

New recommendations for vitamin D intake

Nova priporočila za vnos vitamina D

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Ključne besede:

vitamin D, priporočila,
prehrana, prehranska
dopolnila

Key words:

vitamin D,
recommendations,
nutrition, food
supplements

Citirajte kot/Cite as:

Zdrav Vestn 2013;
82 supl 1: 1-145-51

Prispelo: 20. apr. 2013,
Sprejeto: 23. maj 2013

Izvleček

Vitamin D je v maščobi topen vitamin, ki igra pomembno vlogo pri razvoju kosti in imunskega sistema. O pomanjkanju vitamina D (pod 50 nmol/l) v vseh starostnih skupinah so veliko poročali v zadnjih letih. Pomanjkanje vitamina D se povezuje s povečanim tveganjem za srčno-žilne bolezni, raka, večjo umrljivost in avtoimunske bolezni. Do pomanjkanja prihaja predvsem zaradi sodobnega načina življenja in zaradi motenj v presnovi. Zadosten vnos vitamina D je težko doseči s prehrano, zato se priporoča uživanje prehranskih dopolnil z vitaminom D. Zadostna izpostavljenost soncu v poletnih mesecih (ultravijolični valovanje B, UVB) zagotavlja glaven vir vitamina D, ki se sintetizira v koži. Intenzivnost UVB se spreminja vse leto in ves dan. Najmočnejši UVB žarki so med 10. in 16. uro med aprilom in oktobrom (nad 40° zemljepisne širine). V svetu ni univerzalnih priporočil glede količine vitamina D, ki bi jo bilo potrebno dnevno zaužiti poleg prehranskega vira vitamina D. Svetuje se, da se vitamin D dodaja v celotnem življenjskem ciklu, še zlasti v času dojenja. Z dovolj visokim vnosom vitamina D v času dojenja (4.000 mednarodnih enot, ME/dan) lahko mati pokrije tako svoje prehranske potrebe po vitaminu D ter preko mleka tudi prehranske potrebe otroka (400 ME/dan). Vseeno pa je potrebno opraviti še več raziskav na tem področju, preden se sprejmejo tako visoka priporočila za doječe matere. Nove nemške referenčne vrednosti iz leta 2012 svetujejo 400 ME vitamina D/dan za dojenčke v prvem letu življenja, nato pa 800 ME/dan za vso populacijo.

Abstract

Vitamin D is a fat-soluble vitamin that plays an important role in bone metabolism and immune system. Low vitamin D levels (< 50 nmol/l) have been widely reported in all age groups in recent years. Lack of vitamin D is associated with increased overall and cardiovascular mortality, cancer incidence and mortality, and autoimmune diseases. Vitamin D deficiency is rising, mainly due to modern lifestyle and malabsorption disorders. As an adequate intake of vitamin D is hard to achieve through the diet alone, the dietary supplements of vitamin D are recommended. Sun exposure (ultraviolet B radiation, UVB) represents the main source of vitamin D, which is synthesised in the skin. UVB intensity varies through the year and the time of day. The peak UVB period is between 10 am to 4 pm from April till October (above 40° latitude). There is no universal consent on the amount and frequency of vitamin D supplementation. A sufficient supplementation of vitamin D is necessary through the whole life cycle, especially during lactation. With sufficient supplementation of vitamin D during lactation (4,000 IU/day) mother covers her own and through her breast milk also the child's nutritional needs (400 IU/day) for vitamin D. However, further research in this field is needed before recommending such a high supplementation for nursing mothers. New German Reference values from 2012 advises 400 IU/day for infants during the first year of life, and afterwards 800 IU/day for the entire population.

Introduction

Vitamin D is a nutrient and a hormone. Its blood concentrations are dependent on

dietary intake and exposure to ultraviolet B radiation (UVB, usually sunlight). The

