Vitamin D promotes absorption of calcium from the intestine and inhibits excretion via the kidneys. It also promotes bone mineralization and is thus necessary for healthy bones. In addition to this, vitamin D is important for cell differentiation and proliferation, for modulation of the immune system, and for other metabolic processes.

Vitamin D is not a vitamin in the true sense, but a hormone.

Unlike vitamins, which are only obtained from food, the biologically active hormone 1,25-dihydroxyvitamin D3 is synthesized from precursors by the body itself as a result of exposure to the UV-B fractions of sunlight. Since the intermediate, 25-hydroxyvitamin D3 (vitamin D3 (25-OH)), is the main storage form in the human body, it is this metabolite that should be used for determining total vitamin D status [1, 2].

In the period from February to April, roughly 60% of the German population has vitamin D deficiency, and even in summer the figure is about 40% (Fig. 1).

Causes and classification of vitamin D deficiency

Insufficient synthesis of vitamin in the winter months is due to the low angle of the sun’s rays and to the fact that many people spend less time in the sun. For people who go outside for about 30 minutes between 8:00 and 18:00 each day and keep their hands and face uncovered while they are out, the daily requirement of vitamin D
is 200 IU (5 µg). People who do not go outside for as long or who do not go out at all have a daily requirement of about 1000 IU vitamin D. Severe vitamin D deficiency exists when values are < 10 ng/ml and moderate to mild deficiency is present when values are 10-20 ng/ml. Vitamin D levels are sufficient when values are above 20-30 ng/ml [1].

Fig. 1: Seasonal pattern of 25-OH vitamin D3 levels. Results of the Bochum postmenopausal study on the seasonal course of 25-hydroxyvitamin D3. Investigation of a random sample of 1055 early-postmenopausal women between 45-65 years of age. Pfeilschifter J: 2008 Osteology Conference, Hanover

Possible connection between vitamin D deficiency and various clinical pictures

“Recent studies show the importance of vitamin D in the prevention of diseases. The basis of this is the finding that vitamin D receptors exist in nearly every cell. They are able to convert the inactive 25-hydroxyvitamin D circulating in the blood into the active 1,25-hydroxyvitamin D. It thus appears that, in addition to its classical role in bone metabolism, vitamin D performs a further function in numerous different diseases. Low concentrations of vitamin D may be associated with an increasing risk of chronic diseases, cancer, and autoimmune diseases and even cardiovascular disorders” (Fig. 3).

Osteoporosis, muscle weakness or muscle pain, and fibromyalgia
Low blood concentrations of vitamin D may encourage the development of osteoporosis through the metabolic effect on calcium metabolism in postmenopausal women especially [1, 3].

Diabetes
A predisposition to type 1 and type 2 diabetes appears to be promoted by vitamin D deficiency [3, 11]. Vitamin D receptors have been detected both on beta cells of the pancreas and on immune cells. Epidemiological studies have shown an association between vitamin D deficiency at a young age and the subsequent development of type 1 diabetes [11].
Cancer (breast, colon, prostate)
Vitamin D receptors are found in various tissues, such as the prostate, the mammary gland, and the colon. Vitamin D inhibits cell proliferation and induces cell differentiation. A connection between the relative risk of colorectal cancer and vitamin D levels has been demonstrated. Study results indicate that higher vitamin D concentrations have a positive effect in prostate and breast cancer [1, 3, 8].

A good supply of vitamin D is important in the prevention of bowel cancer. At a serum concentration of 37 ng/ml the incidence of cancer of the colon was half that observed at less than 6 ng/ml [14].

Autoimmune diseases (e.g. multiple sclerosis)
Vitamin D is an immunomodulator [1, 7, 8]. Data from a study from 2004 support the hypothesis that vitamin D can reduce the risk of multiple sclerosis [1, 9, 10].

Cardiovascular diseases
Vitamin D receptors are found on smooth-muscle cells and the endothelium of the blood vessels, among other places. This suggests that vitamin D deficiency has a role in the pathogenesis of vascular diseases [1, 3, 12]. Vitamin D probably has an effect on the renin-angiotensin system and thus, indirectly, on blood pressure [13].

