Energy intake and micronutrient intake in elderly Europeans: seeking the minimum requirement in the SENECA study

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Abstract

Objective: to examine energy intake of elderly people participating in the Survey in Europe on Nutrition and the Elderly, a Concerted Action (SENECA) study in relation to the adequacy of micronutrient intake.

Design: data from eight countries on 486 men and 519 women who were 74–79 years old. Dietary intakes of energy, iron, thiamine, riboflavin and pyridoxine were calculated.

Results: there was inadequate intake of one or more nutrients in 23.9% of men and 46.8% of women. The prevalence of inadequate intakes decreased gradually with higher energy intakes. Of all people with energy intakes exceeding 1500 kcal, 19% of men and 26% of women still had an inadequate intake of at least one micronutrient.

Conclusion: we found no single criterion ensuring level of energy intake with an adequate micronutrient supply. The prevalence of an inadequate intake of micronutrients was high at all energy intake levels, especially in women

Keywords: elderly people, energy intake, micronutrient supply

Introduction

Food intake and energy intake decrease with ageing [1, 2]. Reasons for this include immobility, malabsorption, a decline in the senses of smell and taste, difficulties with chewing and social and financial problems [3–5]. The requirement for dietary energy often falls, because of reduced activity and a lower resting metabolic rate [1, 6–8]. However, the requirement for most minerals and vitamins does not decrease [9, 10], and a well-balanced diet is important to prevent an inadequate intake of micronutrients.

Lowenstein [11] has suggested a reference value of 1500 kcal as minimum daily energy intake level for an adequate micronutrient supply for elderly people. This reference value has been used to evaluate whether the energy intake of elderly people is adequate [12, 13]. Our research question is: at what energy levels are micronutrient needs met for most elderly people who participated in the SENECA (Survey in Europe on Nutrition and Elderly, a Concerted Action) study?

We describe the prevalence of an inadequate intake in relation to energy intake. We hoped to find a minimum requirement value for energy intake in elderly people, for which a regular diet would supply sufficient intake of the selected nutrients.

Subjects and methods

Study design

We used data from the SENECA follow-up study. At the beginning of the study in 1988, the study centres were asked to select a town of 10 000–20 000 inhabitants with a socio-economic and population structure similar to that of the country as a whole. People born between 1913 and 1918 were invited to participate. The median participation rate was 51% at baseline. Overall, 41–74% of the former participants could be reached in towns that had participated. Thirteen towns from 12 countries were included in the follow-up study.
We asked about the socio-geographical situation, life-style, health, activities and dietary habits. Anthropometric data were obtained and blood-samples taken. All measurements were standardized [14].

**Subjects**

We used data from nine of the 13 centres. Other centres were excluded because the nutrient intake data were incomplete, the number of people was too small or because data were collected at the other centres. The towns included were Hamme (Belgium), Roskilde (Denmark), Haguenau (France), Romans (France), Culemborg (The Netherlands), Vila Franca de Xira (Portugal), Betanzos (Spain) and Yverdon (Switzerland). The research towns have been described in more detail with the results of the baseline study [15]. Approval for the study was obtained from local ethical committees.

We collected data from 486 men and 519 women. Table 1 describes these participants by site. The mean age of the total study population was 77.2 years. Men were more highly educated and less likely to live alone. Large differences between the different towns were found, especially in education levels and in percentages of subjects living alone. The large standard deviation of pooled mean weight may be explained in part by a large difference in mean weight between the centres.

### Dietary method

Dietary intake data were obtained by a modified version of the dietary history method [14]. After a 3-day estimated record, a frequency checklist of foods was used to estimate the usual daily intake of food, with the last month as a reference period. Portion sizes were checked by weighing household measures and quantities of foods most frequently eaten. The intake of nutrients was calculated using local food composition tables [15]. We calculated intakes of calcium, iron, retinol (vitamin A), β-carotene, thiamine (vitamin B1), riboflavin (vitamin B2), pyridoxine (vitamin B6) and vitamin C.