term “vitamin D”, encompasses two molecules: cholecalciferol (vitamin D₃; sources: the skin exposure to the UVB and foods of animal origin¹) and ergocalciferol (vitamin D₂; source: foods of plant origin).² Vitamin D is a fat-soluble vitamin synthesized in the skin through UVB exposure or ingested with food or dietary supplements. Ingested vitamin D is absorbed along the entire small intestine mainly by passive diffusion, and partly also by cholesterol transporters mechanism.³ The metabolism starts in the liver, where the presence of specific enzymes convert vitamin D into 25-hydroxyvitamin D (25(OH)D), followed by hydroxylation of 25(OH)D into 1,25-dihydroxyvitamin D (1,25(OH)₂D), which is the biologically active form of vitamin D. Excess concentrations of vitamin D in the blood stream are stored in adipose tissue and skeletal muscles.⁴ The level of 25(OH)D, in the blood is an indicator of vitamin D status. However, there is a lack of standardisation of methods used to measure 25(OH)D status, with different tests producing very different results.⁵ Some laboratories use conventional units (ng/ml) for reporting 25(OH)D concentration whereas other laboratories use international system (SI) units (nmol/l). The conversion factor is: 1 ng/ml = 2.496 nmol/l. The term also often used for 25(OH)D in clinical practice is international unit (IU); 1 µg = 40 IU. Some international policy statements on vitamin D have defined the following levels of serum 25(OH)D: deficient (<25 nmol/l); insufficient (25–50 nmol/l) and adequate (≥ 50 nmol/l).^{6,7} Generally, concentrations above 125 nmol/l are not recommended, as the long-term safety of such level is still unknown.⁶ European food safety authority (EFSA) has set the Tolerable Upper Intake Levels (UL) at: 100 µg/day (4,000 IU/day) for adults (including pregnant and lactating women and adolescents aged 11–17 years), 50 µg/day (2,000 IU/day) for children aged 1–10 years and 25 µg/day (1,000 IU/day) for infants.⁸

The current recommended intakes may be inadequate for the maintenance of health,¹ particularly in pregnant and lactating women.^{9,10} In Danish pregnant women, in-

sufficiency as well as deficiency were found, despite the food supplementation.¹¹

It would be hard to reach acceptable blood levels of vitamin D through the diet alone, so supplementation is advised for all age groups, especially during winter time above 40° latitude (October to April), when the production of vitamin D through sun exposure is insufficient.²

Vitamin D insufficiency as well as deficiency are well-documented, not only in the elderly, but also in the general population around the world.² It has been estimated that 80 % of young people in Europe do not have adequate vitamin D intake.¹² In a recent nationally representative study on dietary habits of Slovenian adolescents^{13,14} we found that they consumed only 4 µg (160 IU) vitamin D/day¹⁵ instead of newly recommended 20 µg (800 IU)/day.¹⁶ In the absence of endogenous synthesis, this quantity is insufficient to reach the estimated value of adequate vitamin D intake that ensures the desired 25(OH)D serum concentration of at least 50 nmol/l. The difference between dietary vitamin D intake through habitual diet and the reference intake value must be covered by endogenous synthesis and/or an additional intake of vitamin D.^{15,16}

Health benefits of Vitamin D

Vitamin D has many functions in our body; some of them are still not clearly understood. It maintains calcium and phosphorus concentrations in a range that supports cellular processes, neuromuscular function, and bone ossification through better absorption from the intestine or by mobilizing from the bone.¹⁷ It optimizes bone health, muscle function cardiovascular system and inhibits the development of cancer cells, especially colon cancer.¹⁸ It also has a beneficial effect on the kidneys, parathyroid glands, and on the division and differentiation of normal cells.^{19,20} Moreover, studies suggest that vitamin D may have a role in reducing all-cause mortality,²¹ prevention of various autoimmune responses and reducing the risk of asthma and allergies.^{22,23} Animal studies show a possible association between the maternal vitamin D status and

Table 1: The content of vitamin D in some foods (µg and IU/100 g)³⁵

Food items	µg/100 g	IU/100 g
Fish oil:		
cod liver oil	250	10.000
sardine oil	8.3	332
Fishes:		
salmon	16.0	640
marinated herring	13.1	524
canned salmon	12.0	480
sardines	11.0	440
Meat and meat products:		
fish pate	0.91	36.4
chicken liver, beef frankfurter	0.41	16.4
veal, liver	0.33	13.2
turkey frankfurter	0.16	6.4
Eggs:		
yolk	5.6	224
egg powder	5.0	200
hens eggs, fresh or boiled	2.9	116
Milk:		
pasteurized (3.5 % milk fat)	0.09	3.6
raw (3.7 % milk fat)	0.07	2.8
sterilized (1.6 % milk fat)	0.03	1.2
goat milk, raw (3.9 % milk fat)	0.25	10
human milk	0.07	2.8
Vegetable drinks:		
soy drink	1.4	56
enriched rice drink	1.1	44
Margarines:		
Becel pro-activ, Becel, Rama, Lätta	7.5	300
Petra	2.5	100
Butter	1.2	48

brain development in pups, which could possibly play a role in cognitive and neurological development.²⁴ It was shown that in the third trimester of pregnancy the 25(OH) D is associated with fetal bone development that may affect prepubertal bone mass accumulation.²⁵ Newborns who were supplemented with vitamin D up to an age of one year presented later in life with greater bone density and more healthy bones.²⁶

