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Dietary Intakes of Energy and Water-Soluble Vitamins in Different Categories of Aging

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The dietary intakes of energy and the vitamins thiamin, riboflavin, B6, and C were assessed in four groups of elderly people, using the same modified dietary history method. The groups consisted of female nursing home residents (n = 40), people at admission to a nursing home (n = 21), free-living elderly people with a sedentary lifestyle (n = 120), and physically active free-living elderly people (n = 66). Mean energy intake varied from 6.5 ± 1.2 Megajoule (MJ)/day (nursing home residents) to 8.8 ± 2.2 MJ/day (physically very active persons) in females and from 8.8 ± 2.5 MJ/day (admission to nursing home) to 10.1 ± 2.3 MJ/day (physically very active persons) in males. Dietary intakes of the selected vitamins were below the minimum requirements in almost half of the nursing home residents. However, the relative contribution of the various food groups to the dietary intake of these vitamins was similar in the four groups of elderly people. Stimulation of physical activity to increase energy requirements and use of foods with a high nutrient density may result in an improvement of dietary adequacy.

The process of aging is characterized by several factors, including an increasing prevalence of poor health status, reduced physical activity, and perhaps as a consequence of this, reduced intakes of food and energy (Goodwin, 1989; James, 1989; Munro, 1989). As energy intake decreases, consumption of a well-balanced diet becomes more important to provide adequate amounts of micronutrients. Dietary intakes of elderly people have been studied in several study settings, and the adequacy of both macro- and micronutrient intakes have been reviewed and criticized by several authors (O’Hanlon and Kohrs, 1978; Suter and Russell, 1987; Horwath, 1989; Russell and Suter, 1993; van der Wielen et al., 1994). Differences in the various dietary intake measurement instruments used in those studies make it difficult to compare the study results. Furthermore, most food consumption studies in elderly people use chronological age of the participants as a criterion for inclusion in the study. However, the heterogeneity of this category of people with respect to chronological functioning should not be neglected, and therefore chronological age alone is a poor selection criterion (Shock, 1984; Fuechini et al., 1992). Rowe and Kahn (1987) made a distinction between usual aging, associated with a variety of chronic medical conditions and disabilities, and successful aging, which is characterized by little or no loss in physiological functions with age. Harris and Feldman (1991) suggest that a third category of high-risk or accelerated aging should be added. This category refers to elderly people who carry the heaviest burden of chronic disease and disability.

The main purpose of this study is to compare anthropometrical parameters of the nutritional status and the adequacy of dietary intakes of energy, thiamin, riboflavin, and the vitamins B6 and C between groups of elderly Dutch people of different health status, using the same dietary history method. The groups under study represent the different categories of aging. The first group consists of elderly nursing home patients (either resident or at admittance) who can be classified as being in the phase of accelerated aging. The second group, representing the usual agers, consists of a free-living, rather healthy sedentary group of elderly people. The third group under study comprises physically active, successful agers who participated in the annual four-day long-distance march in Nijmegen in 1993.

Each of the vitamins studied plays a specific role in energy metabolism, and therefore nutrient densities were included in the analyses (Maclin, 1984). The dietary intakes of the groups were compared with the Dutch dietary recommendations (Dutch Nutrition Council, 1992).

METHODS

Subjects. — Two groups of elderly people with a chronic somatic disability were recruited from three nursing homes, which were located in the central area of The Netherlands. The first group is referred to as the "Resident" group and consists of 40 elderly female nursing home residents aged 65 years and older, with a chronic somatic disability. This group, recruited in April 1993 by the nursing home physicians, was in stable health condition, did not receive parenteral or tube feeding, and was resident for at least three months. Because the number of males who fulfilled these criteria was relatively small, only females were recruited. Initially, 42 women were approached and all of them were willing to participate. Two of these women died before their food consumption was assessed. The second group consisted of both elderly males and females aged 65 years and older, who were examined within five days after admittance to one of the nursing homes mentioned above, and who were free-living up to the moment of admission ("Admission" group). From October 1992 until December 1993 the patients of the
Admission group were asked to participate. People suffering from terminal diseases or receiving parenteral or tube feeding were not included in the study. A total of 21 persons (10 males and 11 females) were enrolled in the study (response rate 75%).

