VITAMIN D

ITS ROLE IN THE MUSCULOSKELETAL SYSTEM AND BEYOND

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ABSTRACT

Vitamin D deficiency has a high prevalence due to inadequate exposure to sunlight and its limited presence in foods. Vitamin D deficiency has well-known consequences on the musculoskeletal system, namely osteoporosis and frequent falls in the elderly, in view of its effect on calcium absorption. The discovery of the vitamin D receptor in many cells and its ability to regulate the transcription of over 200 genes, has created interest with regards to the role of vitamin D in the modulation of cell growth, inflammation and immune functions. Guidelines recommend screening individuals at risk of vitamin D deficiency, and supplementing when necessary.

KEYWORDS

Vitamin D, osteomalacia, autoimmune disease, malignancy, cardiovascular disease

VITAMIN D PHYSIOLOGY AND FUNCTION

Vitamin D is a fat-soluble vitamin which is only present in few foods, mainly in oil-rich fish such as salmon, mackerel, and herring. The main source (80-90%) of vitamin D is its synthesis in the skin upon absorption of UVB radiation by 7-dehydrocholesterol.[1] It then undergoes hydroxylation in the liver to 25-hydroxyvitamin D; and then further hydroxylation to 1,25-hydroxyvitamin D by the enzyme 1α-hydroxylase. 1,25-hydroxyvitamin D interacts with its vitamin D nuclear receptor, which is present in the small intestine, kidneys, and other tissues.[1,2] 1,25-hydroxyvitamin D promotes calcium absorption in the gastrointestinal tract and maintains adequate serum calcium and phosphate concentrations.[3] 1,25-hydroxyvitamin D also acts through its vitamin D receptor (VDR) in the osteoblast to stimulate the expression of receptor activator nuclear factor κB ligand. The latter interacts with the receptor activator of nuclear factor κB to stimulate immature monocytes to become mature osteoclasts, which dissolve the matrix and mobilize calcium and other minerals from the skeleton. It is thus important for bone growth and bone remodelling.[4] In the kidney, 1,25-hydroxyvitamin D stimulates calcium reabsorption from the glomerular filtrate.[1,5] VDR is present in most cells and can regulate the transcription of over 200 genes. It has multiple biological actions, including modulation of cell growth, neuromuscular and immune functions, and reduction of inflammation.[6]

VITAMIN D DEFICIENCY

Vitamin D deficiency has been defined as serum 25-hydroxyvitamin D of less than 20ng/ml; while vitamin D insufficiency is defined as serum 25-hydroxyvitamin D of 21–29ng/ml.[1] Vitamin D deficiency is common; its prevalence in adults in Europe ranges from 34% to 67%.[7] The major cause of vitamin D deficiency is inadequate exposure to sunlight.[8] Vitamin D synthesis in the skin is reduced by more than 95% by using sunscreen with a sun protection factor of 30.[9] People with a naturally dark skin tone are more prone to vitamin D deficiency, since they require at least three to five times longer sun exposure to make the same amount of vitamin D as a person with a white skin tone.[10,11] Other risk factors include obesity, fat malabsorption, and medications including anticonvulsants and anti-retroviral therapy.[12,13]

CONSEQUENCES OF VITAMIN D DEFICIENCY

Vitamin D deficiency results in abnormalities in calcium, phosphorus, and bone metabolism. Vitamin D deficiency causes a decrease in the intestinal calcium and phosphorus absorption, resulting in an increase in parathyroid hormone levels.[1] Secondary hyperparathyroidism maintains normal serum calcium levels by promoting calcium absorption from bone and increasing phosphorus excretion by the kidneys. The increase in osteoclastic activity creates local foci of bone weakness and a generalized decrease in bone mineral density, resulting in osteopaenia and osteoporosis. The increased phosphorus excretion results in lower serum phosphorus levels, causing a mineralization defect in the skeleton.[14] In young children this results in a variety of skeletal deformities classically known as rickets.[15] In adults, this mineralization defect known as an osteomalacia, often goes undetected. It causes a decrease in bone mineral density and is associated with bone and muscles aches.[16] Vitamin D deficiency also causes muscle weakness; affected children

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1. Cashman KD, Dowling KG etc; Vitamin D deficiency in Europe: pandemic?; Am J Clin Nutr. 2016 Apr;103(4):1033-44. doi: 10.3945/ajcn.115.120873
2. FECYT - Spanish Foundation for Science and Technology, Science Daily, January 10, 2012
3. Trials by the National Technical University of Athens and the Swiss Research Centre Pharmabase
4. https://nutritionj.biomedcentral.com/articles/10.1186/s12937-015-0105-1

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[THE PREVALENCE OF VITAMIN D DEFICIENCY] RANGES FROM 34% TO 67% ... GUIDELINES RECOMMEND SCREENING FOR VITAMIN D DEFICIENCY IN PATIENTS AT RISK [INCLUDING] OBESE INDIVIDUALS AND ELDERLY PATIENTS SUFFERING FROM FREQUENT FALLS

have difficulty standing and walking, whereas the elderly have more frequent falls and higher fracture risk.[15,17,18]

The discovery of the presence of VDR and the enzyme 1α-hydroxylase in a large number of different cells has created interest on the importance of VDR-directed gene expression on the function of many tissues. A large number of studies have explored the effects of vitamin D beyond its well-known effects on the musculoskeletal system. Observational studies have described associations between low circulating levels of 25-hydroxyvitamin D and a large number of diseases, including cardiovascular diseases, malignancies, diabetes, obesity and autoimmune diseases.[19-22] Moreover, polymorphisms of VDR have been associated with several autoimmune diseases, such as systemic lupus erythematosus, type 1 diabetes, autoimmune thyroid disease, and with a number of malignancies.[23-29]

DIAGNOSIS OF VITAMIN D DEFICIENCY

Guidelines recommend screening for vitamin D deficiency in patients at risk, such as patients with osteoporosis, chronic kidney disease, liver failure, malabsorption, patients on anticonvulsants, obese individuals and elderly patients suffering from frequent falls.[30] Serum 25-hydroxyvitamin D is the major circulating form of vitamin D, and it is recommended to assess its level in order to evaluate vitamin D status.

TREATMENT OF VITAMIN D DEFICIENCY AND INSUFFICIENCY

The guidelines recommend that adults who are vitamin D deficient are treated with 50,000 IU of vitamin D2 or vitamin D3 once a week for 8 weeks or its equivalent of 6000 IU of vitamin D2 or vitamin D3 daily for 8 weeks to achieve a blood level of 25-hydroxyvitamin D above 30ng/ml. This is then followed by maintenance therapy of 1500–2000 IU daily.[30] To treat vitamin D deficiency in obese patients, patients with malabsorption syndromes, and patients on medications affecting vitamin D metabolism, such as anti-convulsants, the guidelines recommend a loading and maintenance dose that is two to three times higher. They recommend a loading dose of at least 6000–10,000 IU daily, followed by maintenance therapy of at least 3000–6000 IU daily.

CONCLUSION

Adequate vitamin D is vital for maintaining good bone and muscle health. Observational studies suggest a role of vitamin D in the development of autoimmune diseases, malignancy and cardiovascular disease. Large randomised controlled studies are required to define the role of vitamin D in these conditions. Screening for vitamin D deficiency in individuals at risk is recommended, followed by supplementation in vitamin D deficiency and insufficiency.

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