Vitamin D requirement and setting recommendation levels – current Nordic view

Jan I Pedersen

At the latitude of the Nordic countries, where there is almost no dermal formation of vitamin D during winter, dietary intake is required to avoid deficiency. Dietary intake is of the order of 4–5 μg/day but varies widely. The lowest intake is seen among adolescents. Low levels of serum 25(OH)D have been found in population groups in all Nordic countries. The drop in 25(OH)D during the winter months may be considerable, falling below acceptable levels (50 nmol/L) in one half of the population. To ensure an acceptable vitamin D status is maintained in the population and to diminish the seasonal drop in 25(OH)D, the Nordic Nutrition Recommendations 2004 increased the vitamin D recommendation for the age group 2–60 years by 50% from 5 μg/day to 7.5 μg/day. To attain such an intake at the population level, public health actions, including information dissemination and increased fortification of foods, are necessary.

©2008 International Life Sciences Institute

INTRODUCTION

For several decades, the Nordic countries have collaborated in setting guidelines for dietary composition and recommended intakes of nutrients. Similarities in dietary habits as well as in the prevalence of diet-related diseases warrant a common focus on the gross composition of the diet as well as its contents of micronutrients. The first official Nordic Nutrition Recommendations (NNR) were issued in 1980 and the fourth edition in 2004.1 NNR have served as a basis for national recommendations and have been important for various issues in the areas of food, nutrition, and health policy, for the formulation of food-based dietary guidelines, and for diet and health-related campaigns.

The working group of the 2004 edition reviewed and evaluated scientific work, national and international recommendations, and expert reports. A Nordic perspective was taken into consideration and changes were introduced only when strong scientific evidence had evolved since the previous edition. One important change in NNR 2004 was that the recommendation for vitamin D, which had been unaltered since 1989, was increased by 50% for children and adults up to age 60 years. Some of the arguments for the present recommendations for vitamin D are outlined below.

Vitamin D₃ or cholecalciferol* is a steroid-like molecule that is synthesized from 7-dehydrocholesterol in the skin under the influence of ultraviolet B light (wavelength between 290 nm and 315 nm).2 It may also be derived from the diet. Sun exposure of the skin is more important than diet, and dermal production can cover the requirement for the vitamin completely. A rather modest exposure to sunlight is sufficient to produce a satisfactory amount of vitamin D in the skin.2 Exposure of the face, arms, hands, and legs to sunshine for 6–8 min 2–3 times a week is more than adequate to satisfy the requirement.3 Experience demonstrates, however, that under our living conditions and at the latitude of the Nordic countries vitamin D deficiency may occur if the diet is devoid of the

Affiliation: JI Pedersen is with the Institute of Basic Medical Sciences, Department of Nutrition, University of Oslo, Oslo, Norway.

Correspondence: JI Pedersen, Institute of Basic Medical Sciences, Department of Nutrition, University of Oslo, P.O. Box 1046 Blindern, 0316 Oslo, Norway. E-mail: j.i.pedersen@medisin.uio.no, Phone: +47-22851358, Mobile: +47-97534755.

Key words: vitamin D deficiency, vitamin D status, osteomalacia, rickets

* One IU (international unit) corresponds to 0.025 μg vitamin D.


Nutrition Reviews® Vol. 66(Suppl. 2):S165–S169 S165
vitamin. Infants may develop rickets and elderly people osteomalacia. For this reason, vitamin D has to be considered a micronutrient.

The liver rapidly takes up vitamin D formed in the skin or absorbed from the gut where it is hydroxylated to 25-hydroxyvitamin D \([25(OH)D]\). This metabolite is transported in plasma bound to the vitamin D binding protein. The circulating concentration of \(25(OH)D\) is a good marker of vitamin D status. The distribution in the healthy population is generally found to be 25–125 nmol/L.

Vitamin D is also a prohormone because \(25(OH)D\) is further converted to a hormone (1,25-dihydroxyvitamin D) in the kidney. The main functions of this hormone are to stimulate calcium absorption in the gut, mobilize calcium from bone and, to a certain extent, stimulate reabsorption of calcium in the kidney. It is now clear that vitamin D has several other functions related to cellular differentiation and metabolism and which are of importance for several health conditions.4,5

There is a strong seasonal variation in serum \(25(OH)D\).6 A Danish study illustrates the marked downward shift during the winter months, with levels falling below desirable vitamin D status in one half of the population (Figure 1).7

Under Nordic climatic conditions, exposure to sunlight is thus insufficient for enough vitamin D to be formed in the skin and for vitamin D status to be maintained during the winter months. A study from northern Finland in 1980 showed that vitamin D status was satisfactory during the summer months but that a large number of subjects had unsatisfactory vitamin D status during winter.8 On the other hand, more satisfactory serum levels of \(25(OH)D\) and greater seasonal variation was found among adults in a similar study from Tromsø in northern Norway.9 The results of these studies indicate that the light intensity at 70 degrees north is sufficient during summer to elicit vitamin D formation in the skin. One explanation for the difference observed in vitamin D status between the two population groups during the winter months is that, at the time of these studies, the consumption of fish and margarine fortified with vitamin D was much higher in Norway than in Finland. Dietary vitamin D is thus essential to ensure satisfactory vitamin D status at northern latitudes, particularly during the winter months. The question is how much is needed and what intake should be recommended?

