such as iron and calcium. To obtain a more favorable ratio of vitamin B-6 to protein, more fruits, vegetables, and potatoes could be eaten by elderly people.

The existence of a relationship between dose (intake of vitamin B-6 per gram protein and concentration of PLP, respectively) and response (EAST-AC) as well as our results of logistic regression analysis suggest that elderly people require more vitamin B-6. We considered changes in food consumption habits as feasible preventive measures against a marginal vitamin B-6 status. However, much more information on the interactions between nutrition and aging is required before an elderly-specific RDA can be implemented. EAST is only one of the vitamin B-6-dependent enzymes. Our data are still insufficient for definite conclusions on an accurate cutoff point indicative of impairment of vitamin B-6-dependent functions among apparently healthy elderly subjects. Despite these shortcomings our results show the feasibility of an

epidemiological approach and the importance of a proper study design to establish the details of a dose-response relationship. Prospective studies (with and without vitamin B-6 supplementation or dietary changes) on morbidity and mortality as well as on functional deficits associated with inadequate vitamin B-6 intake may offer an opportunity to improve the knowledge on the significance of the observed dose-response relationship among elderly people.

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9. EFFECT OF DIETARY FIBER ON THE VITAMIN B-6 STATUS AMONG VEGETARIAN AND NONVEGETARIAN ELDERLY*

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ABSTRACT

To obtain more insight into the effect of dietary fiber on the vitamin B-6 status among elderly people we studied dietary interrelationships as well as associations between dietary intake and plasma pyridoxal 5'-phosphate (PLP) and cofactor stimulation of aspartate aminotransferase in erythrocytes (EAST-AC) among 441 nonvegetarian (aged 65-79) and 32 vegetarian elderly people (aged 65-94). EAST-AC was found to be inversely related with intake of vitamin B-6 and dietary fiber in bivariate regression analyses. After adjustment for age, intake of energy, protein and fiber, the intake of vitamin B-6 was still inversely related with EAST-AC. The association between EAST-AC and dietary fiber disappeared in the multivariate analysis, whereas total protein intake was found to be positively related with EAST-AC in the multivariate analysis only. The differences between bi- and multivariate analyses are most likely due to the observed interrelationships between intake of vitamin B-6, fiber and protein. It is concluded that dietary fiber does not have a significant impact on the vitamin B-6 status among Dutch elderly people, since only protein (positively) and vitamin B-6 (inversely) intake appeared to be related with EAST-AC in the multivariate analysis.

Introduction

A marginal intake and status of vitamin B-6 is fairly common among the elderly in affluent societies (1-4). Kant et al (5) found lower plasma pyridoxal 5'-phosphate (PLP) levels among elderly people than among younger adults, but no significant differences in vitamin B-6 intake among the age groups were observed (neither in absolute amount nor expressed per gram protein). Since the vitamin B-6 requirement depends on the protein content of the diet

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(6-8), a higher consumption of fruits, vegetables and potatoes results in a higher vitamin B-6:protein ratio of the diet and hence is considered to be preventive against a marginal vitamin B-6 status (4). However, most of these products are rich in dietary fiber, and little is known about the possible inhibitory effect of dietary fiber on the utilization of vitamin B-6 (9-13). Several studies indicate a lower bioavailability of vitamin B-6 of vegetable origin as compared to animal products (11-13). Since the customary vegetarian diet is relatively high in fiber (14), insufficient amounts of nutrients may be available from that diet. Schultz and Leklem (15), studying the bioavailability of vitamin B-6 among middle-aged and elderly vegetarian and nonvegetarian women by just comparing the vitamin B-6 status of these groups, did not find an adverse effect of crude fiber on vitamin B-6 status. However, a food consumption pattern consists of a complex set of interrelated nutrients (16). Any evaluation of the bioavailability of vitamin B-6 should at least take into account the intake of vitamin B-6 as well as of protein and dietary fiber.

To assess the effect of dietary fiber on the vitamin B-6 status among Dutch elderly on their habitual diets we used data on the vitamin B-6 status as well as relevant information on the dietary intake of apparently healthy Dutch elderly people and included vegetarian elderly subjects to obtain more data in the upper range of the intake of dietary fiber.

Subjects and methods

In 1984-1985, a nationwide survey among 539 elderly people and in 1986 a similar survey among 44 vegetarian elderly were carried out within the framework of the Dutch Nutrition Surveillance System (17). The study design of the national survey and procedures have been described in detail (4,18,19). Verbal consent was obtained after the nature of the study was explained by a letter. The study was approved by the TNO-CIVO Toxicology and Nutrition Institute's external Medical Ethics Committee. The response rate in the random sample from a vegetarian elderly community in the Netherlands was 67%; 44 persons were included in the study who met the criteria: aged 65 or over, apparently healthy, Caucasian, and vegetarian (not using meat, fish or poultry).

For the purpose of the present study 57 elderly using drugs known to potentially affect vitamin B-6 requirement, metabolism and/or status were excluded from the analysis (20,21). Furthermore, 10 subjects with frank anemia (hemoglobin < 7.5 mmol/L) and 43 elderly using vitamin B-6 supplements were

excluded. Data on 441 nonvegetarians (aged 65-79 y) and 32 vegetarians (aged 65-94 y) remained for the analyses.

Food consumption data were obtained by a dietitian with a modified version of the dietary history method with cross-check (22). Conversion of the dietary information to the intake of energy and nutrients was established with a computerized version (edition of 1984) of the Dutch Food Composition Table (23). Vitamin B-6 losses due to normal preparation practices are accounted for in this table. Dietary fiber refers to plant polysaccharides and lignin that are resistant to hydrolysis in the human digestive tract. The main components of dietary fiber are cellulose, hemicelluloses, pectic substances and lignin. In the Dutch Food Composition Table dietary fiber is the sum of the forementioned components. Information on demographic variables, lifestyle, clinical condition (including current drug use) and usage of nutritional supplements was collected. A venous blood sample (nonfasted) was obtained for hematologic, biochemical and routine clinical analyses (19). Evaluation of the vitamin B-6 status was based on the biochemical measurement of plasma concentration of pyridoxal 5'-phosphate (measured by a radioenzymatic assay with tyrosine decarboxylase apoenzyme; singular extraction, assay in duplicate) and erythrocyte asparatate aminotransferase (EAST; EC 2.6.1.1) activity before and after in vitro stimulation by PLP (at the cellular level). The EAST activity with and without added PLP was measured in duplicate with a kinetic assay on a Hitachi 705 automatic analyser (24) and expressed as an activation coefficient (EAST-AC). The EAST activity was measured in all available blood samples. Plasma PLP concentrations were determined in all blood samples from vegetarians, but in a random subsample (n=108) of the national survey stratified as in the original group of 539 persons.

The data were analysed by analysis of variance with gender and dietary style as factors and by (multiple) linear regression. The interrelationships between intake of protein (total, vegetable and animal), dietary fiber and vitamin B-6 were assessed through the calculation of correlations. Data were analysed with the statistical computer package BMDP (25). All statistical tests were two-tailed. Effects with a p value lower than 0.05 were considered significant.

Results

In **Table 9.1.** information is presented on general and some dietary characteristics classified according to (non)vegetarianism and gender. On the average, men had a higher body weight and a higher

Table 9.1.
General and dietary characteristics (mean)
of vegetarian and nonvegetarian elderly men and women

Nutrient	Men		Women		Pooled SD	F-test (p value)		
	vege-tarian n=15	nonve-getarian n=225	vege-tarian n=17	nonve-getarian n=216		gender	dietary style	inter-action
Age (years)	81.6	72.2	82.0	72.1	5.1	ns	< 0.001	ns
Body weight (kg)	67.7	76.3	62.0	70.0	11.2	< 0.01	< 0.001	ns
Body mass index (kg/m²)	23.8	25.6	24.5	27.3	3.7	ns	< 0.001	ns
Energy intake (MJ)	8.46	10.14	7.06	7.87	2.28	< 0.001	< 0.001	ns
Total protein (g)	59	82	54	70	18	< 0.01	< 0.001	ns
Protein (% of energy)	11.9	13.7	12.8	15.1	2.6	< 0.01	< 0.001	ns
Total fat (g)	88	110	73	84	30	< 0.001	< 0.001	ns
Fat (% of energy)	38.7	40.7	38.5	40.1	5.8	ns	ns	ns
Total carbohydrates (g)	249	251	202	200	65	< 0.001	ns	ns
Carbohydrates (% of energy)	49.3	41.3	48.5	42.6	6.7	ns	< 0.001	ns
Alcohol (g)*	0.1	14	0.1	6	13	ns	< 0.001	ns
Alcohol (% of energy)*	0.1	4.2	0.1	2.1	4.1	ns	< 0.001	ns
Dietary fiber (g)	33	27	28	23	8	< 0.001	< 0.001	ns
Dietary fiber (g/MJ)	3.9	2.7	3.9	3.0	0.8	ns	< 0.001	ns
Vitamin B-6 (mg)	1.322	1.386	1.099	1.144	0.353	< 0.001	ns	ns
Vitamin B-6 (mg/MJ)	0.157	0.137	0.155	0.147	0.031	ns	< 0.025	ns
Vitamin B-6 (mg/g protein)	0.022	0.017	0.021	0.016	0.004	ns	< 0.001	ns

* Logarithmic transformation in the analysis of variance.

intake of energy, protein, fat, total carbohydrates, dietary fiber, and vitamin B-6. In relative terms only the lower percentage of energy from protein for men appeared to differ significantly from that of women. Among nonvegetarians the intake of alcohol (both in grams and in energy%) was higher for men than for women. Compared to nonvegetarians, the mean body weight, body mass index and energy intake of vegetarians was lower; in the vegetarian diet less energy was derived from protein and alcohol, and more from carbohydrates. Vegetarians had a higher intake of dietary fiber (absolute and per MJ) and vitamin B-6 (per MJ and per gram of protein). Vegetarians had a vegetable:animal protein ratio of 1.01, whereas this ratio was 0.45 among nonvegetarians. In the vegetarian diet virtually all (91%) animal protein originated from milk and milk products, whereas only 14% of the vitamin B-6 was derived from these products in the vegetarian diet.

Table 9.2. presents the vitamin B-6 status classified according to gender and (non)vegetarianism. Except for a somewhat higher mean plasma PLP level among vegetarians no significant differences were observed in the vitamin B-6 status between genders and between dietary styles.

In **Table 9.3.** the interrelationships between the vitamin B-6 status indicators are presented. PLP was significantly correlated with the basal EAST activity and EAST-AC, whereas EAST-AC was correlated with all other indicators, especially the basal EAST activity. The highest correlation was found for the association of the basal EAST activity with the total EAST activity.

In the bivariate analyses, no significant association was found between EAST activity (basal and total), EAST-AC, and PLP on the one hand, and the intake of energy on the other hand (**Table 9.4.**). Among all subjects EAST-AC appeared to be inversely related with dietary fiber and dietary vitamin B-6, whereas PLP was positively associated with intake of vegetable protein, fiber and vitamin B-6. The relationships were somewhat stronger (higher correlation coefficients) for vegetarians than for nonvegetarians, and stronger for men than for women.

In multivariate regression analyses with EAST-AC as dependent variable, and age, and the intake of energy, protein, dietary fiber and vitamin B-6 as independent variables, EAST-AC was found to be inversely related with intake of vitamin B-6 and positively with intake of protein (see **Table 9.5.**). Similar results were observed when age, dietary fiber per MJ and vitamin B-6 per gram protein were the independent variables. EAST-AC was stronger (positively) related with animal protein ($p = 0.06$) than with vegetable protein ($p = 0.19$), both adjusted for each other and for age and intake of energy and vitamin B-6. Dietary fiber was not

Table 9.2.
Vitamin B-6 status (mean) of vegetarian and nonvegetarian elderly men and women

Variable	Men		Women		Pooled SD	F-test (p value)		
	vegetarian n=14	nonvegetarian n=221	vegetarian n=15	nonvegetarian n=205		gender	dietary style	interaction
EAST activity								
basal (U/mmol Hb)	56	57	54	60	13	ns	ns	ns
total (U/mmol Hb)	95	97	95	102	17	ns	ns	ns
EAST-AC (ratio)	1.72	1.71	1.79	1.75	0.21	ns	ns	ns
PLP (nmol/L)	35	24	38	33	15	ns	< 0.025	ns
(number of observations)	(14)	(47)	(14)	(42)				

Table 9.3.
Correlation coefficients between the vitamin B-6 status indicators among the elderly

Variable	PLP+	Basal EAST activity	Total EAST activity
Basal EAST activity#	0.19*		
Total EAST activity#	0.06	0.87***	
EAST-AC#	-0.28**	-0.65***	-0.23***

+ Number of subjects for PLP was 117; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; # EAST: erythrocyte aspartate aminotransferase.

Table 9.4.
Correlation coefficients of age and dietary intake variables with indicators of the vitamin B-6 status in the elderly

Variable	PLP+	Basal EAST activity	Total EAST activity	EAST-AC
Age	0.01	-0.02	-0.03	0.01
Energy	0.03	0.01	-0.05	-0.08
Protein (vegetable)	0.20*	0.02	-0.02	-0.07
Protein (animal)	-0.07	0.05	0.05	-0.03
Protein (total)	0.01	0.05	0.03	-0.05
Dietary fiber	0.24**	0.10*	0.07	-0.11*
Vitamin B-6	0.20*	0.14**	0.09*	-0.15**
Vitamin B-6/protein	0.26**	0.15**	0.08	-0.16***

+ Number of subjects for PLP (pyridoxal 5'-phosphate) was 117 (61 men and 56 women); * $p < 0.05$, ** $p < 0.01$.

Table 9.5.
Results of the multiple regression analysis with EAST-AC as dependent variable*

Independent variables	Regression coefficient	SE	p value	Multiple R
Intercept	704.35			
Age (years)	- 0.55	1.93	ns	
Energy (MJ)	- 0.01	0.01	ns	
Protein (g)	2.63	1.12	< 0.025	
Dietary fiber (g)	2.15	2.23	ns	
Vitamin B-6 (µg)	- 0.21	0.07	< 0.01	0.35

* EAST-AC was transformed logarithmically; all regression coefficients and standard errors (SE) in 10^{-3}.

included in this analysis since dietary fiber is highly (r = 0.74) correlated with vegetable protein. The results of the regression analyses with EAST-AC as dependent variable did not differ between the genders.

In contrast, PLP appeared only to be related with vitamin B-6 for men but not for women (see **Table 9.6.**). An almost significant (p = 0.07) inverse association was found between PLP and intake of protein after adjustment for age and intake of energy, dietary fiber, and vitamin B-6. Unadjusted for dietary fiber the inverse relationship between protein and PLP among men was highly significant (p = 0.01). Among women a relationship between PLP and protein (adjusted for age, intake of energy, dietary fiber and vitamin B-6) was clearly (p = 0.96) nonexistent. Moreover, when intake of vegetable protein and intake of animal protein were included separately in the multivariate model (instead of total protein), only the intake of animal protein appeared to be inversely related to PLP among men (p = 0.08 and p = 0.04 for the multivariate models, including and excluding dietary fiber respectively), but not vegetable protein (p = 0.55 and p = 0.93 respectively).

Inclusion of (non)vegetarianism as factor in the regression models did not affect the results, indicating similar relationships between the dietary factors studied and vitamin B-6 status among vegetarian and nonvegetarian elderly.

Dietary fiber was significantly correlated with intake of energy (r = 0.52), protein (r = 0.46) and vitamin B-6 (r = 0.77); the correlation coefficient between dietary vitamin B-6 and protein was 0.71.

Table 9.6.
Results of the multiple regression analyses with PLP as dependent variable*

Independent variables	Men (n=61) Regression coefficient	SE	p value	Multiple R	Women (n=56) Regression coefficient	SE	p value	Multiple R
Intercept	1710.41				3224.75			
Age (years)	7.94	7.98	ns		- 0.90	12.13	ns	
Energy (MJ)	0.02	0.04	ns		- 0.01	0.07	ns	
Protein (g)	- 7.62	4.18	ns		- 0.39	8.46	ns	
Dietary fiber (g)	17.60	8.94	ns		4.58	14.50	ns	
Vitamin B-6 (µg)	0.59	0.28	< 0.05	0.63	0.24	0.44	ns	0.18

* PLP (pyridoxal 5'-phosphate) was transformed logarithmically in regression analyses; all regression coefficients and standard errors (SE) in 10^{-3}.

Discussion

The aim of this study was to broaden our insight into the (relative) importance of the intake of dietary fiber, protein and vitamin B-6 influencing the vitamin B-6 status of elderly people on their habitual diets. The results show that the intake of protein as well as of vitamin B-6 affect the vitamin B-6 status of elderly people. According to the Food and Nutrition Board (USA) data on the vitamin B-6 content of foodstuffs are still insufficient (26), whereby our results will be somewhat distorted by the imperfect quantification of the vitamin B-6 intake. However, in general, inaccuracies in the measurement of exposures would be expected to weaken rather than produce associations. The adjustment for vitamin B-6 might be incomplete whereby the observed associations in the multivariate analyses may be weaker than they actually are. One of the characteristics of a cross-sectional study is that mostly low-order correlations are found, which is -among other things- due to intra-individual variation and inaccurate assessment of dietary intake and nutritional status indicators. In a cross-sectional design the observation that a particular dietary factor is positively or inversely associated with a relevant variable, and not only the magnitude, is a meaningful observation. Especially because the values refer to the range of intake that is currently prevalent among elderly people.