In the spring of 1993, a follow-up of the SENECA study, which stands for a Study in Europe on Nutrition and the Elderly, a Concerted Action (de Groot et al., 1991), was carried out. Of the 238 apparently healthy, free-living Dutch elderly who had participated in 1988, 38 had died, 69 refused further participation, and 11 persons could not be located for follow-up. The remaining 120 persons, aged 75–80 years, are referred to as the SENECA group.

In July 1993, the SENECA research protocol was used as part of a study on physical activity, exercise capacity, and health in elderly participants in the annual four-day long-distance march in Nijmegen. Food consumption was studied in a subgroup of these elderly participants. At first, this food consumption study was aimed at people above the age of 75 years. Because the number of female participants in this age category was low, the age limit for females was lowered to 70 years. Participants were all able to walk 30 or 40 kilometers on four consecutive days, and therefore can be considered to have a high exercise capacity. In total, 82 elderly people were asked to participate in the food consumption part of the study. Of this group 67 persons initially agreed to participate. One woman refused further participation after the time-consuming dietary assessment. The remaining 66 persons (32 females and 34 males) are referred to as the “4-day marches” group, and it is assumed that this group was in better physical condition than the more sedentary group of free-living elderly people in the SENECA study.

All four of the studies reported here were approved by the Medical Ethical Committee of the Department of Human Nutrition, Wageningen Agricultural University, and informed consent was obtained from all participants.

Anthropometric measurements. — Weight (to the nearest 0.1 kg) and height (to the nearest 0.5 cm) were measured, and the body mass index (BMI) was calculated as weight divided by height squared (kg/m²). In addition, mid upper arm circumference (MUAC) was measured (to the nearest 0.1 cm), as an extra index of body composition.

Health and performance. — A score of basic activities of daily living (ADLs) was calculated from the abilities in bathing, dressing, toileting, feeding, and transfers. For each item the possible scores were 0 (no help needed), 1 (some help needed), and 2 (intensive help needed). The ADL score ranges, therefore, between 0 (no help needed at all) and 10 (intensive help needed). Subjects were asked to compare their health with that of other persons of the same age. Furthermore, information was collected about the presence of chronic diseases and use of prescribed medication, levels of education, and smoking status.

Dietary intake. — In a personal interview, food consumption data were obtained by trained investigators using a modified version of the dietary history method (Cameron and van Staveren, 1988; de Groot and van Staveren, 1988; Nes et al., 1991). To facilitate the dietary interview, first, a global food consumption pattern of weekdays and weekends was estimated, to give the interviewer an idea of the person’s pattern of eating. By using this as background information, the usual pattern of intake was assessed by asking the person’s usual intake, covering the last four weeks as the reference period (for the Admission group the last four weeks before admittance to the nursing home). A checklist of foods was used to find out which foods were used, how often they were used, what alternatives were used on weekdays and weekend days, and what other irregularities in the eating pattern were present. Each meal and all between-meal snacks were discussed, and for composite foods, recipes were specified.

The checklist of foods was completed in a slightly different way for the groups under study. For the Admission group, the interview took place within five days after admittance. In all interviews the partner of the participant or a proxy who helped in the meal preparation was present at the interview. Portion sizes of foods and household measures were estimated with the help of 105 photographs of different portion sizes of 23 items. The National Institute of Public Health and Environment Protection provided 24 of the pictures (Ocké et al., 1994). The same photos were used for the female nursing home residents. The menu of the last four weeks was collected for each participant, and recipes, brands of food products, and portion sizes were obtained from the cooks. For the participants of the SENECA study or the 4-day marches, the interview took place at the home of the participant and usual portion sizes were recorded in household measures. Portion sizes of the foods most frequently used were checked by weighing by the interviewer. All interviewers had the same intensive and standardized training at the Department of Human Nutrition, Wageningen Agricultural University, The Netherlands. Meetings were organized to discuss coding problems.

Data analysis. — Food consumption data were converted into energy, nutrients, and nutrient densities using a computerized version of the Dutch food consumption table (Stichting Nederlands Voedingsstoffenbestand, 1987). All statistical analyses were performed using the SAS statistical package (SAS Institute Inc., Cary, NC).