**RECOMMENDED INTAKE VERSUS REQUIREMENT**

Recommended intake of a nutrient is not equivalent to the requirement. The requirement is the lowest amount needed to avoid clinical symptoms or to avoid physiological or biochemical changes that might indicate sub-optimal health. Recommended intake includes a safety margin that takes into account individual variability and uncertainties in the data. In NNR 2004 the term “recommended intake” (RI) refers to “the amount of a nutrient that according to present knowledge can meet the known requirement and maintain good nutritional status among practically all healthy individuals”.10

Recommended intakes, as expressed in the NNR 2004, are primarily valid for groups of healthy individuals and are to be used as a basis for diet planning. As such, they are essential for the health authorities to make decisions on topics such as food fortification.

**PROBLEMS IN SETTING RECOMMENDATIONS**

A primary problem in setting recommendations is choosing the criteria to be used as a basis for them. Initially, disease states and clinical symptoms were used. Thus, amounts needed to prevent or cure rickets or osteomalacia were used to arrive at recommendations for vitamin...
A daily dose of 2.5 µg of vitamin D was found sufficient to cure or prevent rickets or osteomalacia.\textsuperscript{11,12} Adding what was considered a reasonable margin of safety, a daily intake of 10 µg was recommended for infants and 5 µg for the other age groups. The effect of dietary vitamin D on the concentration of 25-hydroxyvitamin D in plasma is now the criterion generally used as a basis for recommendations. But this raises a new question, namely, what functional criteria should be used to set reference values for 25(OH)D?

**CRITERIA USED FOR EVALUATING VITAMIN D STATUS**

Serum 25(OH)D can be used to grade different levels of vitamin D status based on the following clinical and functional criteria.

1) Clinical symptoms: rickets is seen at levels <12 nmol/L,\textsuperscript{13} osteomalacia is seen in the range of 12–20 nmol/L,\textsuperscript{14–16} histological signs of osteomalacia may be seen at levels <30 nmol/L.\textsuperscript{14,17}

2) Effect on serum concentration of 1,25(OH)\textsubscript{2}D that will increase with serum 25(OH)D up to 40–50 nmol/L.\textsuperscript{18,19}

3) Absorption of radiocalcium attains a level with serum 25(OH)D at 50 nmol/L.\textsuperscript{18}

4) Secretion of parathyroid hormone (PTH) increases at low levels of 25(OH)D and the lowest level associated with normal PTH would ideally be a criterion of choice. PTH, however, also depends on other factors like calcium intake and age; therefore, variable values of 25(OH)D, mostly in the range of 38–80 nmol/L, have been reported to be associated with hyperparathyroidism.\textsuperscript{7,20}

5) Associations with different health outcomes in epidemiological studies have indicated a favorable range of 75–100 nmol/L. Such “soft” endpoints have not, however, been used in connection with recommendations.

6) Results from randomized control studies would be a useful basis for recommendations. Only one such study relevant for vitamin D has been published showing reduced risk of cancer when serum concentration of 25(OH)D was above 80 nmol/L, corresponding to a daily intake of 20 µg vitamin D.\textsuperscript{21}

### REFERENCE VALUES OF 25(OH)D FOR EVALUATION OF VITAMIN D STATUS IN THE POPULATION

The values given below have been used to evaluate vitamin D status in the population in two recent official reports from Denmark\textsuperscript{7,22} and Norway.\textsuperscript{23} They are in agreement with those proposed by Lips.\textsuperscript{20}

Serum or plasma 25(OH)D > 50 nmol/L is characterized as acceptable, 25–50 nmol/L as suboptimal or reflective of vitamin D insufficiency, 12.5–25 nmol/L as indicative of vitamin D deficiency, and <12.5 nmol/L as serious vitamin D deficiency.

### RECOMMENDED DAILY INTAKE OF VITAMIN D

To ensure an acceptable vitamin D status in the population, the daily vitamin D intake according to age, as recommended by NNR 2004,\textsuperscript{24} is as follows: 6–23 months, 10 µg/day; 2–9 years, 7.5 µg/day; 10–60 years, 7.5 µg/day; >61 years, 10 µg/day.