It is suggested that women are at potentially greater risk of a marginal vitamin B-6 status (15,27) due to a lower intake of vitamin B-6 (27). However, our results among elderly people do not support this suggestion, since we did not observe significant differences between the genders regarding vitamin B-6 status and intake of vitamin B-6 per gram of protein as well as per MJ. Body build and body composition has a major impact on the requirement of energy and nutrients, and hence in the normal intake range it is not the absolute vitamin B-6 intake that matters but rather the intake relative to protein and energy intake.

The associations of dietary factors with PLP level among men but not women might be related to (dietary) differences between the genders. The diets of men and women did not differ with regard to vitamin B-6 intake per gram protein as well as the ratio between vegetable and animal protein. Although ethanol is found to decrease the concentration of plasma PLP (28), and alcohol intake was on the average higher among men than among women, PLP appeared to be unrelated (both unadjusted and adjusted for age and intake of vitamin B-6 and protein) with alcohol intake (maximum 70 g/day). Furthermore, protein intake is found to be inversely related with plasma PLP (8). In our study, among men there was an inverse association between the intake of protein and PLP after

adjustment for age and intake of energy and vitamin B-6. Animal protein was found to be more important than vegetable protein. Although the results among men are intriguing, the number of observations (n=61) may be too small for definitive conclusions. Moreover, the relationships between habitual dietary intake and PLP (a short-term indicator) might have been disturbed somewhat due to the fact that nonfasted blood has been used for the analyses. This will have introduced "extra" variation in the PLP levels that is not related to the habitual levels of the dietary factors studied. Although we do not have any indication that this has introduced a systematic error (due to the random sample) in our study, our conclusions are mainly based on the results for EAST-AC.

Foods of animal origin generally have a lower vitamin B-6:protein ratio than vegetable foods (6), whereas animal protein may increase the vitamin B-6 requirement as compared to protein from plants (29). Our results also indicate different effects of animal and vegetable protein on the vitamin B-6 status (PLP as well as EAST-AC) and may partly be due to differences in the amino acid composition in these products (30,31).

Bioavailability can be defined as the percentage of total intake that is digested and absorbed and that is available for physiological functions. Absorption (passive diffusion in the upper jejunum) of vitamin B-6 is thought not to be affected by aging processes (9). To a certain extent plasma PLP reflects absorption, since PLP is an indicator of recent intake of vitamin B-6, whereas EAST-AC can be considered as a long-term indicator. Several studies indicate that the bioavailability of vitamin B-6 from food products may be incomplete (10,13,32,33). The bioavailability of vitamin B-6 in a typically American mixed diet has been estimated to be 71-79% (33) and may be inhibited by such substances as dietary fiber and vitamin B-6 antagonists in foods of vegetable origin. On the other hand, our results show that dietary fiber is strongly ($r = 0.77$) associated with intake of vitamin B-6 indicating that more vitamin B-6 is ingested with fiber-rich diets. Moreover, vitamin B-6 requirement depends on the protein content of the diet (6-8). Dietary fiber intake was much more strongly related to intake of vitamin B-6 than to total protein intake. The differences found (even a change in the sign of the association) between bi- and multivariate analysis are most likely due to the strong interrelationships observed between intake of vitamin B-6, dietary fiber and protein. As protein and dietary fiber were related to vitamin B-6, adjustment for the vitamin B-6 intake in the multivariate analyses provides a better assessment of the separate effects of protein and dietary fiber on the vitamin B-6 status indicators. Therefore, the results of the

multivariate analysis are most likely more valid than the bivariate ones.

The negligible effect of (dietary) fiber on the bioavailability of vitamin B-6 (EAST-AC), as found in our study, is in accordance with previous studies among humans (15). Other studies in humans, however, observed a lower availability of vitamin B-6 in food products of vegetable origin (11,13). In men aged 21-32, vitamin B-6 bioavailability (based on the fecal excretion of vitamin B-6 and urinary excretion of 4-pyridoxic acid) from whole bread was lower than for vitamin B-6-enriched bread and an oral dose of vitamin B-6, respectively (10). However, no significant differences in plasma PLP and EAST-AC were observed in that study with one-week experimental periods. A high bioavailability is demonstrated of synthetic vitamin B-6 as compared to vitamin B-6 from orange juice (32). Lindberg et al (34) indicate that addition of 15 g of wheat bran to the diet of young men decreases the bioavailability of vitamin B-6 by maximally 17%. The apparently discrepancy of these results may be explained by different sources of dietary fiber (a collective term for substances such as cellulose and pectin) and duration of the study period. The lower 4-pyridoxic acid excretion found by Leklem et al (10) indicates lower bioavailability or decreased turnover. In the long-run a decrease in vitamin B-6 stores might occur, indicated by a lower plasma PLP and higher EAST-AC. This implies that an evaluation of the bioavailability should be oriented towards vitamin B-6 as it occurs in foods and after adaptive processes have resulted in steady-state conditions, as we did. A quantitative estimation of available vitamin B-6 is as yet impossible, in view of the multitude of potential dietary interactions affecting the bioavailability of vitamin B-6. However, our results show that an effect on the bioavailability of vitamin B-6 of regularly used sources of dietary fiber consumed by Dutch (vegetarian) elderly is negligible as compared to (animal) protein.

Since intake of dietary fiber was not related to PLP and EAST-AC in the multivariate analyses, we conclude that dietary fiber (intake range: 5-64 g/day) does not have a negative impact on vitamin B-6 status. So, stimulation of consumption of products of plant origin will not adversely affect the vitamin B-6 status due to dietary fiber. On the contrary, these products will most likely exert a positive effect on the vitamin B-6 intake and status because of their higher vitamin B-6:protein ratio.

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10. DEPENDENCE OF VITAMIN B-6 STATUS ASSESSMENT ON ALCOHOL INTAKE AMONG ELDERLY MEN AND WOMEN*

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ABSTRACT

To obtain more insight into the effect of moderate alcohol intake on vitamin B-6 status indicators, we studied the associations of alcohol intake (unadjusted and adjusted for intake of vitamin B-6 and protein) with erythrocyte aspartate aminotransferase activation coefficient (EAST-AC) and plasma pyridoxal 5'-phosphate (PLP) level. Data obtained from men (n=224) and women (n=217) aged 65-79 (nationwide sample in the Netherlands) were used for this purpose. Although alcohol intake tended to be positively associated with PLP, this association never reached significance ($p \geq 0.05$). EAST-AC was inversely associated with alcohol intake, whether it was or was not adjusted for vitamin B-6 and protein intake. Similar results were found for the total EAST activity (after adding PLP) or apo-enzyme activity; the basal EAST activity (before adding PLP) or holo-enzyme activity was not associated with alcohol intake. These results indicate caution in the interpretation on the specificity of EAST-AC as a mere indicator of vitamin B-6 intake, whereby specificity is the degree to which EAST-AC is unaffected by other factors.

Introduction

Vitamin B-6 is involved in a variety of biochemical reactions which can be used to assess the status of this nutrient. Erythrocyte glutamic oxaloacetic transaminase and erythrocyte glutamic pyruvic transaminase are widely used for this purpose, whereas it is still questionable which one should be prefered for humans (1-3). These methods are based on the extent to which pyridoxal 5'-phosphate (PLP) added in vitro increases the transaminase activity over the baseline activity. The latter activity is due to endogenous PLP. In several (population-based)

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studies the erythrocyte glutamic oxaloacetic transaminase (erythrocyte aspartate aminotransferase activation coefficient: EAST-AC; EC 2.6.1.1.) has been used for the assessment of the body's vitamin B-6 status (4-9). Usage of this indicator implies that EAST-AC should be both sensitive and specific with respect to the intake of vitamin B-6. Indeed, several studies report a rapid drop in serum PLP and increments in EAST-AC in apparently healthy subjects on vitamin B-6 deficient diets (4,8). Sauberlich et al (5) emphasized that results obtained in studies inducing a marginal vitamin B-6 deficiency may not be generalized to chronically deficient individuals or population groups with marginal vitamin B-6 intake and to subjects exposed to (dietary) factors that may modulate the vitamin B-6 status. The observation of a dose-response relationship between habitual intake of vitamin B-6 per gram of protein and EAST-AC (9), as well as higher mean PLP concentration, basal and total EAST activity, and lower mean EAST-AC values among habitual vitamin B-6 supplement users as compared to non-supplemented persons (9-12), indicates that EAST-AC is sensitive to vitamin B-6 intake on a long-term basis. Since EAST-AC is an indirect indicator of the vitamin B-6 supply, it may also be influenced by other factors such as protein intake (13-15). Several studies have reported lower and normal mean EAST-AC values among alcoholics than among controls, despite reduced, marginal levels of circulating PLP among alcoholics (16-19). Therefore, the question arises whether moderate alcohol consumption influences EAST-AC. Since a marginal vitamin B-6 intake and status of vitamin B-6 is fairly common among the elderly in affluent societies (9-11), we used the data obtained from men and women aged 65-79 to obtain an insight into the association of EAST-AC with moderate alcohol intake.

Subjects and methods

In 1984/1985 a nutritional survey among 539 apparently healthy elderly (aged 65-79) has been carried out within the framework of the Dutch Nutrition Surveillance System (20). The study was approved by the external Medical-Ethical Committee of the TNO-CIVO Toxicology and Nutrition Institute. Informed consent was obtained after the nature of the study had been explained by letter.

Food consumption data were obtained with a modified version of the dietary history method with cross-check (21). The habitual pattern of food intake, with special attention to the preceding two weeks, was assessed. The frequency of consumption and amounts consumed (in common household measures) were asked. For food products, among other things alcoholic beverages, included in the

checklist this was done against information on the subjects usual intake. The calculation of intake of energy and nutrients was based on the 1984 edition of the Dutch Food Composition Table (22). The vitamin B-6 content of beer (0.2 mg/L according to McCance and Widdowson's (23) composition of foods table as well as 0.5 mg/L according to food composition tables of West Germany and the United States of America [24,25]) was added to this version. In total 884 different food products were used of which 97 had missing values for the vitamin B-6 content. These products were, however, of minor importance for dietary intake figures, since the highest mean consumption was 1.3 g/day. Percentage of users of these products was mostly (75% of the 97 products) below 1.0%. For 7 products the percentage of users was within the range of 5.0-8.7.

Information on clinical condition (including current drug use) and usage of nutritional supplements was obtained. A venous blood sample (nonfasted) was obtained from 529 elderly for hematological, biochemical and routine clinicochemical analyses. Basal (holo-enzyme) erythrocyte aspartate aminotransferase (EAST) activity and total (apo-enzyme) EAST activity, after addition of an excess of PLP, were measured in red cell hemolysate of all available blood samples, and PLP concentrations were determined in plasma samples from a random subsample of 108 respondents. The evaluation of the vitamin B-6 status was based on the biochemical measurement of plasma PLP (26) and EAST activity before and after in vitro stimulation with PLP at the cellular level (27). The activation coefficient was calculated (EAST-AC) as the ratio of total and basal EAST activity. The sampling design, investigation procedures and biochemical methods have been described before (9).

For the purpose of the present study all elderly subjects using drugs known to affect the vitamin B-6 requirement, metabolism and/or status (n=57), were excluded from the statistical analysis. Six people with anemia (hemoglobin < 7.5 mmol/L) were also excluded. Finally, elderly persons using nutritional supplements containing vitamin B-6 were excluded (n=34), since no information was available on daily dosage of the nutritional supplements taken. After exclusion of these persons data on 225 men and 217 women remained for analysis. Plasma PLP values on 89 elderly subjects were available in this sample.

The data were analyzed by means of analysis of variance and linear (multiple) regression. The statistical analyses were performed with the BMDP statistical computer package (28). All statistical tests were two-tailed. Effects with a p value of less than 0.05 were considered as being significant.

Results

The mean age of the elderly was 72.2 y; no significant differences in mean age were observed between the genders and between those using and those not using alcohol. **Table 10.1.** summarizes some dietary intake data of the subjects classified according to gender and alcohol usage. On the average men had a significantly higher intake of energy, alcohol and vitamin B-6 than women; in the diet of men more energy was derived from alcohol but less from protein. Expressed per g of protein the intake of vitamin B-6 did not differ for the genders and for alcohol usage. A significantly higher intake of energy was found among alcohol users, whereas in this group less energy was derived from carbohydrates than among those not using alcohol. Alcohol users had a significantly higher intake of vitamin B-6 when the vitamin B-6 content of beer was assumed to be 0.5 mg/L. In comparison with the basis for the Dutch recommended dietary allowance of 20 µg vitamin B-6 per g of protein (29) the mean levels of intake were somewhat lower. Except for Table 10.1., all results presented on vitamin B-6 intake are based on a vitamin B-6 content of beer of 0.5 mg/L, since this value corresponds with recent analyses of the vitamin B-6 content of Dutch brands of beer (J. Schrijver, personal communication). Among men about 2% of the daily vitamin B-6 intake came from beer; this was less than 1% for women.

Table 10.2. shows the consumption (in g/day) of different groups of alcoholic beverages and the contribution of these beverages to the total alcohol intake according to gender. Among men spirits contribute most to alcohol intake; for women spirits and wines were about of equal importance. Among the spirits Dutch geneva was the most important contributor to the alcohol intake; 51% of the alcohol intake came from geneva among men and 21% among women. Among women 15% of the alcohol intake was derived from sherry (classified as a wine).

In **Table 10.3.** the data regarding the vitamin B-6 status are presented for elderly people classified according to gender and alcohol usage. The mean EAST-AC was significantly lower among the elderly using alcohol than among nonusers. A similar nonsignificant ($p = 0.10$) tendency was observed for total EAST activity. Men had a significantly lower mean total EAST activity and mean PLP concentration than women; on the average the basal EAST activity and EAST-AC were similar for the genders.

In **Table 10.4.** the correlations of alcohol intake with dietary intake variables and vitamin B-6 status indicators are presented. Alcohol intake (g/day) was not significantly associated with intake of protein, dietary fiber and vitamin B-6. There appeared to be a significant inverse correlation between alcohol intake and

Table 10.1.
Mean values of some dietary intake variables according to gender and alcohol usage

Energy and nutrient	Men		Women			F-test (p value)		
	alcohol n=188	no alcohol n=37	alcohol n=149	no alcohol n=68	Pooled SD	gender	alcohol	inter-action
Energy (MJ)	10.2	9.9	8.1	7.4	2.3	<0.001	<0.025	ns
Protein (% of energy)	13.7	14.1	14.9	15.5	2.6	<0.001	ns	ns
Fat (% of energy)	40.4	42.3	40.1	39.9	5.9	ns	ns	ns
Carbohydrates (% of energy)	40.9	43.4	41.9	44.5	6.6	ns	<0.001	ns
Alcohol (% of energy)	5.0	-	3.0	-	4.2	<0.05	-	-
Alcohol (g)	17	-	8	-	13	<0.01	-	-
Vitamin B-6+								
mg	1.40	1.32	1.18	1.09	0.35	<0.001	ns	ns
µg/g protein	17.3	16.3	16.6	16.5	3.2	ns	ns	ns
Vitamin B-6#								
mg	1.42	1.32	1.18	1.09	0.36	<0.001	<0.05	ns
µg/g protein	17.5	16.3	16.8	16.5	3.5	ns	ns	ns

+ Based on a vitamin B-6 content in beer of 0.2 mg/L; # Based on a vitamin B-6 content in beer of 0.5 mg/L; ns: nonsignificant; -: test is not executed.

Table 10.2.
Consumption of alcoholic beverages, amount of alcohol consumed, and contribution to total alcohol intake according to gender

Alcoholic beverage	Men (n=224)			Women (n=217)		
	Product	Alcohol		Product	Alcohol	
	g/day	g/day	%#	g/day	g/day	%#
Beers	44	1.8	12.5	10	0.4	6.8
Wines	22	2.6	18.2	24	2.7	46.8
Spirits	34	9.7	69.1	10	2.6	44.6
Remainder	1	<0.1	0.2	2	0.1	2.0

Contribution of alcoholic beverages to total alcohol intake.

total EAST activity and EAST-AC. Correlation coefficients similar to those presented in Table 10.4. were found after exclusion of the elderly not using alcoholic beverages.

Since the association between alcohol intake and vitamin B-6 status indices might not be linear as assumed in regression analyses we calculated the mean value of the vitamin B-6 status indices (an exception was made for PLP due to low number of observations) for different levels of alcohol. The association of alcohol intake with EAST-AC and with basal and total EAST activity is presented in **Figure 10.1.**. The calculated vitamin B-6 intake (mg/day) for the different intervals was 1.18, 1.26, 1.32, 1.38, 1.33, 1.37, and 1.29, respectively. As shown in Figure 10.1. the total EAST activity and EAST-AC but not the basal EAST activity was lower at higher alcohol intake. The lower EAST-AC of those consuming 0.1-5.0 g of alcohol per day as compared with elderly subjects not consuming alcoholic beverages is striking. The data presented in Figure 10.1. do not indicate that the assumption of a linear association is violated substantially. For all three indicators of the vitamin B-6 status presented in Figure 10.1. the test of lack of fit was not significant indicating that there was no deviation from a linear association.

