Q&As

Vitamin D Deficiency:

Prescription for a Tan?

Moin Khan; and Aliya Khan, MD, FRCPC, FACP

As presented at the Endocrine City Wide Rounds, McMaster University, Hamilton Ontario

Vitamin D is fat-soluble and essential for maintaining blood calcium in the normal range. It is present in very few natural foods; however, it can be found in oily fish, such as mackerel or salmon, cod liver oil and in fortified foods, such as milk and cereal.

Human requirements for vitamin D are largely met by the formation of vitamin D in the skin with ultraviolet B (UVB) irradiation during sun exposure.[1] Vitamin D is hydroxylated in the liver and the kidney and maintains normal blood calcium levels and normal muscle and bone health.

Vitamin D ensures that the levels of calcium and phosphorus are always maintained at ideal levels, enabling mineralization of the soft osteoid bone, which forms normal bone. This process occurs by the passive diffusion of calcium and phosphorus onto the collagen matrix of the bone and is impaired by vitamin D inadequacies.

Shirley's case

- Shirley, 58, presents with osteoporosis.
- She has a history of Crohn's disease.
- Lab tests reveal normal calcium; however, her parathyroid hormone (PTH) is elevated at 7.8 pmol/L and 25 (OH) vitamin D is insufficient at 45 nmol/L.
- Replacement with vitamin D, 50,000 IU weekly, for three months, results in the normalization of PTH and vitamin D.

Human requirements for vitamin D are largely met by the formation of vitamin D in the skin with UVB irradiation during sun exposure.

In the elderly, vitamin D deficiency is relatively common and is associated with impaired bone mineralization and fractures. Vitamin D deficiency also results in muscle aches and pains and weakness. Vitamin D deficiencies can be easily corrected, resulting in major improvements in general well-being.

Q Why does vitamin D deficiency occur?

A number of factors contribute to the development of vitamin D deficiency. Dark-skinned individuals are at an increased risk of vitamin D deficiency, as the higher concentration of melanin in the skin competes with 7-dehydrocholesterol (7-DHC) for UVB photons, decreasing vitamin D synthesis in the skin.[2] With increased age, the level of 7-DHC decreases in the skin, resulting in significantly less vitamin D synthesis, despite sun exposure (Figure 1).[3]

...with increased age, the capacity of the skin to produce pre-vitamin D3 decreases by more than twofold.

Skin samples studies of people between the ages of eight and 18 years and those aged 77 to 82 years show that with increased age, the capacity of the skin to produce pre-vitamin D3 decreases by more than twofold. It is, therefore, necessary for the elderly to receive adequate vitamin D supplementation.

Inadequate sun exposure is a common cause of vitamin D deficiency, as synthesis is dependent on the duration of sun exposure, the season, the time of the day and the latitude. At northern latitudes (above 37°), vitamin D synthesis is very limited. A recent Canadian study conducted in Calgary documented a high prevalence of vitamin D insufficiency.[4] Seasonal variation was also noted, with decreases in vitamin D levels in the fall and winter months, particularly in the elderly.

Sunscreen and excessive clothing worn throughout the year reduces skin exposure to the sun and vitamin D production. An SPF of eight or higher has been shown to reduce vitamin D production in the skin by 97% or more.[5]

An SPF of eight or higher has been shown to reduce vitamin D production in the skin by 97% or more.

Malabsorption of the fat-soluble vitamin D can also result in vitamin D deficiency. This can occur in conditions such as celiac disease and Crohn's disease. Obesity results in excessive vitamin D deposits in the fat stores, causing vitamin D deficiency.

Medications like phenytoin oral and phenobarbital increase hepatic microsomal enzyme activity, resulting in increased vitamin D catabolism and may result in vitamin D deficiency. Liver disease and kidney disease can result in impaired hydroxylation of vitamin D, lowering levels of 1,25 dihydroxyvitamin D, the active form of vitamin D.[1]

Mr. Moin Khan is a Health Sciences student, McMaster University, Hamilton, Ontario.

Dr. Aliya Khan is an Associate Clinical Professor of Medicine, McMaster University and the Director of the Calcium Disorders Clinic, St. Joseph's Healthcare, Hamilton, Ontario.

How low is too low?

A normal 25 hydroxy vitamin D level is ≥ 75 nmol/L. Below this level, an individual is considered vitamin D insufficient—a preclinical stage of vitamin D deficiency. This stage is associated with increases in PTH, increases in the rate of bone turnover and decreases in bone density, associated with an increased risk of skeletal fractures. Vitamin D levels < 25 nmol/L are deficient and are associated with osteomalacia in adults and rickets in children.[4]

How common is vitamin D deficiency?

Vitamin D deficiency is believed to be common in the elderly, in dark-skinned individuals and in people who continuously use sun screen. Conditions associated with liver, kidney or bowel disease can also result in vitamin D deficiency. However, vitamin D deficiency is not limited to these risk factors and should not be overlooked when individuals have unexeplained bone loss or fail to respond to bisphosphonates.

Vitamin D deficiency is believed to be common in the elderly, in dark-skinned individuals and in people who continuously use sun screen.

The prevalence of vitamin D deficiency is a subject of great interest and active clinical research. A recent North American study demonstrated that more than half of postmenopausal women undergoing osteoporosis treatment have vitamin D insufficiency.