For example, in the Health Professionals Follow-Up Study, the risk of a myocardial infarction was 2.4 times higher in men with vitamin D deficiency (25-OH-vitamin D < 15 ng/ml) than in men of the same age with adequate levels of the vitamin (levels over 30 ng/ml) [15].

### Optimal blood levels of vitamin D3 (25-OH)

Scientists recommend a blood vitamin D3 (25-OH) level of > 75 nmol/l (> 30 ng/ml) (Fig. 2) [3, 4, 5].

The optimal ranges are:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Optimal Vitamin D Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 50 years of age</td>
<td>between 20 and 70 ng/ml</td>
</tr>
<tr>
<td>From approx. 50 years of age</td>
<td>between 25 and 70 ng/ml</td>
</tr>
<tr>
<td>From approx. 70 years of age</td>
<td>between 30 and 70 ng/ml</td>
</tr>
</tbody>
</table>

In many people, supplementing the diet with 400 IU (international units, 40 IU corresponds to 1 µg) as recommended by the Deutsche Gesellschaft für Ernährung [German Nutritional Society] is not enough to achieve the minimum blood concentration [6, 7] and thereby ensure a preventive effect.

Experts therefore recommend that the vitamin D supply be checked by measuring the vitamin D3 (25-OH) level. Such a procedure is also recommended by Cannell and Hollis [4]. Sample requirement: 1 ml Serum.

It is often assumed that patients who regularly take vitamin D products will have adequate levels of vitamin D, but in many instances this is not actually the case! [1]
Fig. 2: The optimal serum level of vitamin D3 (25-OH) starts at 75 nmol/l. Relative risk (RR) of fractures and colon cancer as a function of the vitamin D3 25-OH concentration. Broken lines represent the connection between vitamin D3 25-OH concentration and bone density, and function of the lower extremities (measured using the so-called 8-foot (2.4 m) walk test). Continuous lines relate to the left axis, broken lines to the right axis. Fig. modified according to Bischoff-Ferrari et al. 2006 [3]. Factor for converting conventional unit of vitamin D3 (25-OH) concentration [ng/ml] into SI unit [nmol/l]: 2.496 [5].

**Prevention by regular measurement of vitamin D levels**

Vitamin D3 (25-OH) should be measured before and after treatment is started, particularly in patients who are in an at-risk group. It is necessary to make sure that:

- the vitamin D level from normal sources is adequate
- or
- oral intake of vitamin D compensates an existing deficiency

The following patients are particularly at risk:

- The elderly
- Postmenopausal women
- Pregnant women
- People with a dark complexion
- Anyone who spends too little time outdoors or covers up too much
- Patients with chronic kidney disease
- Patients with malabsorption syndrome

Vitamin D levels can be measured all year round.
If the vitamin D level is at the lower limit (below 30 ng/ml) at the first measurement, measurement should be repeated between January and April, as serum vitamin D3 (25-OH) levels are at their lowest and parathyroid hormone levels are at their highest after the winter months. If a deficiency is detected and a vitamin D supplement given (see, in this regard, the recommendations of the Deutsche Gesellschaft für Ernährung (DGE) [German Nutritional Society] for example), a check should be carried out after 4 months at the earliest.
Fig. 3: General significance of vitamin D3 for the various organ systems [16].

References:

2) Packungsbeilage Vitamin D3 (25-OH). Roche Diagnostics.
5) SI Units for Clinical Data, Umrechnungsfaktoren: http://www.unc.edu/~rowlett/units/scales/clinical_data.html
6) Holick MF et al. Vitamin D2 Is as Effective as Vitamin D3 in Maintaining Circulating Concentrations of 25-Hydroxy-vitamin D. J Clin Endocrinol Metab. 2008;93:677–681
10) Deutsche Multiple Sklerose Gesellschaft Bundesverband e.V. http://www.dmsg.de/multiplesklerose-news/inde.php?kategorie=forschung&cnr=31&anr=735
15) Arch Intern Med 168, 2008, 1174