

The Sunshine Vitamin

Suganthan N¹

Abstract

Vitamin D deficiency is the most common nutritional deficiency worldwide, characterized by serum 25(OH)D < 50 nmol/L. It is usually caused by sun avoidance, using sun protection, inadequate dietary and supplementary vitamin D intake, malabsorption syndrome and usage of medications. Most of the patients are asymptomatic; severe and prolonged vitamin deficiency causes rickets and growth retardation in children and osteomalacia, osteopenia and osteoporosis in adults. Vitamin D deficiency and insufficiency are treated with supplementary vitamin D and sensible sunlight exposure.

Introduction

Vitamin D deficiency has been recognized as a worldwide health issue that affects not only musculoskeletal system but also a wide range of other acute and chronic medical conditions. It is one of the common underdiagnosed conditions. Several studies suggest that vitamin D is important for reducing the risk of type 1 diabetes mellitus, certain cancers, cardiovascular disease, depression, cognitive decline, autoimmunity, pregnancy complications, allergy and frailty.

Epidemiology

Vitamin D deficiency has been recognized as a pandemic with a number of health consequences. It is the most common nutritional deficiency in both children and adult worldwide.^{3,4}

Source and Metabolism of vitamin D

Small amounts of vitamin D are found in some foods, but most adults are unlikely to get more than 5-10% of their requirement from food. There are two forms of vitamin D. Ergocalciferol (D2) is a plant product and cholecalciferol (D3) is animal derived, synthesized in the skin.¹ Major active form is 1,25 (OH)D (calcitriol). Vitamin D is fat-soluble which is not only a dietary constituent but also a hormone. Vitamin D3 is produced endogenously in the skin from sun exposure and vitamin D2 and vitamin D3 obtained from foods that contain vitamin D naturally such as fatty fish.¹

An increase in skin melanin pigmentation and the topical application of a sun cream efficiently absorb UVB photons and this markedly diminishes the production of vitamin D3 by more than 90%. As sunlight destroys any excess vitamin D3 produced in the skin, excessive sun exposure to sunlight cannot cause vitamin D3 intoxication.

Daily requirement of vitamin D

Daily requirement of vitamin D is around 800-1000 IU. Patients who are already deficient require larger doses.

Causes of vitamin D deficiency and insufficiency

Exposure to sunlight is the major source for vitamin D for the most of humans. Inadequate intake of dietary and supplemental vitamin D is also considered as another important cause. Table 1 illustrates the common aetiology for vitamin D deficiency or insufficiency. Since the ability of the skin to produce vitamin D decreases with age, aging is also considered as a risk factor for this condition especially in elderly.¹¹

Table 1

Acquired	
•	Lack of sun exposure
•	Application of sun block creams
•	Inadequate dietary & supplemental vitamin D
•	Intestinal malabsorption. (celiac diseases, crohn's disease)
•	Renal failure
•	Severe liver failure
•	Drugs (antiepileptic, glucocorticoids, Rifampicin, HAART)
•	Primary hyperparathyroidism
•	Hypothyroidism
•	Obesity
Inheritance	
•	Vitamin D- Dependent rickets (Type 1, 2, and 3)
•	X-linked hypophosphatemic rickets
•	Autosomal – dominant hypophosphatemic rickets

History and clinical examination

Prompt history taking and clinical examination would be very helpful in making the clinical diagnosis of vitamin D deficiency and identifying individuals at high-risk. Figure 1 illustrates the metabolism of vitamin D in human body.

¹Consultant Physician and senior lecturer, Department of Medicine, Teaching Hospital, Jaffna