### Data treatment

We used a selected number of micronutrients for the study: iron, thiamine, riboflavin and pyridoxin. This was based on the relationship of these micronutrients with energy intake (Table 2) and on data from the validation study, which was part of the baseline survey [16].

As reference values for an inadequate intake of the micronutrients (Table 3), the Dutch Minimum Requirements were used [17]. These values are comparable with two-thirds of the American Recommended Dietary Allowances (RDA) [18] which are close to the UK Estimated Average Requirements for people aged 50+ years [19].

For all statistical procedures the SAS software package was used (Statistical Analyses System, SAS Institute Inc., Cary, NC, USA). All analyses were carried out by gender and centre. Overall data are presented because no large differences between centres emerged.

### Results

**Inadequate intakes of the selected micronutrients**

The prevalence of inadequate nutrient intake was high.
When the Dutch Minimum Requirements were used, 23.9% of the men and 46.8% of the women had an inadequate intake for at least one nutrient. Iron and riboflavin were responsible for the highest prevalences of inadequate intakes. Women more often had a lower nutrient inadequate intake than men (Table 4).

The percentage of men and women with an inadequate intake for at least two nutrients was lower when two-thirds of the American RDA was used. However, the percentage of men with an inadequate intake of at least one nutrient was much larger when this measure was used.

For some nutrients, inadequacies varied markedly between centres. For iron, many people with an inadequate intake were found in Portugal. Many of men and women in Belgium had an inadequate intake for riboflavin.

Micronutrient intake and energy intake

Figure 1 presents the prevalence of inadequate intakes, according to the Dutch Minimum Requirement, using different cut points for energy intake. With increasing energy intake, the percentages of men with an inadequate intake of at least two nutrients fell from 45% to 5%. The percentage of women with an inadequate intake of two nutrients or more fell from 50% to 17%. Also, the prevalence of an inadequate intake of one nutrient decreased with increasing energy intake (from 45% to 19% in men and from 39% to 30% in women). The number of men with an inadequate intake of at least one nutrient increased gradually until the cut-off value of 2200 kcal, whereas the number of women with an inadequate intake of at least one nutrient increased steeply until the cut-off value of 1900 kcal. Between 1900 and 2300 kcal the number of women with an inadequate intake increased more slowly.

Those with a low energy intake did not compensate for the low micronutrient intake by eating foods with a higher nutrient density. Conversely, a very high energy intake did not guarantee an adequate nutrient intake. Of all people with an energy intake of 1900 kcal and more, 13% of the men and 16% of the women still had an inadequate nutrient intake.

Figure 1 and Table 4 show that it is difficult to give a specific recommendation for energy intake. Above a reference value of 1500 kcal/day, many still had an inadequate micronutrient intake (19% of the men and 26% of the women). In order to aim at a certain percentage of individuals with an adequate nutrient intake, a recommendation for energy intake can be estimated.

The prevalence of inadequate intake of iron and riboflavin was very high. These two nutrients were responsible for inadequate nutrient intake in most people. The percentage of men with inadequate iron intake fell from 75% with energy intake of 1300 kcal or less to 17% with energy intake of 1900 kcal or less. For women, this percentage fell from 66% to 30%. With regard to riboflavin, the percentage of men with an inadequate intake fell from 55% to 30% and the percentage of women fell from 68% to 43%. Only four people had an inadequate intake of thiamine. The percentage of people with an inadequate intake of pyridoxine ranged between 8% and 15%.