In the multivariate regression analyses with EAST-AC as dependent variable and alcohol and vitamin B-6 (or vitamin B-6 per gram protein) as independent variables, EAST-AC was found to be significantly inversely associated with intake of vitamin B-6 (absolute and per g protein) and alcohol (**Table 10.5.**). The results did not differ for the genders. In the regression analyses with basal EAST activity as dependent variable no association was found with alcohol intake whether or not adjusted for the intake

Table 10.3.
Mean values of vitamin B-6 status according to gender and alcohol usage

Variable	Men		Women		Pooled SD	F-test (p value)		
	alcohol n=184	no alcohol n=37	alcohol n=146	no alcohol n=60		gender	alcohol	interaction
EAST activity								
basal (U/mmol Hb)+	57	58	60	59	13	ns	ns	ns
total (U/mmol Hb)+	96	100	102	104	17	<0.025	ns	ns
EAST-AC+	1.70	1.77	1.72	1.79	0.20	ns	<0.01	ns
PLP+ (nmol/L plasma)#	24 (37)	24 (10)	36 (32)	30 (10)	15	<0.05	ns	ns

Number of observations in parenthesis; + EAST: erythrocyte aspartate aminotransferase; EAST-AC: erythrocyte aspartate aminotransferase activation coefficient; basal: activity of EAST before adding pyridoxal 5'-phosphate (PLP) or holo-enzyme activity; total EAST activity: activity of EAST after adding PLP or apo-enzyme activity; ns: nonsignificant.

Table 10.4.
Correlation coefficients
of alcohol intake with dietary intake variables and
vitamin B-6 status indicators among men and women aged 65-79

Variable	Men n=221	Women n=206
Dietary intake		
Protein	-0.06	-0.04
Dietary fiber	-0.09	-0.06
Vitamin B-6	-0.03	-0.01
Vitamin B-6/protein	0.01	0.10
Vitamin B-6 status		
Basal EAST activity+	-0.01	-0.02
Total EAST activity+	-0.15*	-0.18**
EAST-AC+	-0.22**	-0.18**
PLP+#	0.26 (47)	0.15 (42)

Number of subjects in parenthesis; + Basal EAST activity is the enzyme activity of erythrocyte aspartate aminotransferase before adding PLP (pyridoxal 5'-phosphate) and total EAST activity is the activity after adding PLP; EAST-AC is the ratio of these activities; * Pearson correlation coefficient significant at $p < 0.05$; ** Pearson correlation coefficient significant at $p < 0.01$.

of vitamin B-6 (absolute and per g of protein). In contrast, total EAST activity was found to be significantly inversely associated with alcohol intake in all three models studied. The observations on the basal and total EAST activity were made for men as well as for women.

In **Table 10.6.** the results of different (multivariate) regression models with PLP as dependent variable are presented. Since the results differed for elderly men and women separate regression equations are shown. Although alcohol intake tended to be positively associated with PLP (especially among men) this association did not reach significance.

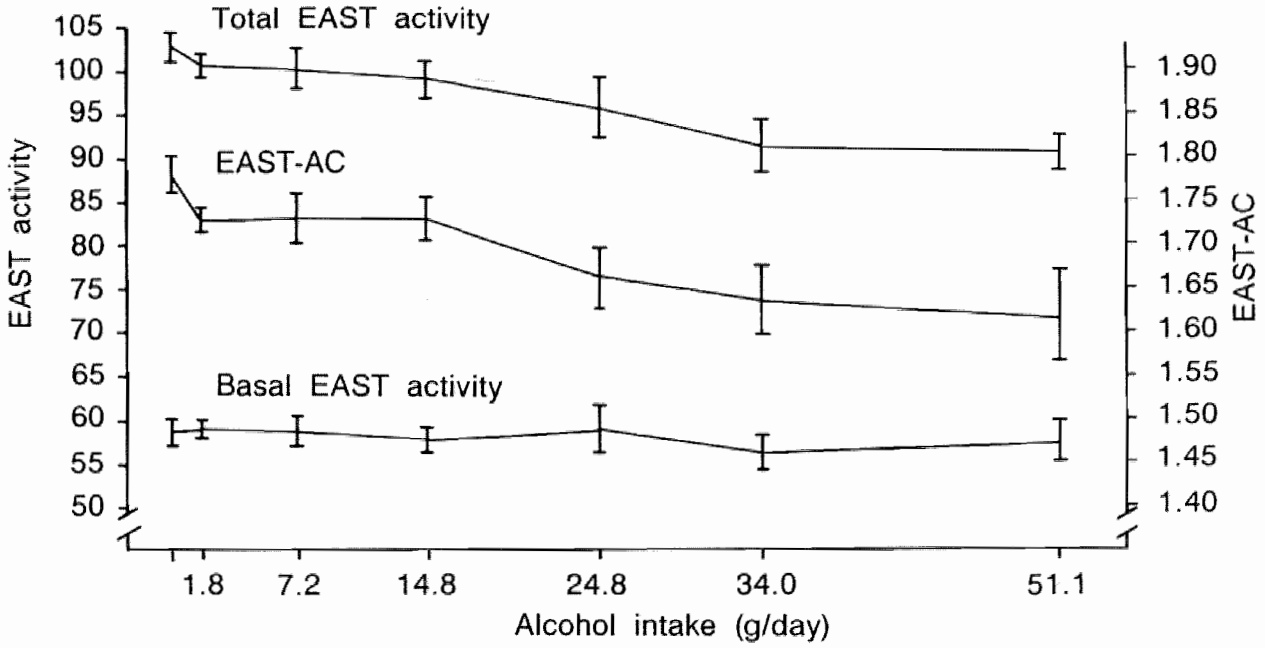

Figure 10.1. Mean value (± standard error of the mean) of basal and total EAST (erythrocyte aspartate aminotransferase) activity (in U/mmol Hb) and the activation coefficient of EAST (EAST-AC; ratio) for different intervals of alcohol intake (characterized by their mean consumption) among elderly people. Intervals chosen for alcohol intake (in g/day) were 0.0, 0.1-5.0, 5.1-10.0, 10.1-15.0, 15.1-20.0, 20.1-30.0, 30.1-40.0 and > 40.0.

Table 10.5.
Results of three multiple regression analyses with EAST-AC+ as dependent variable (elderly men and women together; n=427)

Independent variable in model	Regression coefficient (x 100)	SE (x 100)	T-value	Multiple R
1. Intercept	1.760			
Alcohol (g)	-0.327	0.071	-4.60*	0.22
2. Intercept	1.847			
Vitamin B-6 (µg)	-0.007	0.003	-2.61*	
Alcohol (g)	-0.303	0.071	-4.26*	0.25
3. Intercept	1.890			
Vitamin B-6 per g of protein (µg)	-0.780	0.280	-2.82**	
Alcohol (g)	-0.301	0.071	-4.25**	0.26

* $p < 0.01$; + EAST-AC: total EAST (erythrocyte aspartate aminotransferase) activity divided by basal EAST activity; T value: Test value based on student's t distribution; Multiple R: correlation of EAST-AC with the independent variable(s).

Discussion

Our results indicate a statistically significant inverse association between alcohol intake and EAST-AC due to lower total EAST activity. This association has been found before (30,31), whereas the exact mechanism is a matter of speculation since several factors can explain this observation.

First, although our results indicate an independent (adjusted for intake of vitamin B-6) effect of alcohol on the EAST-AC it is still possible that alcoholic beverages contain much more vitamin B-6 than is indicated by food composition tables. Data on the vitamin B-6 content of foods are still incomplete (32), whereby our results will be somewhat distorted by the imperfect quantification of the vitamin B-6 intake. Moreover, the bioavailability of vitamin B-6 from foodstuffs varies. Since the

Table 10.6.
Results of three multiple regression analyses with PLP# as dependent variable

Independent variable in model	Elderly men (n=47)				Elderly women (n=42)			
	Regression coefficient	SE	T-value	Multiple R	Regression coefficient	SE	T-value	Multiple R
1. Intercept	21.893				31.094			
Alcohol (g/day)	0.184	0.100	1.84	0.26	0.250	0.255	0.98	0.15
2. Intercept	-1.189				21.586			
Vitamin B-6 (µg/day)	0.017	0.004	4.23*		0.008	0.009	0.98	
Alcohol (g/day)	0.146	0.086	1.70	0.58	0.280	0.257	1.09	0.22
3. Intercept	-0.957				50.637			
Vitamin B-6/protein (µg/g)	1.350	0.404	3.34*		-1.187	0.939	-1.26	
Alcohol (g/day)	0.130	0.092	1.42	0.51	0.241	0.253	0.95	0.25

PLP (pyridoxal 5'-phosphate) was measured in nmol/L with no significant numbers to the right of the decimal point; * $p < 0.01$.

bioavailability of vitamin B-6 is incomplete when conjugated with β-glucosides (33) and is adversely affected by (animal) protein (13-15) the bioavailability of vitamin B-6 in alcoholic beverages may expected to be relatively high. However, our results show that the mean values for vitamin B-6 intake (absolute and per g of protein) were only slightly higher when the vitamin B-6 content of beer is taken at 0.5 mg/L instead of 0.2 mg/L. The vitamin B-6 content of four Dutch brands of beer ranged from 0.41 to 0.68 mg/L (J. Schrijver, personal communication). A positive association ($p < 0.01$) between alcohol intake and PLP concentration in erythrocytes is found in West-Germany (30); the authors suggested that this association may be attributed to the vitamin B-6 content of beer and wine. Among 35-y-old men in The Netherlands a positive association ($r = 0.49$; $p < 0.01$) is observed between alcohol intake and plasma PLP (34). Nearly all (about 90%) of the alcohol was derived from beer. Although among these 35-y-old men (n=60) the EAST-AC tended to be inversely associated ($r = -0.22$) with the alcohol intake, this association did not reach statistical significance (34). These results suggest that the lowering of EAST-AC values by alcohol is partly due to higher PLP concentrations in plasma and erythrocytes when the alcoholic beverages (especially beer) contain a substantial amount of vitamin B-6, that may be of a high bioavailability. However, among the elderly studied PLP concentrations in plasma were not significantly associated with alcohol adjusted or unadjusted for the intake of vitamin B-6 (per g protein). The absence of such an association may be partly due to fewer observations, the blood that has been taken from the nonfasted elderly persons, and the use of alcoholic beverages such as spirits which contain little or no vitamin B-6.

The association between habitual dietary intake figures and PLP (a short-term indicator) are probably weakened due to the use of nonfasting blood. Some of the variation in PLP levels will be the result of recent consumption that may deviate from the habitual levels of the dietary factors studied. Inaccuracies in exposure measurements are in general expected to weaken rather than produce associations. In cross-sectional designs mostly low-order correlations are found between nutrient intake and biochemical measurements. However, not only the strength or magnitude of a particular association is important but also its direction (positive or inverse).

Due to the tendency of respondents to give socially acceptable answers the use of alcoholic beverages will most likely be underreported. Furthermore, it may be expected that alcoholics are less likely to participate in a nutritional survey. This may also have weakened the observed association of alcohol with vitamin B-6

indices. A national food consumption survey in The Netherlands conducted in 1987/1988, using two-day dietary records reported similar mean levels of alcohol intake among elderly men (16 g/day) and women (6 g/day) (35). Although underreporting to some extent may be present disturbance of the rank order among the subjects may be absent whereby it is not likely that the associations of alcohol with vitamin B-6 status indices are invalidated by this.

Another explanation of the association between alcohol intake and EAST-AC might be related to the metabolism of vitamin B-6. Acetaldehyde, a metabolite of ethanol, stimulates the degradation of PLP (36), whereby lower basal EAST activities may be expected. Our results indicate an effect of alcohol on the total EAST activity, leading to a lower EAST-AC, but not on the basal EAST activity. This may be the result of a higher enzyme turnover, and a decreased capacity or need to synthesize apoenzymes. Pyridoxine kinase levels in the red cells are higher than normal in alcoholics, whereas these patients have also a basal EAST activity above normal (16). Moreover, Solomon and Hillman (37) found a highly significant correlation ($r = 0.71$; $p < 0.001$) between pyridoxine kinase activity and basal EAST activity. Pyridoxine kinase is responsible for the conversion of the natural occurring vitamin B-6 form pyridoxal into the active coenzyme PLP. Lower and normal EAST-AC values are often observed among alcoholics despite their reduced levels of plasma PLP (16-19). However, alcoholics generally do not have an isolated vitamin B-6 deficiency, but frequently encounter multiple deficiencies and pathologies (18,36). Therefore, the impact of alcohol on pyridoxal kinase found in alcoholics cannot be directly generalized to moderate alcohol usage. Since the physiological origin of the observed association between moderate alcohol intake and EAST-AC is still unknown, it is a matter of speculation whether moderate alcohol intake leads to functional consequences associated with the vitamin B-6 status.

In our survey among elderly people somewhat higher PLP levels were observed among women than among men. This may be explained by a different food selection leading to differences in bioavailability. However, the intake of vitamin B-6 per g of protein did not differ significantly between the genders, whereas elderly people using supplements containing vitamin B-6 were excluded from the statistical analyses. Nondietary (lifestyle) factors, like physical activity, drug usage, health status, and body build and body composition were found to differ significantly between the elderly men and women studied (38).

The observed inverse association between moderate alcohol consumption and EAST-AC may have implications for epidemiological studies with EAST-AC as an indicator of the vitamin B-6 status.

Alcohol consumption lowers EAST-AC values and may give the possibly incorrect impression of an adequate vitamin B-6 status. Such an incorrect interpretation may result in lower mean values and prevalence figures for marginal EAST-AC values among population groups using alcoholic beverages, whereby comparisons between groups may be affected. For instance, we previously reported a marginal vitamin B-6 status (EAST-AC > 2.02) for 9% of the elderly studied not taking a vitamin B-6 supplement (9); the prevalence in the same elderly population was 16% among those not using alcohol and 6% among those using alcoholic beverages. However, in case alcohol does have a positive effect on the bioavailability of vitamin B-6 these percentages may be a correct estimate. In etiological studies using EAST-AC alcohol may be an important confounder, especially in studies on coronary heart disease, since alcohol consumption has been found to be inversely related with coronary heart disease (39,40).

From several studies one may conclude that the EAST-AC is a poor indicator of vitamin B-6 status except in pronounced deficiency, because it is less responsive to vitamin depletion than are plasma PLP levels (18,41). Although plasma PLP level may be more responsive to the supply of vitamin B-6 in the short term, EAST activities reflect the intake of vitamin B-6 over a longer period and may be used as a simple function-oriented index at the cellular level (37). First, because vitamin B-6 depletion and supplementation studies show that there is a time lag in the response of transaminase activities as compared to PLP (4,8). Second, EAST-AC may be affected by relevant factors unrelated to the intake of vitamin B-6. According to Sauberlich et al (5) detection of metabolic changes indicates with a higher degree of certainty to vitamin B-6 deficiency than does a drop in vitamin levels in biological fluids. EAST-AC may integrate the combined effects of relevant dietary and physiological factors over a longer period of time as compared to PLP level in plasma or erythrocytes. Therefore, this function-oriented test may still be of greater value than the rather static levels of the vitamin in body fluids and tissues.

In conclusion, our results indicate caution in the interpretation on the specificity, as the degree to which it is unaffected by other factors, of the EAST-AC as a mere indicator of vitamin B-6 intake.

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11. RISK GROUPS AMONG INDEPENDENTLY LIVING ELDERLY FROM A NUTRITIONAL POINT OF VIEW*

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11.1. ABSTRACT

To obtain insight into differences in nutritional risks among subgroups the impact of several lifestyle and sociodemographic factors on consumption pattern and nutritional status among 539 independently living Dutch elderly people aged 65-79 y was studied. The results indicate that risk of a marginal vitamin D, mineral and eventually iodine status and inadequate water supply increase with age. Low education, low socioeconomic status, low income, singleness, low physical activity and high energy intake were associated with a higher probability of having a less prudent diet. Differences in dietary intake and nutritional status indicators among elderly people differing in region, degree of urbanization, housing and chewing problems were of no significance. Health status was not associated with the quality of dietary intake when elderly people on a dietary regimen were excluded from the analysis. For the quantity of dietary intake gender, health status and physical activity were the most important determining factors, whereas socioeconomic factors were more important for the qualitative aspects of the diet. It is concluded that generalization of frequently reported risk factors for a marginal diet among the elderly may not always be valid for Dutch apparently healthy elderly people aged 65-79 y. Since most differences among subgroups were relatively small and because at group level no unacceptable direct health risks were prevalent in any of the subgroups studied, it is concluded that dietary guidelines should be oriented towards apparently healthy elderly people in general.

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11.2. Introduction

Among the elderly data on dietary intake and nutritional status are mostly studied at group level to identify general nutritional risks that may still be open to preventive or therapeutic measures (1-4). There is a recurrent debate whether recommendations for lifestyle changes should be applied uniformly to the general population or that measures should be oriented to high risk groups (5). Particular subgroups may differ substantially from the overall population, so that targeted measures for these groups may be considered to be necessary. Several factors, such as limited income, social isolation, physical disability, mental impairment and bad dental status, are suggested to make the elderly prone to a poor nutritional status as a result of an inadequate diet (6-12). Therefore, we investigated the impact of age, gender, region, degree of urbanization, housing situation, size of the household, educational level, socioeconomic status, entitlement to supplementary social benefit, physical activity, level of energy intake, chewing problems and health status on dietary intake and nutritional status indicators among the independently living elderly. Some results of this risk group identification have been published in more detail (13-16). These results will be summarized and extended with other factors that may influence nutritional risks.