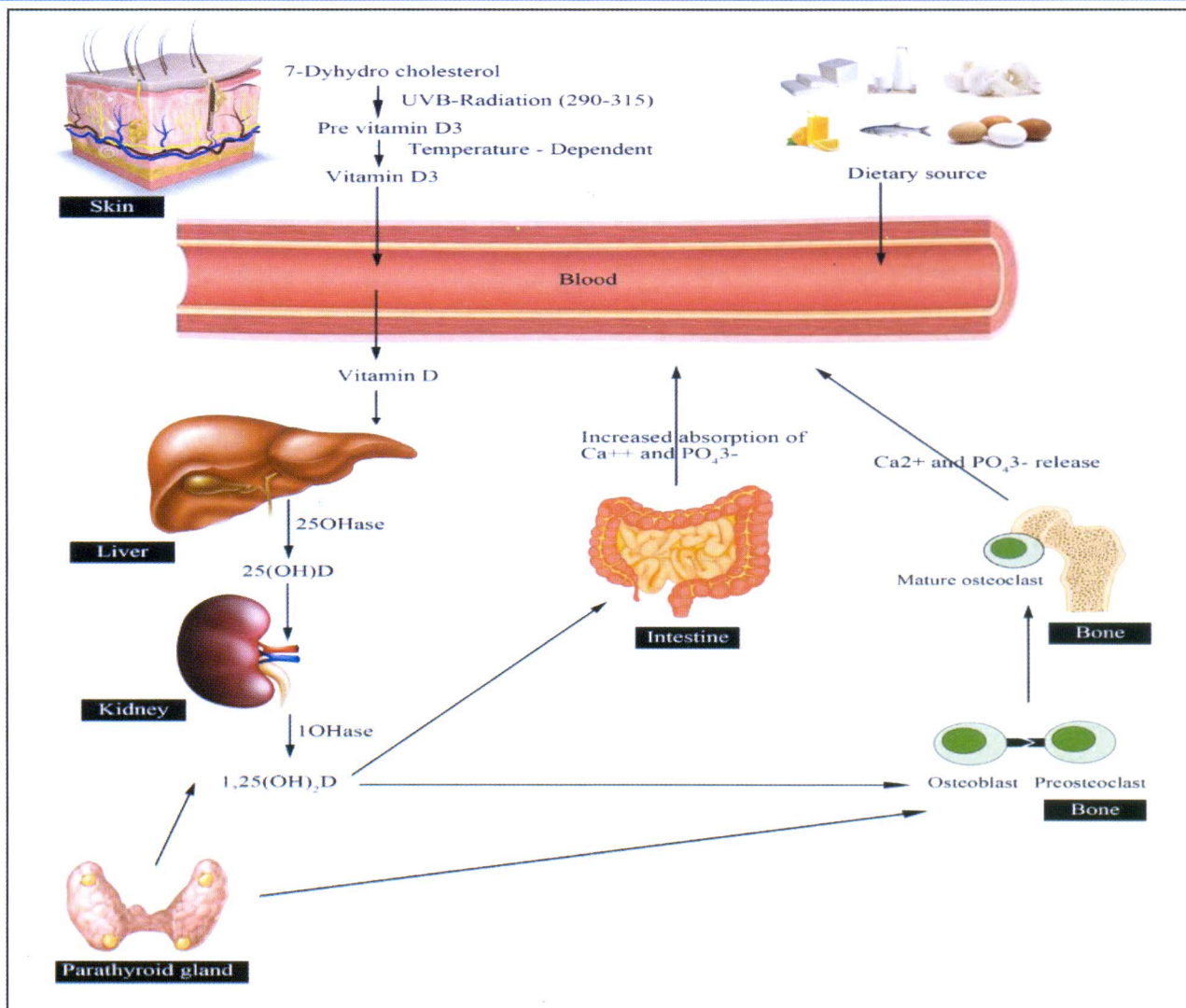


Figure 1 : Metabolism of vitamin D in human body.

In mild or early disease, patient can be completely asymptomatic. History should focus to identify the risk factors, assess the symptoms of vitamin D deficiency and health consequences.^{12, 13,14,15}

Table 2: Symptoms of vitamin D deficiency

Symptoms of vitamin D deficiency	
Adults	Bone pain (localized/generalized) Easily fatigability Malaise Difficulty in rising from a sitting position Muscle cramps
Children	Parasthesia Failure to thrive Delayed achievement of motor milestones

Table 3 shows the physical signs that can be elicited in children and adults

Table 3: Physical signs in children and adults

In children (rickets)	<ul style="list-style-type: none"> • Bone deformity of forearm • Posterior bowing of distal tibia • Genu varus • Valgus deformity of legs • Rachitic rosary • Frontal bossing • Pectus carinatum • Head sweating
In adults-	<ul style="list-style-type: none"> • Bone tenderness • Waddling gait • Proximal myopathy

Laboratory investigation

Serum level of 25(OH) vitamin D is the best method to determine vitamin D status. Although 1,25(OH) vitamin D is the biologically active form, it provides no information about vitamin D status, because it is often normal or even elevated in children and adults who have vitamin D deficiency and 1000times lower than 25-(OH) D and has a half-life of only 4 hours.