Vitamin D in the diet

Dietary sources of vitamin D (vitamin D₃ and D₂) generally account for a very small amount of total vitamin D in the body.²⁰ Vitamin D₃ has better bioavailability than vitamin D₂.²⁷ Table 1 represents a list of different food items with corresponding content of vitamin D. Fish oil is a valuable source of vitamins D and A, as well as long chain polyunsaturated fatty acids (LCP, specially docosahexaenoic acid, C22:6n-3)²⁸ which have in combination an excellent impact on health (regulation of the innate immune response, anti-cancer properties, etc.).^{29,30} As adequate intake of vitamin D is hard to achieve through diet alone, even when fortified, the dietary supplements with vitamin D are recommended. The absorption of vitamin D from supplements is higher if they are taken together with a meal.³¹ Individuals who avoid consuming foods of animal origin, such as vegetarians and vegans, might have lower 25(OH)D concentrations in comparison with meat and fish eaters.^{32,33} For the assessment of dietary vitamin D intake as well as for other macro- and micronutrients a web-based application is very useful.³⁴

Sun exposure

Sun exposure represents the main source of vitamin D. On average, exposure to the sun in the summer time in a bathing suit for at least 20 minutes produces the equivalent of 15,000 to 20,000 IU of vitamin D per day.³⁶ Exposure to low wavelengths in the UVB range is required for vitamin D synthesis; UVA does not contribute to vitamin D production. UVB intensity varies throughout the year and time of day. The

peak UVB period, and hence the greatest sun exposure risk, is between 10.00 and 16.00 from April till October. According to the current recommendations, sun protection (shade, cover-up clothing and hats, sunscreen, sunglasses) is recommended during this time to prevent skin cancer,³⁷ eye diseases, premature ageing of the skin and immune suppression.³⁸ Synthesis of vitamin D in the skin is even better if combined with physical activity. Early morning or late

afternoon daily walk or some other form of outdoor physical activity is recommended.³⁹

Risk factors for vitamin D deficiency

Prevalence of vitamin D deficiency is rising, mainly due to modern lifestyle and malabsorption disorders. Risk factors for vitamin D deficiency in humans can be divided into three groups:

Table 2: Recommended vitamin D allowances (IU/day) for different age groups across the world (in different European countries, Canada, Australia and New Zealand)

Year	Country	3 months	9 months	5 years	10 years	15 years	Adults	Pregnant and lactating mothers	70 years	
2010	Slovenia ⁵⁰	400 ^a		400–1000 ^a						
2004	D-A-CH (Germany, Austria, Switzerland) Slovenia ⁵¹	400 ^b				200 ^b			400 ^b	
2005	Bulgaria ⁵²	200								400
2005	Hungary ⁵³	400					240	400	240	
1990	Romania ⁵⁴	400				300	200			
2001	Republic of Macedonia ⁵⁵	300		400			200	450	200	
2007	Spain ⁵⁶	400			200		400		600	
2001	France ^{56,57}	900			200			400	200	
1996	Italy ⁵⁶	400	700	200		300	200	400		
2009	Belgium ⁵⁸	500		300	250			400		
2012	Germany ¹⁶	400			800					
2004	Denmark, Finland, Sweden ^{56,59}	400			300			400		
2012	The Netherlands ⁵⁹					400				
1991	United Kingdom ⁵⁶	340	280		400 ^c			400	400 ^c	
2010	Canada ^{56,57,60}	400–800 ^d			600			2000	600	
2005	Australia and New Zealand ⁵⁹					200				

^a Slovenia, 2010: 400 IU at 0–18 years, 400–1.000 IU at adolescents⁵⁰

^b D-A-CH, Slovenia, 2004: 400 IU at 0–1 year; 200 IU at 1–65 years, during pregnancy and lactation; 400 IU at 65 years and older⁵¹ Slovenia will probably soon accept the new German reference values from 2012 (from previous 400 IU at 0–1 year; 200 IU at 1–65 years, during pregnancy and lactation; 400 IU at 65 years and older⁵¹ to new 400 IU at 0–1 year (the same), 800 IU at 1–65 years and older as well as during pregnancy and lactation (400% increase)¹⁶).