Another study carried out in Canada evaluated 60 men and 128 women; 34% of these subjects were classified as vitamin D deficient (vitamin D levels < 40 nmol/L). The prevalence of vitamin D deficiency in the elderly population is currently being evaluated, but it is believed to be a major health-care problem, resulting in significant morbidity.

What are the effects of vitamin D deficiency?

Vitamin D deficiency results in slight decreases in serum calcium and secondary physiologic rises in parathyroid hormone (PTH) synthesis and release. PTH increases bone resorption with calcium released from the skeleton and contributes to the development of osteoporosis.

Vitamin D deficiency is a major cause of rickets in children and osteomalacia in adults. Rickets is associated with inadequate mineralization of bone at the growth plate and results in the classic bowing of the tibia.

Enlargement of the costochondral joints in the rib cage can occur, resulting in the deformity known as rachitic rosary. Osteomalacia also results in muscle aches and pains, bone pain and muscle weakness. It can be easily mistaken for arthritis; however, these symptoms are entirely reversible with vitamin D supplementation.

Q How can vitamin D deficiency be evaluated?

A Vitamin D levels are easily measured in the blood, which enables accurate and easy detection of deficiency or insufficiency. Individuals with inadequate vitamin D should have serum calcium and phosphorus levels measured.

The effects of vitamin D deficiency or insufficiency on the skeleton are evaluated by assessing bone density. Bone density is decreased in the presence of vitamin D inadequacy, as there is a physiologic rise in PTH, which increases calcium release from the skeleton and decreases bone mineralization, resulting in an increased risk of fracture.

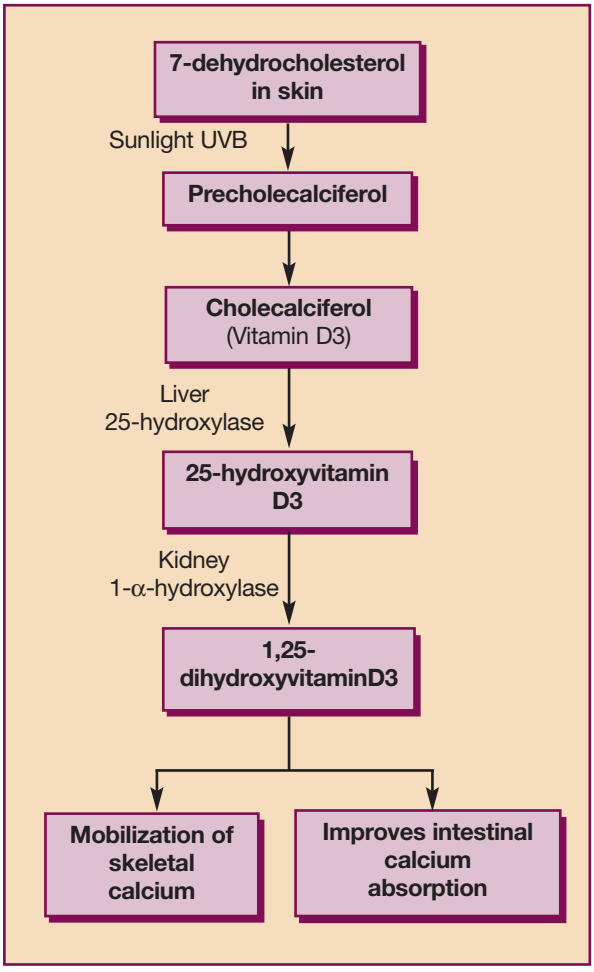

Figure 1. Vitamin D metabolism.

Q Does vitamin D have extraskeletal benefits?

A Vitamin D inhibits cancer cell growth. Normal levels of vitamin D are associated with a 30% lower risk of developing breast, colon or prostate cancer. Vitamin D may also prevent autoimmune disease.

Q How can vitamin D deficiency be treated?

A Vitamin D deficiency is treated with vitamin D supplementation. Ergocalciferol in doses of 50,000 IU, weekly, can replenish the stores and normalize the serum calcium, phophorus and PTH levels. Bone density also improves with correction of the deficiency state. It is recommended that individuals maintain normal levels with daily supplementation after correcting the vitamin D deficiency. The recommended daily vitamin D requirements recently published by the Osteoporosis Society of Canada advocate vitamin D, 400 IU, daily, for men and women younger than the age of 50 and 800 IU, daily, for those older than the age of 50. Dx

References

1. Holick MF: Vitamin D. The underappreciated D-lightful hormone that is important for skeletal and cellular health. Curr Opin Endocrinol Diabetes 2002; 9:87-98.
2. Bouillon R: Vitamin D: From photosynthesis, metabolism and action to clinical applications. Fourth edition, volume two. In: Degroot LL, Jameson JL (eds.) Enocrinology. W.B. Saunders Co., Philadelphia, PA, 2001, pp. 1009-28.
3. MacLaughlin J, Holick MF: Aging decreases the capacity of human skin to produce vitamin D3. J Clin Invest 1985; 76(4):1536-8.
4. Rucker D: Vitamin D insufficiency in a population of healthy western Canadians. CMAJ 2002; 166(12):1517-24.
5. Holick MF: Calciotroopic hormones and the skin: A millennium perspective. J Cell Biochem 2003; 88:296-307.