Measurement of plasma concentration of calcium, phosphate, intact PTH and alkaline phosphatase can identify deficiency and also help in determining the etiology. Table 4 illustrates typical biochemical profile of vitamin D deficiency.

Table 4: Typical biochemical profile of vitamin D deficiency

Biochemical profile	Results
Serum 25(OH)D ₂	Low
Serum Ca ²⁺	Normal
Phosphate	Low-normal
Intact PTH	High-normal/ elevated

Diagnostic criteria

Vitamin D deficiency

It is defined as serum 25-hydroxyvitamin D level of <50nmol/L (<20ng/ml)

Vitamin D insufficiency

It is defined as serum 25-hydroxyvitamin D level between 50-75nmol/L.

In children, a serum 25-(OH)D level of <37nmol/L is usually associated with skeletal manifestation of vitamin D deficiency rickets.^{1,2}

Management

Vitamin D replacement

Vitamin D replacement is the mainstay of treatment to correct the deficiency. Target level of vitamin D in both children and adults is to reach and maintain a serum 25(OH) D₃ level between 75 and 250 nmol/L and is to normalise parathyroid hormone and calcium. Vitamin D deficiency is corrected by treatment with vitamin D₂(ergocalciferol) or vitaminD₃(colecalciferol) given orally for 6 to 8 weeks followed by a lower maintenance dose. Treatment target

is to achieve and maintain a serum level of 25(OH)D level in both children and adults between 30 and 100 ng/ml.

Higher daily oral dose is required in patient with intestinal or fat malabsorption syndromes and history of gastric bypass surgery. Pregnant or lactating women with vitamin D deficiency should be treated as for non-pregnant adults.³

Calcitriol is generally not suitable for treatment of vitamin D deficiency as it has a narrow therapeutic window resulting in an increased risk of hypocalcaemia or hypercaluria. It has a role in the treatment of vitamin D deficiency in renal failure where there is inability to convert 25-hydroxyvitamin D to 1,25 hydroxyvitamin D.

Vitamin D status should be re-assessed 3-5 months after commencing supplements as the full increase in serum 25(OH) vitamin D may not be seen until this time.

Table 5: Classification of vitamin D status and recommendations

Status of Vitamin D	25(OH) Vitamin D	Recommendation
Mild deficiency	30-49 nmol/L	1000-2000 IU per day
Moderate deficiency	12.5-29 nmol/L	3000-5000 IU per day for 6-12 weeks, followed by maintenance dose of 1000-2000 IU per day
Severe deficiency	<12.5 nmol/L	3000-5000 IU per day

UVB radiation exposure

UVB radiation exposure is an excellent source of vitamin D and it should be recommended to all patients of both treatment and prevention of vitamin D deficiency.

It is advised to exposure arm and legs (with sun protection of the face) for about 5 to 15 minutes between 10am and 3pm, 4-6 times a week. It is sufficient to stimulate cutaneous vitamin D production. Darker skinned people require longer exposure (3-6times).

Calcium and phosphate replacement

Patients who do not meet the daily requirements of calcium from dietary source alone should be given supplementation. Recommended dietary intake of calcium is between 1000-1300 mg/day depending on age and sex.

For children, Calcium carbonate is given 45-65mg/kg/day orally in 4 divided doses. Adults are given 1-2g/day orally in 3-4 divided doses for both vitamin D deficiency and insufficiency. Supplementation of phosphate is not orally needed unless there is acquired or inherited disorder-causing phosphate wasting in the kidney.²¹

Prevention of vitamin D deficiency

Vitamin D supplementation is recommended to prevent vitamin D deficiency in people who receive less than optimal sun exposure.

At least 600 IU per day for people under 70

At least 800 IU per day for people over 70

1000 - 2000 IU per day may be required for sun avoiders or those at high risk of deficiency.