11.3. Physical activity

In general, elderly people have a lower intake of energy and lower energy expenditures than younger adults (17). Limited physical activity is the most important determinant. Therefore, we investigated the impact of physical activity and energy intake on dietary intake and nutritional status of elderly people. **Table 11.1.** presents the indicators of the nutritional status that were found to be associated with physical activity among the elderly. On the average, a lower body weight and a lower body mass index were found at higher levels of physical activity. The higher mean urinary creatinine excretion per 24-h and per kg body weight indicates that physical activity is positively associated with muscle mass. Relevant differences in hematological indices, blood pressure, serum cholesterol and vitamin status indicators were not observed among the elderly differing in levels of physical activity. The mean plasma concentration of 25-hydroxyvitamin D was lower at lower physical activity; limited exposure to sunlight is the most likely causal factor. Mean urinary calcium excretion was lower among elderly with limited physical activity, whereas

Table 11.1.
Some characteristics (mean) of the nutritional status of elderly men and women with different levels of physical activity (low, intermediate, high)*

Characteristic	Men			Women			Pooled	
	low	inter-mediate	high	low	inter-mediate	high	SD	F-test (physical activity)
	n=127	n=83	n=55	n=140	n=84	n=37		
Body weight (kg)	75.6	77.5	73.7	71.0	69.0	65.6	11.4	< 0.025
Body mass index (kg/m²)	25.4	26.0	24.7	27.7	26.7	25.6	3.7	< 0.01
Body fatness (%)	29.1	29.9	29.7	40.2	39.5	39.8	7.2	ns
Serum creatinine (µmol/L)	117	112	110	100	97	96	21	< 0.05
Creatinine excretion								
mmol/24-h	11.5	12.6	11.9	8.2	8.6	8.4	3.4	< 0.025
mmol/24-h per kg body weight	0.152	0.162	0.159	0.116	0.126	0.130	0.041	< 0.01
Creatinine clearance (mL/min)	70.1	79.1	75.4	58.2	62.6	62.6	21.2	< 0.01
25-Hydroxyvit.D (nmol/L)+	35	48	43	35	39	46	17	< 0.025
Calcium excretion (mmol/24-h)	3.12	3.52	3.45	2.99	3.44	3.77	1.97	< 0.025
Blood pressure								
Systolic (mmHg)#	152	150	145	152	155	158	22	ns
Diastolic (mmHg)#	85	86	85	87	90	90	11	ns
Pulse pressure (mmHg)#	67	65	60	65	65	68	17	ns
Serum cholesterol								
Total (mmol/L)	6.06	5.96	5.92	6.58	6.51	6.41	1.17	ns
HDL (mmol/L)+	1.08	0.95	0.92	1.37	1.40	1.20	0.35	ns
Total/HDL (ratio)+	6.03	6.28	6.20	5.11	4.93	5.79	1.61	ns

* Low: no sport, intermediate: < 6 h/week, high: ≥ 6 h/week; + Results based on 108 observations; # After exclusion of elderly using antihypertensive drugs.

calcium intake was similar for all groups. Urinary calcium excretion depends among other things, on the 1,25-dihydroxyvitamin D level in plasma which, in turn, depends on the synthesis by the kidney. Therefore, the lower mean calcium excretion at a lower level of physical activity may be associated with lower 25-hydroxyvitamin D levels and impaired kidney function (as assessed by creatinine clearance). As expected, energy intake, especially when expressed per kg body weight or per kg fat-free mass, of physically active elderly is higher than among their less active contemporaries (see **Table 11.2.**). Although a similar tendency was observed for most micronutrients, only intake of iron and intake of ascorbic acid were found to differ significantly among elderly with different levels of physical activity. Among elderly men and women with limited physical activities more energy was derived from fat whereas no differences were found in serum cholesterol level among elderly differing in their level of physical activity. In summary, the results indicate that elderly with a relatively low level of physical activity do not differ substantially regarding nutritional status indicators (except 25-hydroxyvitamin D and body composition) from the general population.

11.4. Energy intake

On the average elderly people have lower energy expenditures and lower intake of energy and nutrients than younger adults. The elderly with a relatively low energy intake may run higher nutritional risks than those with a higher intake. Therefore, the characteristics of a low energy diet were studied by classifying the elderly (men and women separately) into tertiles based on their daily energy intake. As expected, intake (in absolute terms) of macro- and micronutrients was lower among the elderly with a lower energy intake (see **Table 11.3.**). However, the nutrient density was higher when the intake of energy was relatively low. Among women, but not men, mean body weight and body mass index were higher for the elderly with the lowest energy intake. Therefore, the intake of energy per kg body weight and per kg fat-free mass was also lower among the elderly (especially women) with a lower daily intake of energy. Energy intake of the elderly more frequently engaged in physical activities, especially when expressed per kg body weight or per kg fat-free mass, was lower as compared to those with lesser activities. As shown in Table 11.3. more energy was derived from protein and less from fat when the energy intake was relatively low. However, no significant differences were found in energy percentage of polyunsaturated

Table 11.2.
Some characteristics (mean) of the diet of elderly men and women with different levels of physical activity (low, intermediate, high)*

Characteristic	Men			Women			Pooled SD	F-test (physical activity)
	low n=129	inter-mediate n=85	high n=55	low n=145	inter-mediate n=87	high n=37		
Energy								
MJ/day	10.0	10.1	10.6	7.8	7.9	8.3	2.2	< 0.05
kJ/kg body weight	134	133	146	114	118	129	35	< 0.01
kJ/kg fat-free mass	189	190	206	189	195	214	48	< 0.01
Intake in % of energy								
Protein	13.6	14.2	13.4	15.4	14.6	15.1	2.6	ns
Fat	41.6	38.8	40.3	40.3	39.0	38.6	6.0	< 0.01
Carbohydrate	40.8	42.8	41.8	42.7	43.3	44.5	6.7	ns
Alcohol	4.0	4.1	4.5	1.5	3.0	1.8	4.2	ns
Minerals								
Iron (mg/day)	12.7	13.3	13.8	11.0	11.8	11.8	3.0	< 0.01
Calcium (mg/day)	1104	1145	1156	1047	947	1037	359	ns
Potassium (mg/day)	3653	3788	3749	3201	3244	3355	822	ns
Vitamins								
Retinol (mg/day)	1.05	1.03	1.16	0.95	0.93	0.99	0.39	ns
Thiamin (mg/day)	1.08	1.14	1.11	0.91	0.94	0.95	0.26	ns
Riboflavin (mg/day)	1.68	1.70	1.77	1.53	1.46	1.53	0.46	ns
Pyridoxine (mg/day)	1.35	1.38	1.44	1.14	1.16	1.17	0.34	ns
Ascorbic acid (mg/day)	88	98	102	97	104	114	43	< 0.01

* Low = no sport, intermediate = < 6 h/week, high = ≥ 6 h/week.

Table 11.3.
Some characteristics of the dietary intake of elderly men and women with different levels of energy intake (low, intermediate, high)

Daily intake		Energy intake			Pooled SD	F-test (energy)
		Low	Inter-mediate	High		
Energy	men	8.1	9.9	12.4	2.0	p<0.01
(MJ)	women	6.0	7.8	9.9	1.9	p<0.01
Energy (kJ per	men	112	132	164	32	p<0.01
kg body weight)	women	85	115	150	35	p<0.01
Energy (kJ per	men	160	188	230	42	p<0.01
kg fat-free mass)	women	144	190	246	53	p<0.01
Energy percentage						
Protein	men	14.4	14.1	12.7	2.25	p<0.01
	women	16.5	14.9	14.0	2.66	p<0.01
Fat	men	39.1	40.2	42.0	5.8	p<0.01
	women	38.5	39.2	41.2	6.2	p<0.01
Carbohydrate	men	41.6	42.1	41.3	6.8	ns
	women	43.3	43.7	42.5	6.6	ns
Alcohol	men	4.8	3.6	3.9	4.4	ns
	women	1.6	2.3	2.3	3.6	ns
Nutrient density						
Thiamin	men	0.49	0.47	0.43	0.09	p<0.01
(mg/4.2 MJ)	women	0.53	0.49	0.48	0.10	p<0.01
Riboflavin	men	0.76	0.72	0.66	0.18	p<0.01
(mg/4.2 MJ)	women	0.89	0.80	0.76	0.20	p<0.01
Pyridoxine	men	602	592	536	120	p<0.01
(µg/4.2 MJ)	women	656	627	578	129	p<0.01

fatty acids, mono- and disaccharides, P/S ratio, calcium/phosphorus ratio and intake of riboflavin and pyridoxine per gram protein. The percentage of energy derived from polysaccharides was higher at lower energy intake. Despite these differences in dietary intake, especially when expressed in absolute figures, no significant differences were found in hematological indices, vitamin status indicators, serum cholesterol and urinary excretion of minerals (calcium, magnesium, potassium, sodium) and iodine

when expressed per mmol creatinine excretion. Therefore, among independently living, apparently healthy elderly people without an energy deficit it is the relative intake rather than the absolute intake that predominates for an evaluation of dietary intake. In this context "relative" refers to intake of energy, body build and body composition, and physical activity, whereas these variables are interdependent.

11.5. Health status

To obtain a global insight into the potential impact of health status and drug usage on dietary intake and nutritional status of apparently healthy elderly we classified the independently living elderly into two groups. To this end we selected a subsample of 115 healthy elderly subjects from the original sample of 539 apparently healthy elderly. Elderly without specific complaint(s) about their health, not under medical care of a physician or specialist, not using drug(s), with a hemoglobin value ≥ 7.5 mmol/L and a diastolic blood pressure below 95 mmHg were considered to be healthy and called "healthy elite". The dietary intake and nutritional status indicators of these subjects were compared with the remainding elderly of which 322 were using one or more drugs. Analysis of variance with gender, health status and their interaction as factors was used; similar variables were transformed as before (see Chapters 2 and 3). The healthy elite had a higher mean intake of energy, vegetable protein, saturated fat, monounsaturated fat, total fat, cholesterol, polysaccharides, total carbohydrates, dietary fiber, nonheme and total iron, and retinol. Expressed per energy, the intake of cholesterol was higher but the intake of thiamin and riboflavin was lower among the healthy elite than among those with a poorer health status. The intake of riboflavin per gram of protein was lower and the amount of energy derived from saturated fat was higher among the healthy elite.

To a certain extent these observations are comparable with the differences found between elderly people with and without a dietary regimen. Since 6% of the men and none of the women belonging to the healthy elite but 32% and 37% respectively of the other men and women were on a diet we also executed an analysis of variance in which the elderly on a diet were excluded. The significant ($p < 0.05$) differences after exclusion of the elderly on a diet are presented in **Table 11.4.** The results show that the dietary intake only differed in quantitative terms. These differences are most likely due to the observed interdependence of health status and physical activity: more elderly from the healthy

Table 11.4.
Some characteristics (mean) of the dietary intake of elderly people not on a diet according to gender and health status

Daily dietary intake	Men		Women		Pooled SD	F-test (health status)
	HE* n=67	AH* n=133	HE n=46	AH n=139		
Energy (MJ)	10.8	10.2	8.3	8.0	2.3	p<0.05
Total protein (g)	84	81	73	68	17	p<0.05
vegetable (g)	28	25	22	21	7	p<0.01
Total fat (g)	119	110	90	85	31	p<0.05
saturated (g)	52	47	39	38	15	p<0.05
monounsaturated (g)	45	41	34	32	12	p<0.05
Cholesterol (mg)	403	361	323	298	122	p<0.01
Polysaccharides (g)	131	121	103	96	33	p<0.05
Dietary fiber (g)	29	26	24	23	8	p<0.05
Total iron (mg)	14.0	12.6	12.1	11.3	3.0	p<0.01
nonheme (mg)	11.0	9.7	9.3	8.8	2.6	p<0.01
Retinol	1.18	1.00	0.96	0.98	0.37	p<0.05

* HE = healthy elite, AH = apparently healthy.

elite being frequently engaged in physical activities. The results with respect to higher mean values of 25-hydroxyvitamin D and creatinine excretion among the healthy elite (see **Table 11.5.**) also emphasize this interdependence. Besides these differences the healthy elite had on the average a lower blood pressure (mainly due to the classification criterion of having a diastolic blood pressure < 95 mmHg) and serum uric acid concentration, but a higher ferritin concentration, creatinine clearance and 24-h mineral excretion (see Table 11.5.). However, when expressed per mmol creatinine no differences were found in mineral excretions per 24-h. Similar differences, and additionally a lower serum creatinine concentration, basal and total EGR activity among the healthy elite, were found with respect to the nutritional status indicators when those on a diet were included in the analysis of variance. Furthermore, if we classified the elderly into those using and those not using drugs the results hardly differed from those described above.

No differences in the diet were found when intake was expressed in qualitative terms, nor in most indicators of the nutritional status between the healthy elite and those with a poorer health

Table 11.5.
Some characteristics (mean) of the nutritional status of elderly people not on a diet according to gender and health status

Indicator	Men		Women		Pooled SD	F-test (health status)
	HE* n=66	AH* n=134	HE n=44	AH n=136		
Blood pressure (mmHg)						
systolic	148	151	148	157	21	p<0.05
diastolic	84	86	85	89	11	p<0.01
Ferritin (µg/L)#	112	104	89	61	76	p<0.05
25-OH-vitamin D (nmol/L)#	49	39	44	36	18	p<0.05
Uric acid (µmol/L)	319	348	303	308	74	p<0.05
24-h urinary excretion						
creatinine (mmol)	12.7	11.9	8.9	8.3	3.4	p<0.05
(mmol/kg body weight)	0.168	0.157	0.127	0.122	0.041	p<0.05
sodium (mmol)	153	142	132	117	52	p<0.05
potassium (mmol)	68	63	61	55	19	p<0.05
calcium (mmol)	3.34	3.16	3.82	3.05	1.82	p<0.05
Creatinine clearance (mL/min)	80.8	74.7	66.9	59.7	21.2	p<0.01

* HE = healthy elite, AH = apparently healthy; # number of subjects is 13, 26, 18 and 22 respectively.

status. However, it cannot be concluded that such a diet is adequate. The healthy elite among elderly people is likely to be an atypical and inappropriate sample for finding extrinsic determining factors, such as nutrition, that are responsible for successful aging (18). A good health status among elderly people may be the result of genetic make-up and selective survival rather than of favorable extrinsic factors affecting aging and pathological processes. The observation that dietary intake of the elderly healthy elite does not differ from that of the apparently healthy elderly not on a diet does not negate this conclusion. This finding and the absence of differences in most nutritional status indicators suggests that it is fairly indifferent whether apparently healthy or healthy elderly are selected since disease(s) and drug usage prevalent among the apparently healthy elderly generally did not have a major impact on the results with respect to mean values among subgroups. However, as indicated by our study on hemoglobin (19) this conclusion may not be applicable

to the range of and the variance in the variables studied. Furthermore, it should be noted that only apparently healthy elderly subjects were selected, whereas those confronted with severe chronic disease(s) living in institutions are reported to be vulnerable to nutrient deficiencies (20-24). Our preliminary results of a survey conducted in 1988 in a nursing home show indeed that a marginal and perhaps even a deficient status of vitamin C, B-6 and D was frequently seen among those being institutionalized.

11.6. Chewing problems

About 80% of the independently living elderly people were edentulous, whereas about 93% had artificial dentures. These proportions did not differ significantly among the genders or the age groups. Elderly people suffering from loss of teeth without artificial dentures and those with ill-fitting artificial dentures may have problems with chewing certain foods. Among the independently living 6% reported to have chewing problems in general and 18% claimed not to eat certain foods because of chewing problems. These elderly people may experience a restriction in food selection because of their dental state. Most studies among elderly people report that some individuals avoid eating food products such as meat, vegetables and raw fruits because of chewing difficulties (11,25-27). The literature on intake of energy and nutrients and nutritional status indicators is contradictory, and differences related to dental state reported are less pronounced than those found for food products (11,12,26). These somewhat confusing findings may be attributed to confounding by socioeconomic factors, dental care, overall health status, reference group (for instance younger adults) and food selection strategies characterized by substitutions within product groups. To obtain some insight into the effect of chewing problems among Dutch elderly people, we investigated whether dietary intake and nutritional status of the elderly who reported to have chewing difficulties differed significantly from those of the remainding elderly population. For this purpose analyses of variance were carried out with gender and chewing problems as factors. Except for some interactions and for higher mean values for body weight, knee diameter and thyroxine concentration in plasma among the elderly not eating all food products they had been used to eat results were found to be similar for this group and for those who did not report to restrict their food selection as a result of dental state. The elderly who had general chewing problems did not differ significantly from the general population in any aspect of

dietary intake and nutritional status. However, due to the small number of observations in the subsample (n=108) some biochemical measurements in blood could not be studied. Although we did not study the impact of experienced chewing problems on the use of food products, and confounders, such as socioeconomic factors, were not taken into account our results indicate that reported chewing problems are not likely to affect the quantity and quality of the diet; nor were nutritional status indicators affected. Therefore, this frequently reported risk factor is not an important determinant of dietary intake and nutritional status indicators among Dutch apparently healthy elderly subjects.