^c in cases of insufficient UVB exposure

^d in winter time for high-risk infants

Croatia, Federation of Bosnia and Herzegovina, Republic of Srpska and Montenegro are excluded from the table because no recommendations were available. Serbia was excluded due to the lack of published sources.

- Geographical: above 40° latitude and the winter season, when the day light is strongly reduced (from October till April);
 - Socio-cultural: life and work in confined spaces, low physical activities, parasols, hats, due to cultural and religious reasons veiled clothing, shade, use a strong sunscreen with sun protection factor of 8 or more, inadequate nutrition (i. e. vegan diet);
 - Physiological: pregnant and lactating women and their neonates, people with very dark skin, older people, skin cancers or skin-related conditions, people who have received an organ transplant, obese people and people with malabsorption syndrome, chronic renal and hepatic diseases, impaired metabolism of vitamin D and certain medications that increase photosensitivity (anticonvulsants, hypnotics).^{1,11,36,39-43}
- low serum 25(OH)D should be monitored at the beginning and in the mid of pregnancy.⁴⁵ Sufficient vitamin D supplementation (4,000 IU/day) of the lactating mother¹⁰ results in a sufficient amount of vitamin D in human milk, which is called “shifting the vitamin D paradigm”.⁴⁶ Current recommendations in Canada are 2,000 IU/day for lactating mother.⁴⁰ This shift supports lactating mothers who take great pride in providing complete nutritional support to their breastfed infants. In addition, maternal vitamin D supplementation avoids concern of development of allergy or asthma that has been demonstrated with early multi-vitamin administration in water-soluble form,^{47,48} and consequently, avoidance of direct introduction of foreign substances to young infants. Maternal supplementation supports the health of mother and infant at the same time. Current infant supplementation can leave the nursing mother with severe vitamin D deficiency.⁴⁹

Recommendations for the supplementation

Currently, there is no universally accepted dose and frequency for vitamin D supplementation in neonates, children, adolescents, pregnant and lactating women, adults and the elderly (Table 2). With vitamin D supplementation, caution should be taken because of possible toxicity due to excessive oral vitamin D intake. Symptoms of vitamin D toxicity (hypervitaminosis D) include dehydration, vomiting, decreased appetite, irritability, constipation, fatigue and muscle weakness. Hypercalcaemia, hypervitaminosis D or renal osteodystrophy with hyperphosphatemia are the contraindications for vitamin D supplementation. The extra care should be taken when supplemented in the presence of atherosclerosis or cardiac function impairment, hypersensitivity to vitamin D, renal function impairment, or sarcoidosis. By prolonged exposure of the skin to UVB, there is no risk for vitamin D toxicity.⁴⁴

In most countries, the monitoring of serum 25(OH)D levels during pregnancy is not done routinely, however it is recommended that women with one or more risk factors for

Conclusion

The exact functions of vitamin D in the body are still subject of investigation. Deficiency of vitamin D may cause different diseases. For infants and children, rickets is debilitating and dangerous. UVB radiation (above 40° latitude: from April till October) triggers the synthesis of vitamin D in the skin and represents the main source of vitamin D. Adequate intakes of vitamin D is hard to achieve through the diet alone. Supplements of vitamin D are recommended, especially during pregnancy, lactation and for infants during the first year of life. The new D-A-CH Reference values for vitamin D supplementations are 400 IU/day for infants during the first year of life and 800 IU/day for all population. According to “shifting the vitamin D paradigm”, maternal vitamin D supplementation of 4,000 IU/day supports the health of mother and infant simultaneously. Before this will be accepted as a general recommendation, more studies should be performed in this field.

Acknowledgment

Evgen Benedik is a recipient of a PhD scholarship from the Slovenian Research

Agency (ARRS). We would like to thank Nevenka Bratanič, MD, MSc for help with the literature.

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