For males and females separately in each group, means and standard deviations were calculated for sample characteristics and dietary intake variables. For all variables, normality of the frequency distribution was evaluated by visual inspection. To stabilize the variances, logarithmic transformations were carried out before the statistical analyses for daily dietary vitamin C intake and for vitamin C intake per Megajoule (MJ) of energy intake. No statistical tests were performed on alcohol intake, because the distribution remained skewed after transformations. For continuous variables, differences between the groups were tested with analysis of variance (ANOVA). The 95% confidence limits (CL) were calculated, and the least significant difference (LSD) test for multiple comparisons was carried out to test which groups of elderly people had unequal means for the continuous variables.

Prevalence of dietary vitamin intakes below the Dutch Recommendations (RDA) or below the lower limit of the
range of minimum requirements, as determined by the Dutch Nutrition Council (1992), were calculated in each group of elderly people, and pairwise comparisons between the groups and between males and females were tested with Fisher’s exact test at the 1% significance level. All tests were two-tailed.

RESULTS

Demographic, anthropometric, and health data. — The sample characteristics are described in Table 1. Since the selection criteria of the groups under study were different with respect to age, the range and the distribution of age differed. Therefore it was of no use to test for age differences. From the table it is clear, however, that the free-living females were, on average, somewhat younger than the female nursing home residents. ANOVA testing showed a significant difference (p < .05) for weight between the categories of elderly women. However, no significant differences for weight emerged from the multiple comparisons test. Since many of the nursing home residents were confined to a wheelchair or had kyphosis, height could not be measured in the major part of these groups. In the free-living elderly, body mass index (BMI) was significantly higher in the SEN- ECA group compared to the 4-day marches group in both females (p = .001) and males (p = .026). Mid upper arm circumference (MUAC) was higher in the SENECA group compared to the other groups in both males and females.

In line with the fact that the nursing home residents all suffered from chronic somatic disabilities, the score for activities of daily living was very high in these groups, as was the prevalence of chronic diseases and the use of prescribed medication. Small expected cell frequencies hampered statistical testing of these categorical variables.

Dietary intake. — Table 2 shows the dietary energy intakes and the relative sources of energy in the different groups of elderly people. Energy intake varied from 6.5 MJ/day (Resident group) to 8.8 MJ/day (4-day marches group) in females, and from 8.8 MJ/day (Admission group) to 10.1 MJ/day (4-day marches group) in males. Analysis of variance showed a significant difference in the energy intake between groups of females but not in males. Multiple comparisons testing revealed a significant difference in mean energy intake between the Resident group and the other three groups of elderly females (95% CL: 5.9—7.2 MJ for the Resident group, 6.5—8.9 MJ for the Admission group, 7.2—8.2 MJ for the SENECA group, and 8.1—9.6 MJ for the 4-day marches group). In both sex groups, the results suggest a higher energy intake in the 4-day marches group than in the SENECA group, although the data did not reach statistical significance. However, energy intake per kilogram body weight was higher in elderly female participants of the 4-day marches group compared to the other three groups (95% CL: 90—114 kJ for the Residents group, 84—133 kJ at Admission*, 103—120 kJ for the SENECA group, and 127—151 kJ for the 4-day marches group).

No differences of statistical significance were found with respect to percentage of energy provided by macronutrients, with the exception of the percentage of energy provided by protein, which was lower in the females in the Admission