11.7. Gender

As a group men had a higher intake of energy and most nutrients. An exception was ascorbic acid of which the intake tended to be higher among women. Women had a healthier food choice as indicated by the higher nutrient density of their diet. The women consumed slightly more vegetables, fruit and fruit juice and skimmed milk products, but less sugar, alcoholic beverages, coffee, soft drinks, fats, whole milk and fatty meat products than men. Nevertheless a higher prevalence of obesity, hypertension and hypercholesterolemia among women than among men was observed.

11.8. Age

Elderly at older age were more at risk of a marginal 25-hydroxyvitamin D status. The mean volume of 24-h urine and the mean urinary excretion of calcium, magnesium, potassium and iodine were lower at higher age. The lowest mean daily water intake (1870 mL) among the women aged 75-79 y still was within the range considered to be adequate. Since the excretion of potassium (men) and calcium (women) was found to be associated with blood pressure when expressed per mmol creatinine the older age groups may run a higher risk of an inadequate supply or status of these minerals. Body build and body composition, as indicated by body height, body weight and urinary excretion of creatinine and 3-methylhistidine, varied among the age groups. However, relevant effects of age on dietary intake were not observed. Only intake of water, thiamin (absolute and per MJ) and pyridoxine (per MJ) were slightly lower in the oldest age group due to a lower consumption of non-alcoholic beverages and meat products. Only few relevant associations with age were found for the indicators of the nutritional status studied. Since the elderly aged 65 and over

span more than 30 y, and we studied age differences within a range of only 15 y in the national survey, caution is called for conclusions on absence of differences among elderly age groups. Moreover, we only measured static (blood pressure, anthropometric and biochemical) indicators under resting steady-state conditions, when no extrinsic stress factors were or had recently been active. Due to the age-related increase in homeostatic failure, more functionally based assays (such as the glucose tolerance test) measuring dynamic responses of the functional reserve to a specific extrinsic stressor are probably of greater importance in studies oriented at nutrition and aging (28).

11.9. Region and urbanization

Dietary intake and nutritional status indicators hardly varied among the regions (north, east, south and west) and among degrees of urbanization (< 20,000, 20,000-400,000 and > 400,000 inhabitants). In the south, consumption of meat and meat products was somewhat higher, whereas a higher consumption of milk and milk products was found in the north. These differences were reflected by the intake of calcium, heme iron and riboflavin as well as the calcium/phosphorus ratio of the diet. No significant differences were found among the regions with respect to the nutritional status indicators. Only the mean wrist diameter and the mean hydroxyproline excretion in the 24-h urine were higher among those living in places with less than 20.000 inhabitants. Therefore, it was concluded that the dietary intake and nutritional status among independently living, apparently healthy elderly are similar all over the Netherlands (13).

11.10. Housing

Of the independently living elderly subjects about 10% were living in old people's service "flats" (living independently and normally preparing their own meals). These elderly were on the average 3 y older and had consistently (whether or not after exclusion of those on a diet) a higher mean systolic blood pressure (especially the men) than those living in a regular house or flat. Although the percentage of energy derived from polyunsaturated fatty acids and total fat, and the P/S ratio of the diet tended to be higher among the elderly (men only after exclusion of those on a diet) in old people's service flats, these differences were not consistently found. However, it should be noted that after exclusion of the elderly on a diet, dietary intake data of just 17

men and 16 women in old people's service flats were available, whereas the analysis of variance regarding differences in nutritional status indicators were even based on a smaller number of observations. Despite these shortcomings the results indicate that the nutritional risks observed in the general population are also present among those living in old people's service flats. Meulmeester et al (29) has found mean values among institutionalized elderly to be generally similar to those living independently. Exceptions were a lower mean systolic blood pressure and a higher mean hemoglobin value among independently living elderly. These observations are in line with the conclusion of Sahyoun et al (30) that there is no evidence that institutionalization per se leads to impairment of nutritional status. Absence of substantial differences in dietary intake and nutritional status indicators are likely to be largely due to the selection of apparently healthy elderly only.

11.11. Household size

Solitary elderly people (especially men) had a lower P/S ratio in their diet due to higher (saturated) fat intake than non-solitary elderly people. The plasma concentration of total carotenoids was significantly lower in solitary men and women than in non-solitary men and women. Elderly women living alone had a higher calcium/phosphorus ratio, a lower consumption of meat and meat products and a lower HDL-cholesterol concentration in serum than non-solitary elderly women. Moreover, potatoes, vegetables and meat were more frequently prepared for more than one day at a time by the elderly living alone. The observed differences were probably mainly the result of meal pattern and food preparation practices which were most likely contributing factors to the higher (saturated) fat intake and lower plasma total carotenoid concentration among solitary people. Nevertheless these differences, it is concluded that dietary intake and nutritional status of apparently healthy elderly living alone and those living with others is fairly comparable (15).

11.12. Socioeconomic factors

Elderly people with a higher level of education (more than 8 y) were on the average taller. Mean body mass index, wrist diameter and 24-h creatinine excretion (crude indicator of muscle mass) were higher among the elderly with a lower level of education. As shown in **Table 11.6.**, no significant effect of education on energy

Table 11.6.
Some characteristics (mean) of the dietary intake of elderly people according to gender and level of education (low and high)

Dietary variable	Men low n=181	Men high n=86	Women low n=206	Women high n=62	Pooled SD	F-test (education)
Energy (MJ/day)	10.1	10.3	7.8	8.1	2.2	ns
Intake in % of energy						
Protein	13.8	13.6	15.1	15.1	2.5	ns
Fat	41.0	39.2	40.0	38.4	6.0	p<0.01
Carbohydrate	41.6	41.7	43.1	43.6	6.7	ns
Alcohol	3.5	5.4	1.7	2.9	4.1	p<0.01
Iron (mg/day)	12.9	13.7	11.2	11.9	3.0	p<0.01
Riboflavin (mg/day)	1.68	1.77	1.48	1.60	0.46	p<0.05
Ascorbic acid (mg/day)	88	107	100	106	43	p<0.01
Water (g/day)	2115	2221	1942	2113	488	p<0.01

Source: Löwik et al (14).

intake was found. Elderly subjects with a lower educational level consumed less fresh fruit, vegetables and tea, but more potatoes and visible fats. Primarily due to these differences it was found that the elderly with a lower level of education had on the average a lower intake of (nonheme) iron, riboflavin, ascorbic acid and water, whereas the energy derived from (monounsaturated) fatty acids was higher and from alcohol was lower than among the elderly with a higher educational level. Vitamin supplements were used more frequently by elderly with a higher educational level. Comparable differences in dietary intake and nutritional status were found when the socioeconomic status (classification based on education, and [former] occupation and position) was considered instead of education. In **Table 11.7.** data on vitamin status are presented classified according to gender and socioeconomic status. Except for total carotenoids, no significant differences in indicators of the vitamin status were found between the elderly with a higher and those with a lower socioeconomic background.

About 10% of the elderly had received a supplementary social benefit. The results of an analysis of variance indicate a lower intake of ascorbic acid, dietary fiber and (nonheme) iron, and

Table 11.7.
Vitamin status indicators (mean) of the elderly not using supplements according to gender and socioeconomic status (SES)

Indicator	Men#		Women#		Pooled SD	F-test (SES)
	low SES	high SES	low SES	high SES		
Retinol (µmol/L)	1.4	1.5	1.4	1.3	0.4	ns
Total carotenoids (µmol/L)+	1.3	1.9	1.5	2.1	0.8	<0.01
EGR-AC (ratio)	1.12	1.13	1.09	1.10	0.11	ns
EAST-AC (ratio)	1.71	1.69	1.75	1.74	0.21	ns
PLP* (nmol/L)+	24	24	35	31	15	ns
Vitamin B-12 (pmol/L)	297	271	267	268	140	ns
Folate (nmol/L)+	6.6	6.6	7.2	7.4	2.6	ns
25-OH-vitamin D (nmol/L)+	36	44	37	39	18	ns

Number of excluded subjects depends on the supplement used;
+ Maximum number of subjects is 108; * pyridoxal 5'-phosphate.
Source: Löwik et al (14).

higher body fatness among the elderly entitled to a supplementary benefit than among those with a higher income. However, these results are distorted somewhat by the higher prevalence of a dietary regimen as a result of a poorer health status among the elderly with a supplementary benefit.

In summary, a lower educational level, a lower socioeconomic status, singleness and entitlement to a supplementary social benefit were associated with a higher probability of having a less adequate dietary intake. However, no unacceptable direct health risks were observed at a group level (14).

11.13. High risk or mass strategy

The factors studied, especially gender, physical activity, and the socioeconomic factors, were found to influence dietary intake and nutritional status of apparently healthy elderly people. The results did not indicate that these factors on their own are likely to introduce (severe) nutritional risks. However, several factors may be expected to be interrelated and clusters of unfavorable factors have a greater (not necessarily cumulative) impact than any single factor by itself. For instance, our results

indicate an aggravating effect of entitlement to a supplementary social benefit with regard to some unfavorable aspects of the dietary pattern that are also related to a low socioeconomic status (14). Moreover, in the United Kingdom, singleness, irregular use of cooked meals, entitlement to a supplementary social benefit, lower social class, several health status indicators, housebound, smoking and alcoholism have been found to be risk factors for malnutrition. Elderly subjects for whom four or more risk factors applied are considered to be at high risk of malnutrition (31). The diagnosis of malnutrition was made in 3% of the elderly surveyed in the United Kingdom. In the majority of cases an underlying medical condition is responsible, and social and economic factors are rarely the primary cause (31). Although high risk groups might be identified when several factors are combined, the prevalence of these clusters, and hence their relevance to nutrition policy that is oriented at prevention, are likely to be low. The main reason, however, that no combinations were studied is the number of subjects that was to small to do this properly.

Most differences among the subgroups were relatively small, and at a group level no unacceptable direct health risks were prevalent in any of the subgroups studied. On the average, all subgroups had an intake of vitamins (except for vitamin B-6) and minerals in accordance with the Dutch Recommended Daily Allowances. These results do not provide a strong basis for special services or preventive programmes targeted at special groups among independently living, apparently healthy elderly people. Moreover, population-based recommendations for lifestyle changes generally are more effective than measures targeted at high-risk individuals when only slight above-average risks are present in the general population (32-35). However, there is some dissent from this view (36). According to Kottke et al (32) the creation of a social consensus on desired behavior for the whole population might be the most appropriate strategy if risks are widely dispersed throughout the population. Especially since interventions aimed at a particular subgroup requires unequivocal identification (for instance by screening) of the high-risk individuals, acceptance of a change of behavior (that can diverge from the general population) and acceptance of stigmatization, whereas those not belonging to the target population may incorrectly conclude that they are not exposed to a particular risk. Furthermore, Salonen et al (37) showed that people observed to be at high risk of coronary heart disease are probably no more likely to change their risk-enhancing behavior than those at more moderate risk. Therefore, it is concluded that dietary guidelines for apparently healthy elderly people should be oriented towards

elderly people in general. Although associations of diet with blood pressure as well as with serum cholesterol differed somewhat between men and women, these observations should be confirmed by other studies before gender-specific recommendations should be considered.

11.14. Conclusions

Dietary intake and nutritional status varied somewhat among subgroups of the apparently healthy elderly population. The elderly at more advanced age, with a low level of physical activity and with a poorer health status had on the average lower levels of plasma 25-hydroxyvitamin D. Gender, health status and physical activity were important determinants for quantitative aspects of dietary intake, whereas socioeconomic factors were more important for the quality of the diet. A less prudent diet was found among the elderly with a low level of education, those living alone, those with a high energy intake and those with a low level of physical activity. The intake or status of water, minerals, vitamins and dietary fiber differs somewhat for the genders, age groups, educational level, socioeconomic categories, household size, income, energy intake and physical activity. All subgroups studied had a mean intake of vitamins (except vitamin B-6) and minerals in accordance with the Dutch Recommended Dietary Allowances, and no unacceptable direct health risks were prevalent among the subgroups studied. Dietary intake and nutritional status of the independently living elderly hardly varied among regions and degrees of urbanization. Chewing problems did not significantly affect the dietary intake and nutritional status indicators. Generalization of frequently reported risk factors for a marginal diet and nutritional status among elderly people may not always be valid for Dutch apparently healthy elderly subjects aged 65-79 y. Since population-based recommendations for lifestyle changes are considered to be more effective than measures targeted at high-risk individuals when only slightly above-average risks are present and since the differences in nutritional status among the subgroups were relatively small, it is concluded that dietary guidelines for specific groups among apparently healthy elderly are probably not a necessity.

11.15. References

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12. GENERAL DISCUSSION

12.1. Study design

In the national nutrition survey among independently living elderly people a stratified, two-stage (first: selection of places; second: selection of subjects) cluster sampling technique was chosen to reduce the costs of the field work. The sample was stratified according to region and degree of urbanization in order to investigate whether dietary intake and nutritional status of the independently living, apparently healthy elderly aged 65-79 y varied among various parts of The Netherlands.

As a result of the stratification the data presented are not representative for 65-79-y old independently living, apparently healthy Dutch elderly. Although weighting the sample would have resulted in such a sample, it was decided not to do so since unweighted data can be used and interpreted more straightforwardly. Except for results which were similar for men and women, the data are presented separately for the genders. Dietary intake was found hardly to be influenced by age, whereas relatively few indicators of the nutritional status were observed to vary among the age groups. Moreover, as indicated in Chapter 11, effects of region and degree of urbanization were small if present at all. Therefore, the data presented can reasonably be assumed to be representative of the total population. However, the relatively high nonresponse rate of 47% may have introduced some bias. Responders did not differ from nonresponders with respect to civil state and housing situation, whereas the civil state (age- and gender-specific) and the proportion of responders with a supplementary social benefit corresponded to data of the Dutch Central Bureau for Statistics (1). However, it cannot be excluded that the nonresponse have had an impact on the results regarding dietary intake and nutritional status.

It is obvious that the vegetarians investigated represent a selected population. Nonetheless, this population is used for comparison purposes and for obtaining contrasting data on elderly people with a more prudent diet. These data provide suggestive evidence on the adequacy of guidelines for a healthy diet formulated for the overall Dutch population. The insight in the dietary intake (2) and cardiovascular risk factors among the vegetarians provides information on whether the findings are in accord with present concepts on the role of diet in the etiology of cardiovascular diseases.

12.2. Methodology

12.2.1. General

A cross-sectional study may introduce a systematic error in the estimation of the prevalence of low or high values and thereby in the outcome of the nutritional assessment. For instance, our data on blood pressure are based on single-encounter measurements and blood pressure tends to regress to the mean when measured serially in multiple visits (3), so that the prevalence of hypertension found has probably been slightly overestimated. In general, 25-hydroxyvitamin D varies seasonally in northern European countries, the lowest values occurring in the winter (4,5). Since our nationwide survey has been carried out from October 1, 1984 until February 8, 1985 the prevalence of low 25-hydroxyvitamin D concentrations will be overestimated somewhat, especially since the reference population of blood donors was selected throughout the year. On the other hand, for quite different reasons (socially acceptable answers), the use of alcoholic beverages has, most likely been underreported somewhat. This may have weakened the observed associations of alcohol with EAST-AC, total EAST activity, total serum cholesterol and serum HDL-cholesterol. Furthermore, it may be expected that alcoholics are less likely to participate in a nutritional survey. A recently published national survey in the Netherlands using two-day dietary records reported similar mean levels of alcohol (ethanol) intake among elderly men (16 g/day) and women (6 g/day) (6). Although underreporting to some extent may be present, the rank order of the subjects may not have been disturbed. Consequently the associations of EAST-AC, serum (HDL-) cholesterol and serum uric acid with alcohol as found are likely to be valid.

One of the characteristics of a cross-sectional study is that usually only low-order correlations are found, which is - among other things - due to intra-individual variation and inaccurate assessment of the dietary intake and nutritional status indicators. These inaccuracies are expected to weaken rather than produce associations (7-9). In a cross-sectional design not only the magnitude of a particular dietary factor is meaningful, but also the observation that the factor is positively or inversely associated with a relevant outcome variable. However, the existence of unknown confounders that may actually be responsible for associations between variables can cause invalid associations. This holds true especially for dietary factors, since any diet consists of a complex set of interrelated nutrients (10).

In this context the dietary determinants of the activation coefficient of aspartate aminotransferase in the erythrocytes (EAST-AC) may be given as an example. Dietary fiber was found to be inversely associated with EAST-AC in the bivariate analysis but positively (although not significantly) in multivariate analysis. Alcohol, which was inversely correlated with EAST-AC, was not included in this multivariate model. Since alcohol intake was independent of intake of protein, dietary fiber and vitamin B-6 (assuming an accurate assessment of vitamin B-6 intake), the observations among the elderly studied (presented in Chapters 8 and 9) are most likely unaffected. To test this assumption, we excluded elderly using alcoholic beverages from the analyses. The results (regression coefficients) for the elderly not using alcohol were as before, whereas some associations and some differences between subgroups were no longer significant due to the smaller number of observations. Moreover, as shown in Chapter 10 (Table 10.4.), the intake of vitamin B-6 (absolute and per gram of protein) was still inversely associated with EAST-AC after adjustment for intake of alcohol.