Table 2. Spearman’s rank-correlation coefficients of energy intake with micronutrient intake

<table>
<thead>
<tr>
<th>Selected nutrients</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>0.64</td>
<td>0.73</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.65</td>
<td>0.75</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.47</td>
<td>0.57</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>0.58</td>
<td>0.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excluded nutrients</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>0.41</td>
<td>0.56</td>
</tr>
<tr>
<td>Retinol</td>
<td>0.31</td>
<td>0.37</td>
</tr>
<tr>
<td>β-carotene</td>
<td>0.25</td>
<td>0.18</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>0.14</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Table 3. Recommendations for the intakes of iron, thiamine, riboflavin and pyridoxine, according to different sources

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Dutch Minimum Requirement&lt;sup&gt;a&lt;/sup&gt; (adults)</th>
<th>Two-thirds of the American RDA&lt;sup&gt;b,c&lt;/sup&gt; (≥51 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (mg/day)</td>
<td>8</td>
<td>6.7</td>
</tr>
<tr>
<td>Thiamine (mg/day)</td>
<td>0.8 and 0.29 mg/1000 kcal</td>
<td>Men: 0.8 and 0.33 mg/1000 kcal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Women: 0.7 and 0.33 mg/1000 kcal</td>
</tr>
<tr>
<td>Riboflavin (mg/day)</td>
<td>1.1</td>
<td>0.9 (men)/0.8 (women)</td>
</tr>
<tr>
<td>Pyridoxine (mg/day)</td>
<td>1.0 and 0.015 mg/g protein</td>
<td>1.3 (men)/1.1 (women)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Source: Netherlands Food and Nutrition Council [17]; <sup>b</sup>Recommended Dietary Allowances. Source: National Research Council [18].
<sup>c</sup>CLOSE to dietary reference values for the United Kingdom [19]: iron: 6.7 mg/day; thiamine 0.3 mg/1000 kcal; riboflavin 1.0/0.9 mg/day (all Estimated Average Requirements); pyridoxine 1.4/1.1 mg/day (RNI).
Our results show a decrease in the prevalence of an inadequate nutrient intake with higher energy intakes in elderly people. Iron and riboflavin were the nutrients which accounted for most inadequacies. The inadequate intake in some towns is most probably due to differences in food habits, since centres with less valid intake measurements were excluded. Above the reference value of 1500 kcal [11], 19% of the men and 26% of the women still had inadequate nutrient intake.

The recommendations of the Dutch Minimum Requirement differed only slightly from those of two-thirds of the American RDA (which for thiamine, riboflavin and iron are close to the UK Estimated Average Requirements). However, for some nutrients the differences in percentages of subjects with an inadequate nutrient intake were large. The overall percentage of inadequate nutrient intake in men was higher when two-thirds of the American RDA was used, mainly because the prevalence of subjects with an inadequate pyridoxine intake was much higher. Although the prevalence of pyridoxine-inadequacy was also higher in women when two-thirds of the American RDA was used, the overall percentage of women with an inadequate nutrient intake was almost the same according to the two reference values. A lower prevalence of riboflavin-inadequacy compensated for the higher prevalence of pyridoxine-inadequacy. The Dutch Minimum Requirement estimated a value necessary to maintain a metabolic balance, to prevent deficiency, to maintain an adequate store of a nutrient in the body and to compensate for losses of a nutrient in all adults [17].

For the American RDA the oldest group for which recommendations are given was 51 years and older. Russell and Suter studied whether the American RDA of 1989 for vitamins should be adjusted for elderly people [10]. There was no evidence that the RDA for thiamine was inappropriate according to their study. The RDAs for riboflavin and pyridoxine should be raised: the margin for error appeared to be too small for riboflavin intake, while the pyridoxine requirement seemed to be affected by age. This will lead to a higher prevalence of an inadequate intake of riboflavin and pyridoxine, and thus a higher prevalence of inadequacy of the diet in general.

The diet varied between towns and socio-demographic groups. In this study, a quite healthy population was studied and still many had an inadequate nutrient intake. The low intakes were not paralleled by biochemical deficiencies. However, inadequate nutrient reserves may make elderly people more vulnerable during illness.