| Table 1. Demographic, Anthropometric and Health Data of Four Groups of Elderly People* |
|-----------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| **Variable**                               | **Nursing Homes**            | **SENECA**                   | **4-Day Marches**           | **Nursing Homes**            | **SENECA**                   | **4-Day Marches**           |
|                                            | **Females**                  |                             |                             | **Males**                   |                             |                             |
|                                            | **Resident n = 40**           | **Admission n = 11**         | **n = 68**                  | **n = 32**                  | **Admission n = 10**         | **n = 52**                  | **n = 34**                  |
| Age (years)                               | 81.5 (7.1)                   | 81.4 (8.2)                  | 76.9 (1.8)                  | 74.6 (3.6)                  | 78.1 (10.0)                 | 76.8 (1.7)                  | 77.5 (2.2)                  |
| Weight (kg)                               | 65.7 (11.2)                  | 66.1 (14.4)                 | 70.9 (11.1)                 | 65.3 (9.7)                  | 75.7 (15.2)                 | 76.3 (10.3)                 | 73.9 (9.7)                  |
| Height (m)                                | 1.60 (.07)                   | 1.62 (.05)                  |                            |                            | 1.71 (.07)                  | 1.73 (.07)                  |                            |
| BMI (kg/m²)                               | 27.8 (4.3)                   | 24.9 (3.1)                  | 28.1 (2.8)                  |                            | 27.9 (4.5)                  | 30.2 (2.4)                  | 28.1 (2.0)                  |
| MUAC (CM)                                 | 6.8 (2.3)                    | 6.4 (1.4)                   | .0 (.2)                     | .0 (.0)                     | 6.1 (2.1)                   | .0 (1.1)                    | .0 (1.0)                    |
| ADL score (0—10)                          | 100                          | 100                         | 59                          | 53                          | 100                         | 50                          | 38                          |
| Chronic disease (% yes)                   | 100                          | 91                          | 79                          | 50                          | 90                          | 69                          | 44                          |
| Drug use (% yes)                          | 100                          | 91                          | 79                          | 50                          | 90                          | 69                          | 44                          |
| Relative health (%)                       |                               |                             |                             |                             |                             |                             |                             |
| Worse                                     | 12                           | 36                          | 4                           | 0                           | 20                          | 4                           | 0                           |
| The same                                  | 58                           | 18                          | 41                          | 25                          | 30                          | 40                          | 9                           |
| Better                                    | 30                           | 45                          | 54                          | 75                          | 50                          | 56                          | 91                          |
| Education (%)                             |                               |                             |                             |                             |                             |                             |                             |
| Primary                                   | 35                           | 45                          | 44                          | 41                          | 24                          | 33                          | 12                          |
| Secondary                                 | 52                           | 55                          | 47                          | 41                          | 70                          | 56                          | 50                          |
| Higher                                    | 12                           | 0                           | 9                           | 19                          | 10                          | 12                          | 38                          |
| Smoking (% yes)                           | 8                            | 0                           | 1                           | 6                           | 40                          | 29                          | 21                          |

Notes: *Mean (SD in parentheses) or percentage. **Incomplete data (b = 4, c = 2, d = 3, e = 1 observations missing). ***Results of analysis of variance (ANOVA) (f = p < .05 for females; g = p < .001 for females and p < .05 for males; h = p < .001 for females and males). ^Subjective health judgment compared to people of the same age. On each row, means sharing the same capital letter are not significantly different (least significant difference test for females and males separately). BMI, body mass index; MUAC, mid upper arm circumference; ADL, activities of daily living.
group compared to the two groups of free-living elderly women, and the percentage of energy provided by fat, which was higher for males in the Admission group compared to the 4-day marches group.

Mean dietary intakes of thiamin, riboflavin, vitamin B6, and vitamin C are presented in Table 3. The intakes of all four vitamins under study were higher in the 4-day marches group compared to both nursing home groups, with the exception of riboflavin intake in males. For vitamin C, the dietary intake was almost three times higher in the 4-day marches group compared to the nursing home groups (Table 3). In females, the dietary intakes of thiamin, vitamin B6, and vitamin C were significantly higher in the 4-day marches group compared to the SENECA group, and the intakes of riboflavin, vitamin B6, and vitamin C in the SENECA group were significantly higher than in the Resident group. In males, no differences in intakes were found between the SENECA group and the 4-day marches group. Except for riboflavin, the vitamin intakes in both groups of free-living males were higher than in the Admission group (Table 3).

The differences between the two groups of free-living elderly disappeared when the dietary intakes were expressed per MJ energy intake, but generally remained significant when comparing the free-living groups with the nursing home groups (Table 3).

Riboflavin intakes in females, expressed per gram protein intake, were lower in the Resident group and the 4-day marches group compared to the Admission group. This may be explained by the lower protein intakes in the latter group (Table 3).

Dietary adequacy. — Mean dietary intakes of the vitamins under study (Table 3) were below the RDAs in the free-living elderly, whereas in the Admission group, the differences between the two groups of free-living elderly disappeared when the dietary intakes were expressed per MJ energy intake, but generally remained significant when comparing the free-living groups with the nursing home groups (Table 3).