In contrast to the problem of confounding, inclusion of several interrelated dietary variables into a regression analysis gives rise to "multicollinearity" and may impede the identification of the contribution of each factor separately; the estimated coefficients will also be affected (11). On the other hand, bivariate analysis might come up with associations or differences between groups that are not real, i.e., they are actually due to one or more confounding factors. In order to take both considerations into account effects were studied both bivariately, and multivariately (controlling for confounders that have frequently been reported to potentially affect the particular dependent variable). Another strategy to deal with confounding, which was often used in this study, is the exclusion of relatively small groups of people with a characteristic or condition known to have an impact on the variables studied.

12.2.2. Dietary history

The dietary history with cross-check (12,13) was chosen as the dietary survey method to obtain an insight in the habitual food consumption pattern of elderly people. The dietary history has the drawback of being liable to errors of memory and to errors in the perception of the total diet (14), but has the advantage not to rely on written instructions which may be difficult to read or interpret for elderly people. It was assumed that elderly people have a more constant food consumption pattern than younger people.

The elderly who were unable to participate in the entire study protocol were not eligible. For a detailed discussion on the methodology for food consumption studies, their pitfalls and limitations, see Cameron and Van Staveren (15).

The choice of dietary methodology has its consequences for the analysis and interpretation of the results, especially since nutritional status indicators may refer to different periods of time. For instance, blood pressure might be the dynamic reflection of day-to-day mineral status (16). We studied, however, the association between dietary variables and blood pressure on a more long-term basis, because elderly people on a prescribed diet were excluded from the analyses and dietary intake was assessed through dietary histories with cross-check. Ethanol and coffee exert an acute pressor effect, thus making the design of our study less appropriate for studying the effects of these dietary components on blood pressure.

12.2.3. Body mass index

Body mass index (body weight divided by height squared) was used as a measure of fatness of the body. In several studies (predominantly cross-sectional ones) a significant lower body weight and less lean body mass but a significant higher percentage body fat at higher ages has been found (17-20). Since validity of the body mass index as an indirect measure of body fatness has been studied almost exclusively among younger healthy adults extrapolation to the elderly may be incorrect. Among the independently living elderly we found lower correlation coefficients between body mass index and body fatness (assessed through biceps and triceps skinfolds) than reported for younger adults (21). Due to differences in body composition, its pattern of distribution and interindividual variation a particular value for body mass index may represent a different degree of body fatness among the elderly than among younger adults (22-24). Although body mass index as a measure of body fatness may be less adequate at old age than for younger adults, no appropriate alternative weight-height index is available for large-scale surveys. Among the elderly subjects in our nationwide sample we found positive associations between body mass index on the one hand and blood pressure (men), serum total cholesterol (men), and serum uric acid (25) on the other hand. However, it is not clear what ideal weight and body fatness is for an elderly person, since the percentage of body fat at old age (assuming a correct assessment) may not reflect a similar risk of disease or death as in younger adults (26).

12.2.4. 24-h urine

Several indicators of the nutritional status were measured in a 24-h urine sample. These values may have been distorted by incorrect collection. In order to check for an accurate 24-h collection, the correlations of urinary output and water intake with density of the urine were calculated (**Table 12.1.**). The

Table 12.1.
Correlation coefficients of urine density with water intake and volume of the urine#

	Urine density	
	men (n=262)	women (n=258)
Water intake		
g/day	-0.26	-0.40
g/day per kg body weight	-0.27	-0.41
Volume urine		
mL/24-h	-0.63	-0.64
mL/24-h per kg body weight	-0.65	-0.66

All correlation coefficients are statistically significant at $p < 0.01$.

results show a strong inverse association between urine density and urine volume among elderly men and women. Major determinants of the lower correlation coefficients between habitual water intake and density of the urine are most likely the differences between short-term (24-h urine) and longer-term assessments (water intake) and extra-renal water loss. Both may vary substantially among individuals. The mean 24-h excretion of creatinine among the Dutch elderly men corresponds with the results of Rowe et al (27) who studied healthy (free of disease and not using drugs that may affect glomerular filtration rate) elderly men. The observation that mean creatinine excretion per kg body weight is higher in our study among independently living elderly than among elderly populations studied by others (28-30) does not point to serious incompleteness of the 24-h urines either. Our analyses at a group level have most probably counteracted the potential distortion of results due to inaccurate collection; differences between groups being less affected by incompleteness of 24-h urine collection

when the individuals with inaccurate collections are evenly distributed over the various groups. Moreover, in our study into the association of blood pressure with nutrition-related variables we also included in the analyses relevant urinary excretion ratios. Ratios, being more qualitative indicators, are much less affected by incomplete collection or by overcollection, especially if excretions are constant throughout the day. In conclusion, inaccurate urine collection may have distorted the assessment of the 24-h excretion figures, but there are no indications that they have affected the results substantially and systematically.

12.3. Prospective and intervention studies

12.3.1. General

The scientific basis for dietary guidelines for the elderly that will promote health and reduce the risk of morbidity, dependence and mortality in the years to come is still insufficient. In this thesis data are presented to provide a more scientific rationale for dietary guidelines. The study was, however, confined to the associations of dietary factors with nutritional status indicators, function- and risk-oriented indices in a cross-sectional design.

Probably the most important limitation of our approach is that epidemiological studies can only contribute to discussions about causation, which holds true especially for cross-sectional studies due to measurements at one moment only (31). Therefore, cause-effect relationships can only be suggested on the basis of reasonable assumptions. Ideally, causal inferences obtained from epidemiologic studies must be based on:

- strength of the association,
- specificity of the association,
- existence of dose-response relationships,
- consistency of the association and
- biological credibility (32).

In general, we found low-order correlations only which can partly be attributed to the cross-sectional design of the surveys. The specificity of particular associations was tested by using both bivariate and multivariate analyses. Since regression analysis was used primarily it was implicitly tested whether there was a (linear) dose-response relationship. The consistency of particular associations (comparison with results found in other studies) and their biological credibility (making sense in the light of current biological knowledge) were judged on the basis of

the literature. A rationale for guidelines for the elderly should also be based on the linkage of dietary factors with morbidity and mortality as well as the proof that function- and risk-oriented indicators can still be modified in a more favorable direction. Prospective studies and intervention trials can provide evidence for such a causal inference. It is beyond the scope of this thesis to discuss the results of all findings available. Therefore, global statements will be made mainly with respect to prospective and intervention studies that have investigated the major nutritional risks (vitamin B-6, vitamin D and cardiovascular risk factors) found in The Netherlands.

12.3.2. Mortality

A wide variation in predictors of mortality, such as serum albumin, serum total cholesterol, blood pressure, degree of kyphosis, drug usage, health status, smoking, hematocrit, hemoglobin, dietary intake variables, and socioeconomic and demographic factors, has been reported for elderly populations (33-51). Due to, among other things, differences in populations and variables studied it is not yet possible to identify the most important predictors of mortality among elderly people. Furthermore, interdependencies may hinder the identification of causal inferences actually responsible for a particular association (52). For studies on the prognostic value for mortality of dietary factors confounding by (subclinical) diseases may be of special importance since dietary intake and nutritional status may be affected by these diseases, whereas a marginal diet may also contribute to premature death. In prospective studies among the elderly a low intake of ascorbic acid, iron, protein and thiamin, a low body weight and low ascorbic acid levels in plasma and leucocytes among men, and low body weight, serum pyridoxal 5'-phosphate and ascorbic acid levels in leucocytes and plasma among women have been found to be associated with an increased mortality (49-51). The elderly's health status also had a predictive ability towards mortality.

12.3.3. Vitamin B-6

A marginal vitamin B-6 status may contribute to mental disorders, impaired immune function and cardiovascular disease (53-57). Although the vitamin B-6 status can be improved by a higher intake of vitamin B-6 (58-60), no study among elderly people I know of has found that improvement of the vitamin status actually has an

impact on dependence, morbidity or mortality. Goodwin et al (61) studied among elderly people the association of vitamin intake and status with cognitive functions. They did find some correlations, but not between vitamin B-6 and cognitive function. Although the hypothesis that an insufficient supply of different vitamins adversely affects various psychological and behavioral functions has been strongly supported in a pilot (intervention) study of Chomé et al (62), vitamin B-6 was not among the vitamins being of special importance. One study has reported that their (unpublished) data suggested an improvement in several psychological tests among elderly people supplemented for one year with vitamins (including vitamin B-6) but not in the control group. However, the scores of the psychological tests were not correlated with the indicators of the vitamin B-6 status (59). As indicated in Chapter 10 the association of vitamin B-6 with cardiovascular diseases may be confounded by the use of alcoholic beverages. Nutritional deficiencies are associated with impaired immune response (63,64). Humoral and cell-mediated immunity are affected by vitamin B-6 deficiency states (64). Vitamin B-6 supplementation (50 mg/day) for 2 months of elderly subjects increased immunocompetence, especially among those with lowest initial plasma pyridoxal 5'-phosphate levels (65).

In conclusion, the relevance to health among elderly people of differences within the "normal" range of vitamin B-6 intake and of EAST-AC values, as a functional assay of the vitamin B-6 status, has still to be demonstrated.

12.3.4. Vitamin D

In general, 25-hydroxyvitamin D levels decrease with age and vary seasonally in northern European countries, lowest values occurring in the winter (4,5,66,67). When Danish elderly were using vitamin D supplements a seasonal variation was not found (4), whereas Lawson et al (66) observed among elderly people in England a positive association between intake of vitamin D and plasma 25-hydroxyvitamin D levels in the winter. In The Netherlands a positive correlation between vitamin D intake and serum 25-hydroxyvitamin D levels has been observed in patients with low sunshine exposure (68). Bouillon et al (5) have shown that oral 25-hydroxyvitamin D treatment rapidly normalizes serum concentrations of 1,25-dihydroxyvitamin D, as the most important regulator of intestinal calcium absorption, in vitamin D-deficient elderly subjects. Therefore, vitamin D derived from the diet or from supplements may restore low 25-hydroxyvitamin D levels in elderly people. Prolonged vitamin D deficiency causes

osteomalacia, which can be accompanied by bone pain and muscle weakness (69).

12.3.5. Cardiovascular risk profile

According to Kannel (70) established major cardiovascular risk factors, such as hypertension, hyperlipidemia, physical inactivity and cigarette smoking, also apply to the elderly albeit with less impact than in younger adults. On the other hand, low blood pressure as well as relatively low total cholesterol levels (37,39,47) have been reported to act as prognostic indicators for morbidity and mortality, the association may be J- or U-shaped rather than linear. Therefore, both ends of the curve merit separate consideration. Subclinical disease(s) predisposing to death may be responsible for an increased mortality rate on one side of the curve. Prevalence of coronary heart diseases may be a more important predictor of mortality than cardiovascular risk factors among elderly people (45,48).

Assuming that hypercholesterolemia and hypertension are important risk factors among elderly people the next step should be a proof that elderly people may actually benefit from improvement of these factors.

The Veterans Administration Cooperative Study has provided evidence that in men aged 60-69 y with moderate to severe hypertension, treatment could significantly lower morbidity and mortality (71). Other recent, large-scale randomized clinical trials among elderly people have demonstrated a beneficial impact of antihypertensive therapy (drugs) on cardiac and cardiovascular morbidity and mortality as well (72-75). Information on the effect of changes in dietary factors on morbidity and mortality associated with blood pressure at old age are not yet available. Sodium restriction needs special attention since this is the most frequently reported characteristic of those on a diet. To be effective in reducing blood pressure, the diet must contain less than 1 gram of sodium (= 2.5 gram salt), a level at which the diet is commonly found less palatable (26). Although blood pressure response to sodium restriction in older hypertensive patients has been reported to be greater (76) it is questionable whether elderly people actually benefit from sodium restriction. On the average, the elderly on a sodium-restricted diet studied in our nationwide survey still had a sodium excretion higher than the equivalent of 5 gram salt per day, which is indicated for a diet with a light sodium restriction. This observation may challenge the need and significance of sodium restriction among the elderly. Moreover, although a more prudent food pattern and a diet of a

higher nutrient density has been observed among the elderly on a diet than among those not on a diet the differences found were relatively small. This observation and the finding that about 26% of the elderly men and 33% of the elderly women studied in the nationwide survey were on a diet lead to the conclusion that an evaluation of its compliance and its effect should be one of the concerns for future investigations. Especially, because a positive association was found between the urinary sodium-potassium ratio and blood pressure among elderly men.

According to Kashyap (77) it may be possible to reverse cholesterol accumulation at old age, whereas advanced fibrotic or calcified lesions in elderly persons may not be amenable to treatment. A significantly lower serum total cholesterol level was found among postmenopausal women after an intervention study of 3 months when fat intake was reduced from a baseline value of nearly 35% of energy to 21% (78).

Although hypertension and hypercholesterolemia may still predict risk of cardiovascular disease at higher age and these factors may still be influenced among the elderly by dietary changes, direct evidence that dietary changes can reduce the risk of cardiovascular diseases in the elderly is still lacking (70).

12.3.6. Conclusions

In summary, the studies cited indicate that a potential gain can be accrued by dietary changes at old age, but that more research is needed before dietary guidelines can be implemented that imply dramatic changes in their habitual food consumption pattern and that deviate substantially from the Dutch dietary guidelines for a healthy diet. The potential advantage of dietary change at old age is still open to doubt, since hardly any intervention studies have proved the benefits of particular modifications. Since certain diseases and disorders affecting the elderly, such as diabetes, osteoporosis and periodontal disease, are associated with food consumption pattern at younger age, dramatic modifications of pathological processes by changing dietary patterns at a later stage of life only cannot be expected (79). Moreover, nutrition is not the sole means of prevention and treatment of disease(s); the development of the major chronic disease conditions is affected by multiple factors. For the time being, severe restrictions and modifications in the habitual diet of the elderly should therefore be imposed only on individuals who are really afflicted by or are shown to be at great risk of nutritional problems.

12.4. Nutritional assessment

12.4.1. General

The main purpose of the surveys presented in this thesis was assessment of the nutritional risks among apparently healthy elderly in The Netherlands. Assessment includes a normative evaluation of dietary intake and nutritional status indicators. For food consumption data recommended dietary allowances (RDA) and for nutritional status indicators reference values obtained from younger adults are mostly used for this purpose.

Although the indicators of the nutritional status are potentially more valid and more precise than dietary assessment methods (80), they are harder to evaluate since the function-oriented and health consequences of all but the extreme levels of almost all indicators are still unknown. Clearly, interpretation depends on knowledge of the normal range of values that is appropriate to elderly men and women. To partly surmount the lack of standards for elderly people the indicators of the nutritional status of the elderly were compared with those of apparently healthy younger adults. Age dependence of the nutritional status indicators was studied in both surveys. From the comparison between vegetarian, who had long had a divergent consumption pattern, and omnivorous elderly some insight was obtained into the question whether the values at old age are due to aging per se. Such an insight may be used in scientifically sound statements about the nutritional risks that can be prevented or modified. For instance, low values of folate and total carotenoids in plasma were frequently observed among the omnivorous elderly people but absent among the vegetarian elderly (81). This observation suggest that low values of these nutrients at old age are most likely due to dietary factors.

RDAs are a set of dietary reference standards considered to correspond with an adequate intake of essential nutrients (82). Although RDAs are given for different age-sex categories, there is still a serious lack of information on the impact of aging processes on nutrient requirement. The current RDAs are mostly based on extrapolations from a limited body of information obtained from younger adults. Study of associations between different levels of intake and the adequacy of some specific biological function of direct relevance to health will contribute substantially to a more solid scientific underpinning of RDAs and guidelines (83). The results presented in Chapters 6-10 should be seen in this perspective. The observed associations of vitamin B-6, protein (especially of animal origin) and alcohol, but not

dietary fiber with EAST-AC among Dutch elderly people might be a step towards more function-oriented statements about the nutrient requirements of elderly people compatible with current-day lifestyles familiar in The Netherlands.

The investigation into the nutrition-related correlates of blood pressure and serum cholesterol is also in line with the testing of the general question whether there is a need for elderly-specific nutritional guidelines. Although the analyses were restricted to factors that have frequently been reported to be associated with blood pressure or serum cholesterol levels, one or more associations may have occurred by chance. However, only variables that were found to be consistently associated with these cardiovascular risk factors are considered as being relevant.

In accordance with other studies (84-87) serum uric acid levels were found to be positively associated with alcohol intake (men), consumption of meat and fish (women) and body mass index (25). The results of large-scale prospective studies are inconsistent for men with regard to the relationship between serum uric acid and mortality from all causes, from cardiovascular diseases and from cancer, but for women the data tend to indicate a consistent higher mortality due to hyperuricemia (88-91). Levine et al (88) have found that baseline serum uric acid levels were strongly and significantly associated with all causes mortality, especially for women in the oldest age group studied (55-64 y).