The modified dietary history method has been validated with different reference methods. In both the baseline and the follow-up study of the SENECA project, the method was validated using a record

### Table 4. Prevalences of inadequate intakes of various nutrients in men and women, according to the Dutch Minimum Requirement and two-thirds of the American Recommended Dietary Allowances (RDA)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean intake (and SD)</th>
<th>Inadequate intake according to</th>
<th>Two-thirds of the American RDAb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (mg) Nutritional density (mg/1000 kcal)</td>
<td>Dutch Minimum Requirementa</td>
<td>n</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------</td>
<td>--------------------------------</td>
<td>n</td>
</tr>
<tr>
<td>Men</td>
<td>Iron 13.4 (4.1) 6.4 (1.4)</td>
<td>35</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>Thiamine 1.1 (0.4) 0.6 (0.2)</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Riboflavin 1.7 (0.9) 0.8 (0.4)</td>
<td>85</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Pyridoxine 1.5 (0.5) 0.7 (0.2)</td>
<td>25</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>≥1 nutrient</td>
<td>116</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>≥2 nutrients</td>
<td>24</td>
<td>4.9</td>
</tr>
<tr>
<td>Women</td>
<td>Iron 10.2 (3.1) 6.3 (1.4)</td>
<td>121</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td>Thiamine 0.9 (0.3) 0.6 (0.1)</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Riboflavin 1.4 (0.7) 0.9 (0.4)</td>
<td>177</td>
<td>34.1</td>
</tr>
<tr>
<td></td>
<td>Pyridoxine 1.1 (0.4) 0.7 (0.2)</td>
<td>46</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td>≥1 nutrient</td>
<td>243</td>
<td>46.8</td>
</tr>
<tr>
<td></td>
<td>≥2 nutrients</td>
<td>90</td>
<td>17.3</td>
</tr>
</tbody>
</table>

aSource: Netherlands Food and Nutrition Council [17]; bSource: National Research Council [18].

cRange of percentages for the eight centres.

**Discussion**

Our results show a decrease in the prevalence of an inadequate nutrient intake with higher energy intakes in elderly people. Iron and riboflavin were the nutrients which accounted for most inadequacies. The inadequate intake in some towns is most probably due to differences in food habits, since centres with less valid intake measurements were excluded. Above the reference value of 1500 kcal [11], 19% of the men and 26% of the women still had inadequate nutrient intake.

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The modified dietary history method has been validated with different reference methods. In both the baseline and the follow-up study of the SENECA project, the method was validated using a record
method as a reference [16, 20]. Both validation studies found a relative overestimation of the intakes of energy and most nutrients when the dietary history method was used. However, the nutrient density (intake per 1000 kcal) of the diet was measured correctly by the dietary history method.

The dietary history method has also been validated using a measurement of total energy expenditure as a reference method [21]. There is an underestimation of energy intake of about 12% with the dietary history method. If the intakes of the selected micronutrients have also been underestimated, the problem of inadequate dietary intakes in our study population might be less serious than stated. The perfect method to measure dietary intakes in elderly subjects has yet to be developed.

Observed trends toward decreasing energy intakes in older age [22–24] have led to concerns that energy intakes may become too low to support an adequate intake of all essential nutrients [25]. Older individuals may have higher energy requirements than current recommendations [26, 27] and are less able to control food intake [27]. Our findings support the recommendation of the UK Working Group on the Nutrition of Elderly People of the Committee on Medical Aspects of Food Policy [25] that energy intakes of elderly people should be increased. However, obesity should be avoided as, even in old age, heavier weights are associated with morbidity [28] and mortality [29]. Increased physical activity—both aerobic and strength-training—should be encouraged as it will encourage higher energy intakes as well as improving the general health of elderly people [30, 31].

Figure 1. Number and percentage of a men and b women with an inadequate intake of no nutrients (□ and △), one nutrient (■ and ○) and at least two nutrients (■ and □) for groups with energy intakes under different cut points.
Key points

- There is inadequate intake of one or more nutrients in 24% of elderly European men and 47% of elderly European women.
- Iron and riboflavin accounted for most of the inadequacies studied.
- No single criterion value for energy intake ensuring an adequate micronutrient supply could be identified.
- Above the reference value of 1500 kcal/day, 19% of elderly men and 26% of elderly women still had an inadequate nutrient intake.

References


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