Table 2. Daily Dietary Intakes of Energy and Nutrients Contributing to Energy in Four Groups of Elderly People

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nursing Homes</th>
<th>Free Living</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residents</td>
<td>Admission</td>
<td>SENECA</td>
</tr>
<tr>
<td></td>
<td>n = 40</td>
<td>n = 11</td>
<td>n = 68</td>
</tr>
<tr>
<td>Energy MJ/day</td>
<td>6.5 (1.2)A</td>
<td>7.7 (2.3)B</td>
<td>7.7 (2.3)B</td>
</tr>
<tr>
<td>kJ/kg body weight</td>
<td>103 (22)A</td>
<td>119 (39)A</td>
<td>111 (37)A</td>
</tr>
<tr>
<td>Protein %Energy</td>
<td>13.4 (2.4)AB</td>
<td>12.9 (3.0)A</td>
<td>15.6 (3.0)A</td>
</tr>
<tr>
<td>Fat %Energy</td>
<td>38.5 (5.8)</td>
<td>41.7 (6.2)</td>
<td>39.3 (8.7)</td>
</tr>
<tr>
<td>Carbohydrate %Energy</td>
<td>47.4 (6.6)</td>
<td>46.1 (6.4)</td>
<td>45.1 (7.7)</td>
</tr>
<tr>
<td>Alcohol %Energy</td>
<td>1.0 (1.6)</td>
<td>6.1 (1.1)</td>
<td>1.3 (4.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
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</tr>
<tr>
<td></td>
<td>n = 52</td>
<td>n = 34</td>
<td>n = 52</td>
</tr>
<tr>
<td>Energy MJ/day</td>
<td>8.8 (2.5)</td>
<td>9.3 (2.0)</td>
<td>10.1 (2.3)</td>
</tr>
<tr>
<td>kJ/kg body weight</td>
<td>132 (31)A</td>
<td>123 (31)B</td>
<td>138 (38)</td>
</tr>
<tr>
<td>Protein %Energy</td>
<td>14.6 (2.3)</td>
<td>14.4 (2.7)</td>
<td>13.6 (2.6)</td>
</tr>
<tr>
<td>Fat %Energy</td>
<td>43.3 (2.8)A</td>
<td>39.8 (6.0)A</td>
<td>38.2 (5.6)A</td>
</tr>
<tr>
<td>Carbohydrate %Energy</td>
<td>41.1 (5.3)</td>
<td>44.0 (6.7)</td>
<td>44.6 (7.9)</td>
</tr>
<tr>
<td>Alcohol %Energy</td>
<td>2.2 (4.4)</td>
<td>3.1 (3.8)</td>
<td>4.7 (5.6)</td>
</tr>
</tbody>
</table>

Notes. *Mean, SD in parentheses. aStatistical significance in analysis of variance (ns, not significant; nt, not tested). abIncomplete data (c = 4, d = 2, e = 3, f = 1 observations missing). ABOn each row, means sharing the same capital letter are not significantly different (least significant difference test for females and males separately).

Table 3. Daily Dietary Intakes of Thiamin, Riboflavin, Vitamin B6, and Vitamin C in Four Groups of Elderly People

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nursing Homes</th>
<th>Free Living</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Residents</td>
<td>Admission</td>
<td>SENECA</td>
</tr>
<tr>
<td></td>
<td>n = 40</td>
<td>n = 11</td>
<td>n = 68</td>
</tr>
<tr>
<td>Thiamin mg</td>
<td>.81 (.18)A</td>
<td>.81 (.26)A</td>
<td>.94 (.27)A</td>
</tr>
<tr>
<td>mg/MJ</td>
<td>.13 (.02)A</td>
<td>.11 (.02)B</td>
<td>.13 (.03)A</td>
</tr>
<tr>
<td>Riboflavin mg</td>
<td>1.20 (.36)A</td>
<td>1.41 (.51)AB</td>
<td>1.63 (.56)BC</td>
</tr>
<tr>
<td>mg/MJ</td>
<td>.19 (.05)A</td>
<td>.18 (.04)A</td>
<td>.22 (.06)A</td>
</tr>
<tr>
<td>µg/g protein</td>
<td>22 (4)</td>
<td>25 (6)</td>
<td>24 (4)</td>
</tr>
<tr>
<td>Vitamin B6 mg</td>
<td>.96 (.19)A</td>
<td>1.09 (.42)A</td>
<td>1.29 (.34)A</td>
</tr>
<tr>
<td>mg/MJ</td>
<td>.15 (.03)A</td>
<td>.14 (.03)A</td>
<td>.17 (.05)A</td>
</tr>
<tr>
<td>µg/g protein</td>
<td>18 (3)A</td>
<td>19 (4)A</td>
<td>19 (4)A</td>
</tr>
<tr>
<td>Vitamin C mg</td>
<td>56 (26)A</td>
<td>68 (26)A</td>
<td>118 (56)A</td>
</tr>
<tr>
<td>mg/MJ</td>
<td>9 (4)A</td>
<td>9 (5)A</td>
<td>16 (9)A</td>
</tr>
</tbody>
</table>