12.4.2. Water

To assess the adequacy of water supply the association of water intake and volume of urine with hematocrit were studied. From the results it appeared that among men, but not among women, the volume of the 24-h urine was significantly correlated ($r = -0.15$; $p = 0.02$) with hematocrit when expressed per kg body weight. However, in multivariate regression analysis with hematocrit as dependent variable and body weight and volume of the urine as independent variables, body weight (regression coefficient = 0.078; $p < 0.01$), but not the volume (in L) of the 24-h urine (regression coefficient = -0.292; $p = 0.55$), was associated with hematocrit among the men. If water intake (in L) was included instead of volume of urine a higher but still non-significant regression coefficient was observed among the elderly men (regression coefficient = -0.850; $p = 0.09$). Adjustment for age resulted in slightly higher regression coefficients and lower p values. Among the vegetarian elderly men and women hematocrit was not associated with water intake and 24-h urine volume when adjusted for body weight or adjusted for body weight and age,

whereas body weight was positively correlated with hematocrit. Therefore, caution is required when drawing conclusions from the association between hematocrit and water intake and urinary output (volume) when expressed per kg body weight with respect to the adequacy of water supply. Absence of an association between water supply and hematocrit should not be interpreted as proof for an adequate water intake since hematocrit is a non-specific indicator of the water status which will only be influenced in case of severe dehydration (92).

12.4.3. Vitamins

For an assessment of the risks introduced by low plasma concentrations of vitamin B-12 and folate the correlations of these vitamins with the mean corpuscular volume (MCV) of the erythrocytes were calculated. Neither among the vegetarian nor among the omnivorous elderly people a significant correlation between folate and MCV was found. Among the 54 omnivorous men MCV tended to be lower at higher folate levels ($r = -0.20$; $p = 0.14$). Only 2% (men) and 1% (women) of the omnivorous elderly subjects had a MCV value higher than 100 fL indicating that the folate and the vitamin B-12 status were probably adequate for almost all these elderly. Among the vegetarian women an inverse correlation was observed between vitamin B-12 concentration and MCV ($r = -0.50$; $p = 0.03$) which points to functional consequences of the observed low vitamin B-12 concentration. A similar albeit non-significant tendency was found among vegetarian men ($r = -0.29$; $p = 0.29$), but the association was clearly absent among the omnivorous elderly people. Although among omnivorous elderly the level of all-trans-retinol tended to be positively correlated with higher carotenoid levels (men: $r = 0.22$; women $r = 0.12$) and vitamin A intake (men: $r = 0.02$; women: $r = 0.15$) these correlations were not significant. However, it should be noted that these correlations among omnivorous elderly were based on a subsample of 108 subjects, whereas among vegetarians the number of observations was even lower. If the correlations are similar for the total sample most of the presented correlation coefficients would be significant. Therefore, caution is required when conclusions are drawn as to the absence of statistical associations based on a relatively small number of observations. However, only 4% of the omnivorous elderly and none of the vegetarian elderly had an all-trans retinol concentration below the 2.5 percentile (P 2.5) of younger adults suggesting that most of the elderly people studied were not at (high) risk of an inadequate vitamin A supply. Among the vegetarian elderly low

values (< P 2.5 of younger adults) of folate and total carotenoids were not observed which indicates that the low values found among omnivorous elderly people are most likely due to lifestyle (dietary) factors. The association between dietary factors and vitamin B-6 status indicators is comprehensively studied in the Chapters 8-10.

12.4.4. Conclusion

In conclusion, it can be stated that the main nutritional risks among apparently healthy elderly are the supply of vitamin B-6 and vitamin D and those dietary factors (such as fat intake and body mass index) associated with the cardiovascular risk indicators serum cholesterol and blood pressure. This identification of the nutritional risks prevalent in the general population should be used in the development of goals for an adequate dietary intake (in the sense of health impact) as well as for future studies among elderly people.

12.5. Dietary guidelines

According to Harper (82) dietary guidelines are proposed as part of health policy to provide guidance for maintenance and improvement of health. These integrated guidelines refer to a co-ordinated set of goals that most likely serve to prevent or modify the (chronic) disorders affecting this age group simultaneously. Our results suggest that as far as nutrition is concerned the greatest contribution to health of the elderly is in the minimization of the risk of chronic (degenerative) diseases provided the risk of specific deficiencies (especially vitamin B-6 and vitamin D) is allowed for. Dietary guidelines for the elderly should at least be consistent with respect to possible adverse effects in these aspects of the diet.

Elderly at older age, elderly with a limited exposure to sunlight, the elderly with a low level of physical activity and the elderly with a relatively poor health status were at higher probability of low 25-hydroxyvitamin D values; these factors are interrelated. Moreover, the institutionalized vegetarian elderly had lower 25-hydroxyvitamin D concentrations than those living independently. Higher 25-hydroxyvitamin D concentrations in plasma can easily be achieved by exposure of the skin to UV radiation. Adequate levels of the vitamin B-6 intake per gram of protein could reasonably be achieved by a different selection from the current food supply. Therefore, it is concluded that it is not

necessary to recommend the use of vitamin D and/or B-6 supplements by apparently healthy elderly people as a group. The vegetarian elderly had aged more successfully with respect to the cardiovascular risk factors obesity, hypercholesterolemia and hypertension, whereas their diet fairly well corresponded with the Dutch guidelines for a healthy diet (see **Table 12.2.**). To improve the food pattern of apparently healthy elderly in The Netherlands

Table 12.2.
Some characteristics of the dietary intake of 44 vegetarian elderly and the guidelines for a healthy diet

Characteristic	Guideline	Intake
Energy percentage		
Protein	10 - 15	13
Fat	30 - 35	37
Carbohydrates	55	50
Alcohol		0.03
Dietary fiber (g/MJ)	≥ 3	4.0
Cholesterol (mg/MJ)	≤ 33	28
P/S ratio	0.5 - 1.0	0.64

Source: Brants et al (2).

it is indicated to restrict the intake of fat and sodium, to increase the intake of polysaccharides and to maintain a normal body weight. The vitamin B-6 status, which is of special importance for the elderly, may be expected to be improved somewhat by compliance with these general guidelines. The intake of vitamin B-6 per gram protein was correlated ($r = 0.30$ for men and $r = 0.15$ for women) with the percentage of energy derived from polysaccharides. The correlations with the energy percentage of total fat were -0.11 and -0.05 respectively.

According to Hegsted (93) all dietary standards must ultimately be translated into food products keeping in mind the nature of the food supply and current dietary practices. Furthermore, most nutritional factors are interdependent with other (dietary) factors and many play a role in more than one disease. Our results stress the importance of looking dynamically at interrelationships among dietary components in combination with physiological processes rather than studying the impact of isolated nutrients.

For instance, the dietary interrelationship between dietary fiber and intake of protein and vitamin B-6 are most likely responsible for the inverse association between dietary fiber and EAST-AC in the bivariate regression analyses that became positive after adjustment for other relevant dietary factors. Furthermore, significant interactions were found between urinary excretion of sodium, urinary calcium:creatinine ratio, blood pressure and coffee consumption. Therefore, guidelines should also be evaluated within the context of the habitual dietary pattern and the potential health consequences associated with it. Recommendations regarding one nutrient that are inconsistent with those made for another when translated into food may be counterproductive and confusing (93). In **Tables 12.3.-12.6.** the contribution (%) of different groups of food products to the intake of energy and nutrients are presented. Fat is mainly obtained from oils & fats, meat & meat products, and milk & milk products. Bread, sugar, potatoes, fruit, bisquit & pastry, and milk & milk products, were the food groups contributing most to the carbohydrate intake. Eggs, meat & meat products, milk & milk products, and oils & fats provided most of the cholesterol. The amount of vitamin B-6 per gram of protein was relatively high in potatoes, bread, vegetables and fruit. In order to improve the vitamin B-6 status it was indicated to increase the use of these products. Fats might be "substituted" by carbohydrates (polysaccharides) as indicated by the results obtained from the association of dietary factors with serum cholesterol. For this purpose products of animal origin may be restricted and the use of vegetable products with a high polysaccharide content increased. However, our results obtained among lacto(-ovo)-vegetarian elderly people indicate that, although their dietary intake can be considered as being prudent with respect to the energy-providing nutrients, such a diet may result in an inadequate supply of some nutrients such as iron, zinc and vitamin B-12. Therefore, it should not be recommended to avoid animal products entirely, but on the contrary to select animal products with a relatively low fat and salt content. Especially since dietary habits of elderly people are the result of a life-long "tradition" and a dramatic change to a lacto(-ovo)-vegetarian diet would require careful planning and nutritional knowledge, which prerequisites are usually not fulfilled.

Elderly women might restrict their coffee consumption since our data suggest the possibility of an increased urinary calcium excretion due to coffee consumption and a positive association with blood pressure. Our results show that a high sodium intake may attribute to hypertension among elderly men and perhaps (as a result of the interaction with calcium excretion) among elderly women as well. Elderly people may benefit from moderate

Table 12.3.
Contribution (in %) of food groups to the intake of energy and nutrients among elderly men (n=269)

Food group	energy	protein	fat	choles-terol	carbohy-drates	dietary fiber	water	calcium	iron heme	iron nonheme
Oils and fats	15.7	-	38.9	15.0	-	-	0.4	-	-	-
Bread	14.1	14.1	3.4	0.8	26.3	30.2	2.7	3.0	-	26.3
Meat(products)	12.7	33.0	20.0	23.9	0.5	-	3.0	1.0	89.6	1.6
Milk(products)	10.3	16.5	10.0	9.8	9.7	0.9	14.4	42.9	-	1.2
Bisquit/pastry	7.0	2.9	6.3	6.6	9.8	3.6	0.4	1.6	-	7.2
Cheese	5.7	11.9	10.2	10.2	-	-	0.6	28.5	-	0.7
Sugar	5.3	-	-	-	12.8	-	-	-	-	-
Potatoes	5.2	4.3	-	-	10.6	19.7	6.3	1.3	-	8.7
Alc. beverages	4.8	-	-	-	1.3	-	4.0	-	-	1.6
Fruit	4.3	-	-	-	10.2	14.8	7.9	3.0	-	5.6
Sweet(spread)	3.1	0.5	1.4	-	5.8	1.2	0.2	1.0	-	4.3
Vegetables	2.1	3.9	-	-	3.6	17.1	7.2	5.6	-	13.0
Nuts/seeds#	1.3	1.4	2.5	-	-	1.3	-	-	-	1.0
Beverages	1.2	-	-	-	2.7	3.5	48.9	6.9	-	17.1
Eggs	1.1	3.2	1.7	27.3	-	-	0.7	1.0	-	2.3
Rice/paste	1.0	0.6	-	-	1.7	0.8	0.4	-	-	-
Fish	0.9	3.0	1.1	3.4	0.1	-	0.4	0.8	5.3	-
Pulses	0.5	1.1	-	-	0.8	3.0	0.3	-	-	2.5
Remainder	3.6	3.6	4.5	3.2	4.1	4.0	2.0	3.7	5.1	7.1

peanut butter included; -: contribution less than 0.5%

Table 12.4.
Contribution (in %) of food groups to the intake of energy and nutrients among elderly women (n=269)

Food group	energy	protein	fat	choles-terol	carbohy-drates	dietary fiber	water	calcium	iron heme	iron nonheme
Oils and fats	14.5	-	36.5	13.6	-	-	0.4	0.7	-	-
Bread	14.5	13.1	3.6	0.9	25.9	28.6	2.3	2.5	-	24.8
Meat(products)	12.8	33.1	18.9	24.2	0.5	-	2.7	0.9	91.8	1.3
Milk(products)	10.4	17.8	10.5	10.8	12.0	0.6	13.7	42.8	-	1.0
Bisquit/pastry	8.5	3.3	7.1	7.1	9.8	4.1	0.5	1.8	-	8.5
Cheese	6.7	12.5	12.0	11.3	-	-	0.7	28.3	-	0.6
Sugar	3.3	-	-	-	7.7	-	-	-	-	-
Potatoes	4.4	3.4	-	-	8.8	15.5	4.6	1.0	-	6.7
Alc. beverages	2.8	-	-	0.5	1.4	-	1.8	-	-	1.9
Fruit	5.5	-	-	-	12.7	19.0	9.0	3.8	-	7.0
Sweet(spread)	2.9	-	1.4	-	5.3	1.0	0.2	0.7	-	3.8
Vegetables	2.5	4.5	-	-	4.0	19.3	8.0	6.0	-	14.0
Nuts/seeds#	1.2	1.1	2.4	-	-	1.2	-	-	-	1.0
Beverages	1.6	-	-	-	3.6	3.5	51.7	7.4	-	18.7
Eggs	1.2	3.0	1.8	26.6	-	-	0.6	0.9	-	2.1
Rice/paste	1.3	0.7	-	-	2.1	0.9	0.4	-	-	0.5
Fish	0.7	2.6	0.8	3.1	-	-	0.3	0.6	4.2	-
Pulses	0.5	0.9	-	-	0.7	2.2	0.2	-	-	1.8
Remainder	4.6	4.0	5.0	1.9	5.5	4.1	2.9	2.6	4.0	6.3

peanut butter included; -: contribution less than 0.5%

Table 12.5.
Contribution (in %) of food groups to the intake of vitamins among elderly men

Food group	retinol	thiamin	ribo-flavin	pyri-doxine	ascorbic acid
Oils and fats	30.1	-	-	-	-
Bread	-	17.3	6.3	13.6	-
Meat(products)	10.7	21.1	14.1	18.2	-
Milk(products)	9.0	11.2	38.5	10.8	1.9
Bisquit/pastry	3.2	2.5	1.4	2.0	-
Cheese	11.7	1.0	4.4	1.6	-
Sugar	-	-	-	-	-
Potatoes	-	15.9	4.1	24.4	15.0
Alcoholic beverages	-	-	1.0	-	-
Fruit	2.3	6.6	3.0	9.9	28.3
Sweet(spread)	-	0.6	1.0	-	2.6
Vegetables	27.1	9.0	5.9	11.0	33.1
Nuts/seeds#	-	1.3	-	1.2	-
Beverages	-	5.3	12.0	0.6	16.6
Eggs	3.4	0.9	4.5	0.7	-
Rice/paste	-	-	-	-	-
Fish	-	0.9	1.2	1.3	-
Pulses	-	2.1	-	0.8	-
Remainder	2.6	4.4	2.8	3.9	2.5

peanut butter included; -: contribution less than 0.5%

consumption of alcoholic beverages as suggested by the associations with HDL-cholesterol and EAST-AC. On the other hand, intake of alcohol was found to be positively correlated with serum uric acid among elderly men, which emphasizes that alcohol must be used in moderation.

To increase 25-hydroxyvitamin D concentrations in plasma regular exposition to sunlight or artificial ultraviolet radiation is considered to be more appropriate than dietary changes because the main dietary sources of vitamin D for Dutch elderly people are fats and oils, biscuits and pastry, meat and meat products, milk and milk products (including cheese) and fish (94). A higher consumption of these products with a relatively high fat content is inconsistent with the general guideline advising restriction of fat intake.

Table 12.6.
Contribution (in %) of food groups to the intake of vitamins among elderly women

Food group	retinol	thiamin	ribo-flavin	pyri-doxine	ascorbic acid
Oils and fats	26.8	-	-	-	-
Bread	-	17.1	5.7	12.9	-
Meat(products)	9.1	19.7	12.8	18.6	-
Milk(products)	8.4	12.0	39.3	11.0	0.7
Bisquit/pastry	3.1	2.9	1.5	2.3	-
Cheese	12.1	1.1	4.6	1.7	-
Sugar	-	-	-	-	-
Potatoes	-	12.6	3.2	20.2	9.1
Alcoholic beverages	-	-	-	-	-
Fruit	3.3	8.7	3.7	10.8	31.9
Sweet(spread)	-	0.5	0.8	-	0.7
Vegetables	32.0	10.7	6.5	13.5	33.2
Nuts/seeds#	-	1.2	-	1.0	-
Beverages	0.5	6.3	14.1	1.1	22.3
Eggs	3.1	0.8	4.0	0.7	-
Rice/paste	-	0.5	-	-	-
Fish	-	0.8	1.0	1.1	-
Pulses	-	1.6	-	0.6	-
Remainder	1.7	3.6	2.9	4.5	2.1

peanut butter included; -: contribution less than 0.5%

The recommendations described above are fairly in accordance with the general Dutch guidelines for a healthy diet:
- eat a variety of foodstuffs;
- maintain normal body weight;
- avoid too much fat (especially saturated fatty acids) and cholesterol;
- eat foods with an adequate starch and fiber content;
- avoid too much sugar;
- avoid too much sodium;
- drink alcoholic beverages only in moderation (96).

The presented guidelines for elderly people are not new, but they are now substantiated by more scientific evidence obtained from Dutch elderly people on their habitual diet. The differences between elderly men and women regarding the association of dietary factors with blood pressure and serum cholesterol needs further

study. If these differences are found to be consistent as well as biologically plausible, the general guidelines may need to be expanded with gender-specific recommendations.

In summary, it is concluded that the results obtained from cross-sectional studies among elderly people in The Netherlands do not argue against the current general recommendations for the Dutch population. More research is needed to provide stronger scientific foundations as to whether gender-specific recommendations are necessary. Although many unresolved issues remain concerning adequate nutrition for elderly people, we are confronted with the immediate need for a rational approach to the diet of elderly people. On the basis of the information available, it can be stated that the current Dutch guidelines for a healthy diet are most likely sensible too for the apparently healthy, independently living elderly aged 65-79 in The Netherlands. These guidelines are conditional to an adequate exposure to UV radiation. If these conditions are met there is most likely no need for nutritional supplements for the apparently healthy elderly population as a whole.