Conclusion

Vitamin D deficiency is common and diagnosed by measuring serum 25-hydroxyvitamin D concentration. It is usually treated with vitamin D supplementation and vitamin D concentration should be monitored after 3-4 months.

References:

1. Sunil J Wimalawansa. *Sri Lanka Journal of Diabetes, Endocrinology and Metabolism* 2012; 2: 73-88
2. A Gupta et al. *Aust Prescr* 39 (2), 40-46. 2016 Apr 01
3. Hossein-Nezhad A, Holick MF. Vitamin D for health: a global perspective. *Mayo Clin Proc.* 2013;88:720-755.
4. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab.* 2011;96:1911-1930.
5. McKenna MJ. Differences in vitamin D status between countries in young adults and the elderly. *Am J Med.* 1992;93:69-77.
6. Pettifor JM. Vitamin D deficiency and nutritional rickets in children. In: Feldman D, Pike JW, Glorieux FH, eds. *Vitamin D*. 2nd ed. Boston, MA: Elsevier Academic Press; 2005:1065-1084.
7. Bodnar LM, Simhan HN, Powers RW, et al. High prevalence of vitamin D insufficiency in black and white pregnant women residing in the northern United States and their neonates. *J Nutr.* 2007;137:447-452.
8. Lee JM, Smith JR, Philipp BL, et al. Vitamin D deficiency in a healthy group of mothers and newborn infants. *Clin Pediatr (Phila).* 2007;46:42-44.
9. Malabanan A, Veronikis IE, Holick MF. Redefining vitamin D insufficiency. *Lancet.* 1998;351:805-806.
10. Heaney RP, Dowell MS, Hale CA, et al. Calcium absorption varies within the reference range for serum 25-hydroxyvitamin D. *J Am Coll Nutr.* 2003;22:142-146.
11. Holick MF, Matsuoka LY, Wortsman J. Age, vitamin D, and solar ultraviolet. *Lancet.* 1989;2:1104-1105.
12. El-Hajj Fuleihan G, Nabulsi M, Tamim H, et al. Effect of vitamin D replacement on musculoskeletal parameters in school children: a randomized controlled trial. *J Clin Endocrinol Metab.* 2006;91:405-412.
13. Chesney RW. Bone structure, growth, and hormonal regulation. In: Behrman RE, Kliegman RM, Jenson HB, eds. *Nelson textbook of pediatrics*. 17th ed. Philadelphia, PA: Saunders; 2004:2341-2343.
14. Nield LS, Mahajan P, Joshi A, et al. Rickets: not a disease of the past. *Am Fam Physician.* 2006;74:619-626.
15. Dobrescu MO, Garcia AC, Robert M. Rickets. *CMAJ.* 2006;174:1710-1712.
16. Fort P, Salas AA, Nicola T, et al. A comparison of 3 vitamin D dosing regimens in extremely preterm infants: a randomized controlled trial. *J Pediatr.* 2016;174:132-138.
17. Wortsman J, Matsuoka LY, Chen TC, et al. Decreased bioavailability of vitamin D in obesity. *Am J Clin Nutr.* 2000;72:690-693. [Erratum in: *Am J Clin Nutr.* 2003;77:1342.]
18. Wagner CL, Greer FR; American Academy of Pediatrics Section on Breastfeeding. Prevention of rickets and vitamin D deficiency in infants, children, and adolescents. *Pediatrics.* 2008;122:1142-1152. [Erratum in: *Pediatrics.* 2009;123:197.]
19. Bischoff-Ferrari HA, Giovannucci E, Willett WC, et al. Estimation of optimal serum concentrations of 25-hydroxyvitamin D for multiple health outcomes. *Am J Clin Nutr.* 2006;84:18-28. [Errata in: *Am J Clin Nutr.* 2006;84:1253; *Am J Clin Nutr.* 2007;86:809; dosage errors in abstract corrected.]
20. Cashman KD, Wallace JM, Horigan G, et al. Estimation of the dietary requirement for vitamin D in free-living adults ≥ 64 y of age. *Am J Clin Nutr.* 2009;89:1366-1374.
21. Thacher TD, Fischer PR, Pettifor JM. Vitamin D treatment in calcium-deficiency rickets: a randomised controlled trial. *Arch Dis Child.* 2014;99:807-811.