Notes. *Mean, SD in parentheses. aStatistical significance in analysis of variance (ns, not significant). bStatistical analysis performed after logarithmic transformation. ABOn each row, means sharing the same capital letter are not significantly different (least significant difference test for females and males separately).
with the exception of dietary riboflavin intake in the latter
group. In the female SENECA group, mean dietary intakes
of thiamin (mg) and of vitamin B6 (expressed per gram
protein) were below the RDAs. None of the mean dietary
vitamin intakes reached the RDA in elderly males in the
Admission group.

The prevalence of dietary intakes below the Dutch RDAs
or below the minimum requirements are presented in Table 4
for the vitamins under study. The RDAs are judged to be
adequate to meet the nutrient needs of practically all healthy
people. To judge the dietary adequacy of a section of the
population, the minimum dietary needs (i.e., the lower level
of the distribution of the individual minimum nutrient re­
quirements to maintain normal metabolic functioning) are a
more sensible guideline (Dutch Nutrition Council, 1992).
Pairwise comparison of the prevalences of dietary intakes
below the minimum requirements at the 99% confidence
level, resulted in statistically significant higher prevalences
in the Resident group compared to either of the two groups of
free-living elderly females for all four vitamins under study
(p < .01), except for the prevalence of low thiamin intakes in
the SENECA females. No statistically significant differ­
ces were present between the females in the Admission
group compared to the Resident group or the SENECA


group; however, the prevalences of low dietary intakes of
either thiamin, vitamin B6, or vitamin C were significantly
higher than in the 4-day marches group. Prevalences of
inadequacy were also found to be significantly higher in the
female SENECA group compared to the 4-day marches
group for thiamin and vitamin B6 (p < .01). In males, no
statistically significant differences in prevalences of inade­
quacy were found between the three groups, except for the
prevalences of low vitamin B6 and vitamin C intakes, which
were significantly higher in the Admission group compared
to the 4-day marches group. In the SENECA group, the
prevalences of dietary inadequacy were significantly higher
in females compared to males for thiamin as well as for
vitamin B6 (p < .005).

**Vitamin sources.** — About 40% of thiamin in the diet was
provided by animal sources (meat, fish, eggs, and milk
products) in all but the 4-day marches group (Figure 1A). In
the latter group this was about 30%. For riboflavin, 40–50%
was provided by milk products (Figure 1B) and about 25%
was provided by grain products, vegetables, potatoes, fruits
and fruit juices. As with thiamin, about 40% of vitamin B6
was also provided by animal products (Figure 1C). For
vitamin C (Figure 1D) it can be seen that the relative amount
provided by vegetables (excluding potatoes) seemed to be
somewhat higher in the groups of free-living elderly than in
the nursing home groups. The relative contribution of each
product group to the total amount of the vitamins consumed
with the diet, however, was about the same for each category
of elderly people. This evidence suggests that the food
patterns are not strikingly different between the four groups
under study.

**DISCUSSION**

This study shows that sedentary elderly people living in or
awaiting admission to a nursing home have lower dietary
intakes of thiamin, riboflavin, and the vitamins B6 and C
than independently living, physically active elderly people.
However, the food pattern is not strikingly different between
the groups.