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SUMMARY

The elderly are considered to run nutritional risks due to their lower energy intake, (patho) physiological (aging) processes and socioeconomic conditions. To identify the general nutritional risks prevalent among apparently healthy Dutch elderly people a nationwide survey among 539 independently living elderly people aged 65-79 years and a survey among 44 vegetarian elderly aged 65-97 years were executed within the framework of the Dutch Nutrition Surveillance System. In both surveys data on habitual dietary intake (assessed through dietary histories with cross-check) and nutritional status (assessed by anthropometric indices, and biochemical and hematological variables in blood and 24-hour urine) were obtained by standardized methods and procedures.

The dietary intake among the apparently healthy Dutch elderly had the characteristics that are typical for a diet of adults in an affluent society. Compared to the guidelines for a healthy diet of the Netherlands Nutrition Council, the intake of fat (especially saturated fatty acids), cholesterol, sugars and salt (24-hour excretion of sodium in the urine) was high, whereas the intake of polysaccharides and the P/S ratio of the diet was low. Therefore, the average diet is not a prudent one with respect to cardiovascular disease.

Prevalence of obesity (13% had a body mass index ≥ 30 kg/m^2), hypertension (63%), hypercholesterolemia (38% had a serum total cholesterol level ≥ 6.5 mmol/L) was found to be high, particularly among the women. Hypertension was defined as systolic blood pressure ≥ 160 mmHg, diastolic blood pressure ≥ 95 mmHg and/or usage of antihypertensive drugs. The vegetarian elderly (especially the men) had aged more successfully with respect to these cardiovascular risk factors. Therefore, an unfavorable cardiovascular risk profile cannot be considered to be a "normal" concomitant of aging in affluent societies.

The association found between nutrition-related factors (including body mass index) and blood pressure as well as serum total cholesterol among independently living elderly indicate that these risk factors may still be liable for modification by dietary factors at old age. Among elderly men obesity may be a risk factor for hypertension. Potassium may protect against hypertension when exposure of sodium is relatively high. Among women a positive association between urinary calcium:creatinine ratio and blood pressure was observed, which may be partly due to coffee consumption. Serum total cholesterol was found to be positively associated with body mass index and intake of monounsaturated fatty acids and alcohol (probably due to an increase in high-density lipoprotein cholesterol) among the men. Among men the

intake of monounsaturated fatty acids was highly ($r > 0.60$) positively correlated with the intake of total fat and saturated fatty acids, and inversely with total carbohydrates. In the bivariate analyses these variables were significantly associated with serum total cholesterol. Among women alcohol was consistently and positively associated with serum total cholesterol, whereas the data also revealed a positive association with saturated fatty acids and an inverse association with polysaccharides.

Although the intake of energy and nutrients was lower among the elderly than among younger adults the intake of most nutrients was assessed as being adequate according to the Dutch Recommended Dietary Allowances. An exception was made for vitamin B-6. Based on a cutoff point of 2.02 for EAST-AC, 9% of the independently living elderly not using vitamin B-6 supplements had a marginal vitamin B-6 status. The intake of vitamin B-6 (per gram protein) was inversely associated with erythrocyte aspartate aminotransferase activation coefficient (EAST-AC). Besides, EAST-AC was found to be positively associated with protein (especially of animal origin) and inversely with alcohol, but not with dietary fiber. Therefore, stimulation of consumption of food products of vegetable origin will most likely exert a positive effect on vitamin B-6 intake and status because of their relatively high vitamin B-6/protein ratio. This recommendation is consistent with the guidelines for a healthy diet.

Relatively low (< 31 nmol/L: 2.5 percentile of younger adults) plasma 25-hydroxyvitamin D levels were frequently observed. On the average, lower values were found among those at more advanced age, among those rarely exposed to sunlight, in those with a low level of physical activity and among those with a poor health status. These factors were interrelated. Regular exposure to sunlight or artificial UV radiation is considered to be a more appropriate preventive measure than dietary changes since the main dietary sources of vitamin D have a relatively high fat content as well.

To obtain insight into the need for special measures for subgroups among the independently living elderly the impact of age, gender, region, degree of urbanization, household size, housing situation, education, socioeconomic status, income, physical activity, energy intake, health status and chewing problems on dietary intake and nutritional status was investigated. Quantitatively dietary intake was mainly influenced by gender, health status and physical activity, whereas for the qualitative aspects of the diet socioeconomic factors were found to be the most important determinants. The nutritional status of the elderly with a relatively low energy and thereby nutrient intake was comparable with the results observed among those with a higher intake of energy. Expressed per MJ the intake of nutrients

was higher among elderly with a relatively low energy intake. Differences in dietary intake and nutritional status indicators among elderly people differing in region and degree of urbanization were of no significance, whereas housing situation and chewing problems hardly exerted any effect on dietary intake and nutritional status indicators. It is concluded that generalization of frequently reported risk factors for a marginal diet and nutritional status among elderly people may not always be valid for Dutch apparently healthy subjects aged 65-79 years. Since the differences between the different subgroups regarding the nutritional status indicators (possibly with the exception of plasma 25-hydroxyvitamin D) were relatively small or absent, it is concluded that adaptation of dietary guidelines to nutritional risks among special groups among apparently healthy elderly are most likely not necessary.

To improve the current food pattern of apparently healthy elderly in The Netherlands it is indicated to restrict the intake of fat (mainly through selection of leaner varieties of foodstuffs) and sodium but at the same time to increase the intake of products of vegetable origin and to maintain normal body weight. Elderly women may profit from reducing coffee consumption since our data suggest the possibility of an increased urinary calcium excretion due to coffee consumption, whereas coffee consumption and calcium excretion were both positively associated with blood pressure. These aspects needs further study. Although the associations with HDL-cholesterol and EAST-AC suggest that elderly people may potentially benefit from alcohol intake, alcoholic beverages should be used only in moderation.

The recommendations mentioned are in accordance with the guidelines for a healthy diet formulated by the Netherlands Nutrition Council for the overall Dutch population. Although the diet of the vegetarian elderly fairly approximate these guidelines, a vegetarian diet is not recommended for the elderly. Risks associated with a marginal status of iron, zinc and vitamin B-12 may be introduced by such a diet. Provided exposure to UV radiation is adequate and the suggested dietary changes are realized it is not necessary to recommend nutritional supplements for apparently healthy elderly aged 65-79 years.

EVALUATIE VAN VOEDINGSRISICO'S BIJ NEDERLANDSE OUDEREN

Samenvatting

Ouderen worden tot de groepen gerekend met verhoogde voedingsrisico's door de gemiddeld lagere energie-inneming, (patho-) fysiologische (verouderings) processen en sociaal-economische omstandigheden. Voor het verkrijgen van inzicht in de voedingsrisico's bij ogenschijnlijk gezonde ouderen in Nederland is een landelijk onderzoek onder 539 zelfstandig wonende personen (65-79 jaar) en een vergelijkbaar onderzoek, wat betreft (wijze van) gegevensverzameling, bij 44 vegetarische ouderen (65-97 jaar) uitgevoerd in het kader van het voedingspeilingssysteem. In beide onderzoeken zijn op gestandaardiseerde wijze gegevens verzameld omtrent de gebruikelijke voeding (door middel van de kruisvraagmethode) en voedingstoestand (lichaamsmaten en biochemische en hematologische bepalingen in bloed en biochemische bepalingen in de 24-uurs urine).

De voeding van de ogenschijnlijk gezonde, zelfstandig wonende 65-79 jarigen vertoonde de algemene kenmerken van de voeding van volwassenen in westerse geïndustrialiseerde landen, waaronder Nederland. In vergelijking met de Richtlijnen Goede Voeding van de Voedingsraad was de gemiddelde inneming van vet (met name verzadigd vet), cholesterol en zout (uitscheiding in de 24-uurs urine) hoog, terwijl de inneming van polysacchariden en de P/S ratio van de voeding laag was. Deze aspecten worden als ongunstig beschouwd voor met name hart- en vaatziekten. De prevalentie van aan voeding gerelateerde risico-indicatoren voor hart- en vaatziekten, te weten obesitas (13% had een Quetelet index ≥ 30 kg/m²), hypertensie (63% had een systolische bloeddruk ≥ 160 mm Hg, diastolische bloeddruk ≥ 95 mm Hg en/of gebruikte bloeddrukverlagende geneesmiddelen) en hypercholesterolemie (38% had een serum totaal cholesterol ≥ 6.5 mmol/L) was relatief hoog. De percentages waren hoger voor vrouwen dan voor mannen. De resultaten verkregen bij vegetarische ouderen geven aan dat ouder worden niet noodzakelijkerwijs behoeft te resulteren in een ongunstig cardiovasculair risicoprofiel op oudere leeftijd (vooral bij mannen). In het landelijke onderzoek zijn associaties waargenomen tussen voedingsfactoren (inclusief de Quetelet index) enerzijds en bloeddruk en serum cholesterol anderzijds hetgeen aangeeft dat het niveau van deze risicofactoren mogelijk nog wordt beïnvloed door voedingsfactoren. Bij mannen bleek de bloeddruk positief samen te hangen met de Quetelet index en met de natrium/kalium-verhouding in de urine (diastolische bloeddruk). Bij vrouwen bestond een positief verband tussen de calcium/creatinine-verhouding in de

urine en de bloeddruk, hetgeen waarschijnlijk samenhangt met het drinken van koffie. Serum totaal cholesterol bleek bij mannen positief samen te hangen met de Quetelet index en de inneming van enkelvoudig onverzadigd vet en alcohol (waarschijnlijk door hogere HDL-cholesterol concentraties). De energie afkomstig van enkelvoudig onverzadigd vet bleek bij mannen sterk samen te hangen met de energie afkomstig van totaal vet ($r = 0,82$), verzadigd vet ($r = 0,64$) en totaal koolhydraten ($r = -0,66$). In de bivariate regressie analyse waren voornoemde voedingsfactoren bij mannen significant geassocieerd met serum totaal cholesterol. Evenals bij mannen was bij vrouwen alcohol positief geassocieerd met serum totaal cholesterol, terwijl bij vrouwen de inneming van verzadigd vet positief en de inneming van polysacchariden invers samenhing met het serum totaal cholesterolgehalte. Deze resultaten zijn niet strijdig met hetgeen in de Richtlijnen Goede Voeding wordt aangegeven als wenselijke veranderingen in de Nederlandse voeding.

Ondanks dat ouderen gemiddeld een lagere inneming van energie en voedingsstoffen hebben dan jongere volwassenen is de inneming van de meeste onderzochte vitamines en mineralen als adequaat beoordeeld. Deze beoordeling vond plaats aan de hand van de Nederlandse aanbevolen hoeveelheden die van kracht waren ten tijde van het onderzoek. Uitzondering op deze algemene constatering was vitamine B-6, waarvan de gemiddelde inneming relatief laag was. De inneming van vitamine B-6 per gram eiwit was invers geassocieerd met de activeringscoëfficiënt van het vitamine B-6 afhankelijke enzym aspartaat aminotransferase in de erythrocyten (EAST-AC). Op basis van de maximum waarde (2,02) bij ouderen die vitamine B-6 bevattende preparaten gebruikten had 9% van de ouderen die deze preparaten niet slikten relatief hoge (marginale) EAST-AC waarden. EAST-AC bleek invers samen te hangen met de inneming van vitamine B-6 en alcohol, maar positief met eiwit (vooral dierlijk eiwit). Voedselvezel heeft waarschijnlijk geen wezenlijke invloed op de beschikbaarheid van vitamine B-6. Aangezien plantaardige produkten een hogere vitamine B-6/eiwit verhouding hebben dan produkten van dierlijke oorsprong mag, gezien de waargenomen associaties, van de stimulering van het gebruik van plantaardige produkten een positief effect op de vitamine B-6 status worden verwacht.

Lage (< 31 nmol/L: 2,5 percentiel van jongere volwassenen) plasma 25-hydroxyvitamine D spiegels zijn bij relatief veel (vegetarische) ouderen waargenomen. Gemiddeld zijn lagere waarden geconstateerd bij ouderen op hogere leeftijd, bij ouderen met een geringe expositie aan zonlicht, bij ouderen met een relatief laag niveau van lichamelijke activiteit en bij ouderen met een slechtere gezondheid. Tussen deze factoren bestaat een onderlinge samenhang. Voor het verbeteren van de vitamine D voorziening is

regelmatige expositie aan zonlicht of kunstmatige ultraviolette straling waarschijnlijk een betere preventieve maatregel dan veranderingen in de voeding daar belangrijke vitamine D bronnen relatief veel vet bevatten.

In de landelijke steekproef is nagegaan in hoeverre leeftijd, geslacht, regio, urbanisatiegraad, grootte van de huishouding, huisvesting, opleidingsniveau, sociaal-economische status, ontvangst éénmalige uitkering, lichamelijke activiteit, energie-inneming, gezondheidstoestand en kauwproblemen van invloed waren op de voeding en voedingstoestand. In kwantitatieve termen bleek de voeding vooral samen te hangen met geslacht, gezondheidstoestand en lichamelijke activiteit, terwijl de kwaliteit van de voeding (met name de verhouding tussen de energie leverende voedingsstoffen) vooral, maar niet uitsluitend, werd beïnvloed door sociaal-economische factoren. De voedingstoestand van ouderen met een relatief lage energie-inneming verschilde niet wezenlijk van ouderen met een hogere energie-inneming. Bij de ouderen met een relatief hoge energie-inneming was de inneming van voedingsstoffen in absolute termen hoger maar lager wanneer uitgedrukt per MJ. De voeding en voedingstoestand verschilde nauwelijks voor de diverse regio's, urbanisatiegraden, huisvestingen en gebitstoestanden (problemen met kauwen). Aangezien de verschillen in de indicatoren van de voedingstoestand (eventueel met uitzondering van 25-hydroxyvitamine D) tussen de onderzochte subgroepen relatief klein dan wel afwezig waren, werd geconcludeerd dat het waarschijnlijk niet nodig is speciale aanbevelingen voor de voedingsrisico's bij subgroepen van de ogenschijnlijk gezonde ouderen te formuleren.

Ter verbetering van de huidige voeding van zelfstandig wonende ogenschijnlijk gezonde ouderen wordt aangegeven de inneming van vet (vooral door magere produkten te kiezen binnen produktgroepen die een belangrijke bijdrage aan de vetinneming leveren) en eventueel van zout te beperken, het gebruik van plantaardige produkten te stimuleren alsmede een normaal lichaamsgewicht te handhaven. Mogelijk zou het koffiegebruik door vrouwen wat beperkt kunnen worden aangezien er een positieve associatie bestond met de calcium-uitscheiding in de urine. De koffieconsumptie en vooral de calcium/creatinine verhouding in de urine bleken bij vrouwen positief samen te hangen met de bloeddruk. Deze associaties vereisen nader onderzoek. De resultaten geven aan dat het (matig) gebruik van alcoholische dranken een positief effect kan hebben op de vitamine B-6 status en HDL-cholesterol.

Bovenstaande aanbevelingen zijn redelijk in overeenstemming met de Richtlijnen Goede Voeding zoals de Voedingsraad deze heeft geformuleerd voor de Nederlandse bevolking in het algemeen. Hoewel de voeding van vegetarische ouderen de Richtlijnen beter benaderde

dan de voeding van ouderen in de landelijke steekproef wordt een vegetarische voeding op oudere leeftijd niet zonder meer aanbevolen. Gezondheidsrisico's verbonden aan een marginale ijzer, zink en vitamine B-12 status kunnen hierdoor worden geïntroduceerd. Onder de voorwaarde van voldoende expositie aan zonlicht en een voeding meer in overeenstemming met de Richtlijnen Goede Voeding is het niet nodig om voedingssupplementen aan te bevelen voor de groep van ogenschijnlijk gezonde ouderen (65-79 jaar).

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CURRICULUM VITAE

Michiel R.H. Löwik was born in Almelo on 21 February 1955. After having completed Atheneum-B (grammar school) at the Carmel Lyceum in Oldenzaal in 1974, he started studying Human Nutrition at the Agricultural University in Wageningen. This study was completed (with distinction) in 1981. In that year he received a stipendium for participation in the Food and Agriculture Programme of the International Institute for Applied Systems Analysis, Laxenburg (Austria). In 1981, he started studying at the Graduate School of Management, Delft. In 1984, he obtained a Master of Business Administration degree, with specialization on international affairs especially regarding 'Food strategies for developing countries'. In 1984, he was appointed as nutritional epidemiologist at the Section Epidemiology (Head: Dr.Ir. F.J. Kok) of the Department of Human Nutrition (Head: Dr. Th. Ockhuizen) of the TNO-CIVO Toxicology and Nutrition Institute (Director: Prof.Dr.Ir. R.J.J. Hermus) located in Zeist. Since 1986 he is working as project leader of a nutrition surveillance programme among special groups. Part of the publications based on two surveys of this programme were the subject of his doctoral thesis. In 1988, he followed the summer programme epidemiology at the University of Michigan, Ann Arbor (USA) and became the executive secretary of the Committee of the Dutch National Food Consumption Survey. In 1989, he was enrolled as a trainee member of the American College of Nutrition.