Compared to the previous edition of NNR, the recommendation for the age groups 2–60 years has been increased by 50% from 5 µg/day to 7.5 µg/day; this is in order to diminish the seasonal drop in plasma 25(OH)D during the winter months. It has been estimated that 12.5 µg/day might be needed to more completely alleviate the drop during winter.\textsuperscript{25} At the present time, such a high recommendation would be difficult to satisfy at the population level through dietary or fortification measures. For the elderly population >61 years it is, in principle, possible to plan diets containing 10 µg/day, but in practice, most elderly individuals would have to rely on supplementation. Elderly individuals with little or no sun exposure should receive a supplement of 10 µg/day in addition to their dietary intake. This is based on several studies showing the effect of calcium and vitamin D supplementation on the risk of osteoporotic fractures.\textsuperscript{26}

### DIETARY INTAKE OF VITAMIN D

The mean intake of vitamin D in Nordic populations is considerably lower than that recommended in all Nordic countries. In a recent report on vitamin D status in the Norwegian population from the National Nutrition Council, vitamin D intake was estimated from several dietary surveys,\textsuperscript{23} the results are shown in Tables 1 and 2.

**Table 1: Dietary intake of vitamin D (supplements excluded) during the last 25 years in Norway, household surveys.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>µg/day (mean)</td>
<td>4.1</td>
<td>4.0</td>
<td>4.5</td>
<td>4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>µg/10 MJ</td>
<td>4.0</td>
<td>3.9</td>
<td>4.9</td>
<td>4.7</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Reproduced from the National Nutrition Council (2006).\textsuperscript{21}
More than half of the individuals in the different age groups had intake levels below the recommended amount. Even if supplements are taken into account, the intake is low in many age groups. Most seriously, the intake is very low during adolescence, the period of life when bone formation and the need for absorbed calcium is highest.

The most important sources of vitamin D in Norway are enriched margarine and fish. A large variation in intake is found when considering both dietary and total intake when supplements are included (Figure 2).

**CONCLUSION**

Vitamin D intake is at about the same low level in Norway and the other Nordic countries. It is slightly higher in Iceland due to widespread use of cod liver oil and slightly lower in Denmark because, until recently, food fortification has not been used. In all Nordic countries, steps are now taken to increase vitamin D intake at the population level in order to reach the new increased recommendations. In addition to disseminating information, increased fortification of foods is essential to reach this goal.

**Acknowledgment**

*Declaration of interest.* The author has no relevant interests to declare.

**REFERENCES**


---

**Table 2** Intake of vitamin D (µg/day) in different age groups according to a Norwegian nationwide survey (mean SD).

<table>
<thead>
<tr>
<th>Age group</th>
<th>No. of subjects</th>
<th>Vitamin D without supplement (µg/d)</th>
<th>Vitamin D with supplement (µg/d)</th>
<th>Below recommended intake (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 months, not breast fed</td>
<td>1231</td>
<td>9.4 (6.2)</td>
<td>10.0 (7.0)</td>
<td>66</td>
</tr>
<tr>
<td>2 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>852</td>
<td>2.5 (1.2)</td>
<td>7.1 (5.6)</td>
<td>64</td>
</tr>
<tr>
<td>Boys</td>
<td>868</td>
<td>2.8 (1.5)</td>
<td>6.8 (5.3)</td>
<td>64</td>
</tr>
<tr>
<td>4 år years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>185</td>
<td>2.4 (1.5)</td>
<td>5.0</td>
<td>77</td>
</tr>
<tr>
<td>Boys</td>
<td>206</td>
<td>2.7 (2.1)</td>
<td>6.4</td>
<td>69</td>
</tr>
<tr>
<td>9 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>411</td>
<td>2.6 (2.1)</td>
<td>3.9</td>
<td>87</td>
</tr>
<tr>
<td>Boys</td>
<td>404</td>
<td>3.1 (3.0)</td>
<td>4.5</td>
<td>85</td>
</tr>
<tr>
<td>13 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>517</td>
<td>2.4 (2.5)</td>
<td>3.9</td>
<td>87</td>
</tr>
<tr>
<td>Boys</td>
<td>492</td>
<td>2.8 (3.0)</td>
<td>4.5</td>
<td>85</td>
</tr>
<tr>
<td>16–29 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>354</td>
<td>3.4 (2.5)</td>
<td>8.8 (9.0)</td>
<td>55</td>
</tr>
<tr>
<td>Men</td>
<td>340</td>
<td>5.5 (4.1)</td>
<td>9.8 (10.0)</td>
<td>54</td>
</tr>
<tr>
<td>30–59 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>774</td>
<td>4.2 (2.8)</td>
<td>10.3 (9.1)</td>
<td>48</td>
</tr>
<tr>
<td>Men</td>
<td>721</td>
<td>5.9 (4.1)</td>
<td>11.0 (10.9)</td>
<td>51</td>
</tr>
<tr>
<td>60–79 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>246</td>
<td>4.0 (2.2)</td>
<td>12.5 (10.8)</td>
<td>47</td>
</tr>
<tr>
<td>Men</td>
<td>237</td>
<td>5.8 (3.8)</td>
<td>13.9 (11.0)</td>
<td>48</td>
</tr>
</tbody>
</table>

Data from the National Nutrition Council (2006).23

Figure 2 Vitamin D intake, including cod liver oil and supplements, in 2651 Norwegian women and men aged 16–79 years (1997). (Data from 21 persons with intakes >50 µg are not shown.) Reproduced from the National Nutrition Council (2006).23