Differences in dietary intakes between the groups under
study can be explained by the differences in physical condi­
tion, rather than by age differences. Although the mean age
of the two groups of female nursing home residents is
somewhat higher than the mean age of the free-living elderly
females, statistical analyses excluding people outside the
age range of 70–80 years (n = 23) in the Resident group did
not yield different results. In fact, mean energy intake in this
subgroup was even lower (mean ± SD = 6.1 ± 1.2 MJ/


day, n = 17). The nursing home residents all suffer from
chronic somatic disabilities, which means they are in poor
physical condition. Within the two groups of free-living
elderly, the higher BMI and MUAC, together with the

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**Table 4. Percentage of Elderly People in Different Categories Receiving Less Than the Recommendations (RDA)
or Less Than the Minimum Requirements (Minimum Need) From Diet Alone**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Reference Value</th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nursing Homes</td>
<td>Free Living</td>
<td>Nursing Homes</td>
<td>Free Living</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resident</td>
<td>Admission</td>
<td>SENECA</td>
<td>4-Day Marches</td>
</tr>
<tr>
<td>Thiamin</td>
<td>RDA .12 mg/MJ and &gt;1.0 mg/day</td>
<td>88^a</td>
<td>91^ab</td>
<td>71^ab</td>
<td>44^a</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>RDA .13 mg/day (females); .15 mg/day (males)</td>
<td>55^a</td>
<td>45^a</td>
<td>31^a</td>
<td>6^a</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>RDA .02 mg/g protein^b</td>
<td>62^a</td>
<td>45^a</td>
<td>26^a</td>
<td>12^a</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>RDA 70 mg/day</td>
<td>45^a</td>
<td>36^b</td>
<td>19^a</td>
<td>9^a</td>
</tr>
<tr>
<td></td>
<td>Minimum need .015 mg/g prot. and &gt;1.0 mg/day</td>
<td>58^a</td>
<td>45^a</td>
<td>31^b</td>
<td>6^c</td>
</tr>
<tr>
<td></td>
<td>Minimum need 50 mg/day</td>
<td>72^a</td>
<td>64^a</td>
<td>16^a</td>
<td>3^a</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

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Notes. ^Requirements according to the Dutch Nutrition Council (1992). Intakes should be at least 1.0 mg/day and 1.1 mg/day for females and males, respectively (aged 65 years and older). ^bOn each row, for females and males separately, values sharing the same capital letter are not significantly different (Fisher's exact test for 2 x 2 tables, p < .01).
energy intakes which tended to be lower in the SENECA group compared to the 4-day marches group, confirm that energy expenditure in the latter group is higher. As a consequence the groups can be classified as different categories of aging. Both nursing home groups represent the accelerated or high-risk agers, whereas the sedentary Dutch SENECA participants can be considered as usual agers, and the elderly participants in the annual four-day long-distance march are successful agers (Rowe and Kahn, 1987; Harris and Feldman, 1991).

In all groups, the same modified dietary history technique was used, thus enabling a valid comparison of habitual food consumption between these groups. This technique has been validated against a 3-day weighed record (Nes et al., 1991), and our research group has much experience in its use of groups of apparently healthy, free-living elderly but not in institutionalized people (de Groot and van Staveren, 1988; Amorim Cruz et al., 1991; Nes et al., 1991; Voorrips et al., 1991; Visser et al., in press). There are no indications, however, that the results are confounded by the presence of somatic disabilities in the latter groups.

The energy requirement is dependent mainly on basic metabolic rate (BMR), dietary induced thermogenesis (DIT), and physical activity (FAO/WHO/UNU Expert Consultation, 1985; Young, 1992). It is suggested by the FAO/WHO/UNU that the survival requirement for energy is 1.27 \( \times \) BMR and that at group level the adequate energy intake should be at least 1.4 \( \times \) BMR. Goldberg et al. (1991) concluded that recorded energy intakes below 1.35 \( \times \) BMR, either in individuals or on group level, are most unlikely to represent habitual intake. By using the regression equations calculated by Schofield (1983) to estimate BMR from body weight, the assessed mean energy intakes in all groups of males as well as females in the present study exceeded the estimated minimum energy needs (based on 1.4 \( \times \) BMR). The exception was the females in the Resident group (7.3 MJ/day for female nursing home residents, 7.3 and 8.6 MJ/day in the Admission group, 7.6 and 8.7 MJ/day in the SENECA group, and 7.3 and 8.5 MJ/day in the 4-day marches group for females and males, respectively). The reason for the low intake figures in the Resident group may be due to the very sedentary life style or to underreporting.

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**Figure 1.** A: percentage of dietary thiamin intake provided by different food groups. B: percentage of dietary riboflavin intake provided by different food groups. C: percentage of dietary vitamin B6 intake provided by different food groups. D: percentage of dietary vitamin C intake provided by different food groups.
However, the results are in line with another Dutch study in which dietary intakes of female elderly nursing home residents were compared with females living in service flats (assisted living apartments) or independently living elderly females (Löwik et al., 1992).

In a recent study using our dietary assessment technique, it was found that healthy elderly women tended to underestimate their energy intake by 12% (Visser et al., in press). This indicates that the actual prevalences in dietary inadequacy in the 4-day marches group and possibly in the SENECA group may be lower than reported here.

Studies on seasonal variation in intake of energy and water-soluble vitamins showed that such variation is unlikely to occur in The Netherlands (van Staveren et al., 1986; Hulshof, 1993). Therefore, although the dietary data in our study have not been collected in exactly the same period of the year, it is not likely that the differences in dietary intakes as found between the groups are biased by seasonal influences.

In contrast to Mensink and Arab (1989) and Voorrips et al. (1991), we detected a difference in energy intake of about 1 MJ/day between the physically active 4-day marches group and the more sedentary SENECA group. This is most likely a result of the greater difference in degree of physical activity between the groups we studied. All groups in the other studies may fall within the range of physical activeness in the SENECA participants.

The Dutch recommendations for micronutrients (RDAs) are defined as "levels of intake which are desirable to aim at when programming the food supply of a section of a population or a homogenous category within this population" (Dutch Nutrition Council, 1992). In the United States (National Research Council, 1989) the RDA for thiamin is the same as in The Netherlands (Dutch Nutrition Council, 1992). For riboflavin, vitamin B6, and vitamin C, however, the Dutch recommendations are higher than the United States RDAs. Another difference between the recommendations is that, unlike in The Netherlands, the United States RDAs do not utilize minimum needs of vitamins, but use a proportion of the RDA (most often 2/3) as the cut-off for judgment of dietary adequacy. Estimating the minimum need by using 2/3 of the United States RDA results in lower prevalences of inadequate dietary riboflavin intakes. In females the prevalences become 8% for the Resident group, 45 and 30% for Admission females and males, and 4% for the SENECA group, and in males 10% for the Resident group, 10% for the Admission group, and 15% for 4-day marches females and males, respectively. The United States RDA for vitamin C is 60 mg/day, leading to slightly lower prevalences of inadequate intakes when using 2/3 of the recommendation. Although the prevalence of inadequate intakes of the vitamins thiamin, riboflavin, B6, and C is lowest in the 4-day marches participants, and despite the reasonably normal mean energy intake in this group, a few persons still have intakes below the minimum requirements, as determined by the Dutch Nutrition Council. Whether this is due to inadequacy of actual intakes, to underreporting of dietary intake by the more active people (Visser et al., in press), or to a conservative safe level of minimum requirements is not clear.

No clear differences in food consumption patterns have been found between the four groups of elderly people. For example, in males and females of all groups, 75—85% of the B vitamins provided by grain products came from brown or whole grain products. Therefore, a reduced absolute amount of food consumed (energy intake) seems to be the main reason for dietary inadequacy in this study. It has been stipulated that below an energy intake of 6.3 MJ/day (1500 kcal), it is very difficult to maintain adequate dietary micro-nutrient density (Lowenstein, 1982). A total of 50 participants in our study (45 females and 5 males) had an energy intake less than 6.3 MJ. Of these participants, 88% had dietary intakes below the minimum needs of at least one, and 60% of at least two out of the four vitamins under study. For comparison with higher intakes, of the people consuming 7 MJ/day or more (n = 81 females and 83 males), these figures were 25 and 6%, and of the people consuming at least 8 MJ/day (n = 58 females and 69 males) 20 and 2%, respectively.

From this study, it can be concluded that the dietary intakes of the vitamins thiamin, riboflavin, B6, and C are inadequate in almost half of the nursing home residents under study. It can be questioned whether adequate intake levels could be achieved by a change in food selection alone, since the energy intake is low. Although the absolute food intake of free-living elderly is higher than the intakes in nursing homes, a substantial part of the former category is still at risk of having an inadequate supply of these vitamins from diet alone. For those people, stimulating an increase in physical activity may stimulate the energy intake without leading to problems of weight gain. In periods of lack of appetite for various reasons, easily consumable micro-nutrient-dense products might help to ensure adequate intakes of these micronutrients and to prevent nutrient deficiencies.

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