Vitamin D
The Sunshine Superhormone
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Biochemistry

Vitamin D is not a true vitamin, as it is not an essential dietary factor - it is actually a hormone precursor that is normally produced in the skin through the action of sunlight (UVB) on 7-dehydrocholesterol.

Vitamin D3, made in the skin, is transported to the liver where it is metabolised to 25-hydroxyvitamin D [25(OH)D; aka calcidiol], the major circulating form. Further metabolism occurs in the kidney (and throughout the body) to form the highly biologically active 1,25-dihydroxyvitamin D [1,25(OH)2D; aka calcitriol].

Vitamin D is stored in fat, and excess oral vitamin D is excreted in the bile.

It is largely through historical accident that vitamin D was classified in the early 1920s as a vitamin rather than a steroid hormone. The molecular structure of vitamin D is closely related to that of classic steroid hormones (e.g. oestradiol, progesterone, testosterone, DHEA and cortisol). 1,25(OH)2D is the most potent steroid hormone in the human body, active at 1/1,000,000,000,000 of a gram!

Actions

- Regulates blood calcium levels
  - Stimulates intestinal calcium absorption
  - Stimulates bone calcium release
  - Stimulates resorption of calcium from the kidneys

- Increases magnesium absorption

- Regulates osteoblasts (bone-building cells)
  - 1,25(OH)2D stimulates differentiation of osteoblasts (but high levels may have inhibitory effect)

- Regulates osteoclasts (bone resorbing cells)
  - 1,25(OH)2D [toxic levels] stimulates formation and function of osteoclasts
  - 24,24(OH)2D inhibits formation and function of osteoclasts

- Stimulates synthesis of osteocalcin (a bone protein)

- Maintains healthy cartilage
  - Regulates chondrocyte proliferation and proteoglycan synthesis

- Helps maintain optimal muscle strength

- Antioxidant

- Anti-inflammatory
  - Inhibits cyclooxygenase-2 (COX-2)
  - Lowers CRP and IL-6, two measures of inflammation in the body

- Reproduction
  - Essential for normal reproductive function in both sexes
  - Important for spermatogenesis and maturation of spermatozoa
  - Important for implantation and successful maintenance of pregnancy
  - Crucial for normal foetal growth and optimal development of the foetal brain, lungs, skeleton and immune system

- Anti-cancer properties
  - Antiproliferative (inhibits cancer cell proliferation)
  - Prodifferentiating (induces cancer cell differentiation)
  - Proapoptotic (induces apoptosis - programmed cell death)
  - Antiangiogenic (inhibits angiogenesis - new blood vessel formation)
  - Antimetastatic (inhibits metastasis)
  - Immunomodulating
  - Inhibits COX-2
  - Potentiates the anticancer effects of many cytotoxic and antiproliferative anticancer agents
  - Down-regulates oestrogen receptor levels and decreases growth-stimulatory effect of oestradiol on breast cancer cells

- Blood sugar control
  - Improves insulin sensitivity
  - Stimulates insulin secretion

- Inhibits leptin secretion by adipose tissue

- Modulates immune function
  - Enhances activity of immune cells that have vitamin D receptors
  - Regulates synthesis and action of naturally occurring defensin molecules against bacterial antigens
Regulates antimicrobial peptides in the skin
Also dampens immune activity in some circumstances

**Cardiovascular**
- Regulates blood pressure; inhibits rennin synthesis in the kidney
- Improves endothelial function; modulates vascular tone
- Improves cardiac function
- Antihypertrophic role in the heart
- May suppress cardiovascular risk markers (e.g. CRP)
- Anti-atherosclerotic activity

**Thyroid**
- Affects thyroid function

**Multiple functions in the nervous system**
- brain development
- adult brain function
- neuroprotective
- antiepileptic effects
- anticalcification effects,
- neuro-immunomodulation
- interplay with neurotransmitters and hormones
- modulation of behaviors
- brain ageing

**Has mood modulating effects**
- Helps relieve symptoms of depression

**Involved in energy metabolism**

**Important for normal balance**

**Promotes production of IGF-1** (insulin-like growth factor)

**Regulates proliferation and differentiation of keratinocytes** (skin cells)

**Important in the maturation of the hair follicle**

**Anti-thrombotic (reduces blood clots)**

Most tissues and cells in the body have receptors for vitamin D (VDRs), including:

- Bone (osteoblasts, osteoclasts, bone marrow)
- Cartilage (chondrocytes)
- Muscle
- Kidney
- Adrenal
- Thyroid
- Parathyroid
- Skin
- Hair follicles
- Fat cells (adipocytes)
- Immune cells
- Thymus
- Breast
- Ovary, uterus, cervix, fallopian tubes
- Placenta
- Testes, sperm
- Prostate
- Stomach, small intestine, colon

- Pancreas (beta cell)
- Liver
- Lung
- Heart and blood vessels
- Brain, pituitary
- Inner ear (semicircular canal)
- Cancer cells (many)

**Sources**

**Sunlight:** For people living in Australia, the main source of vitamin D is through exposure to sunlight. Studies have shown that between 90-100% of the daily requirement for vitamin D comes simply from being in the sun for about 15-20 minutes a day.

**Dietary sources:** Very few foods naturally contain vitamin D, and it is exceptionally difficult to obtain adequate levels of vitamin D solely from the diet. Oily fish, such as wild salmon, sardines, mackerel and herring are the best sources. Other food sources include shitake mushrooms, egg yolk and fortified foods.

**Vitamin D deficiency**

Vitamin D deficiency is a global health problem. A significant number of Australians are deficient in vitamin D – it is a fallacy that Australians receive adequate vitamin D from casual exposure to sunlight.

**Risk factors for vitamin D deficiency**

- **Inadequate sun exposure**
  - Time spent outdoors
  - Excessive ‘Slip, Slop, Slap’-ing (using sunscreen can reduce your body’s vitamin D production by almost 100%)
  - Infants (especially if solely breast fed)
  - Elderly
  - Dark skin
  - Religious/cultural (covered-up style of dress)
  - Latitude
  - Seasonal variation
  - Global dimming (due to atmospheric pollution)

- Washing after sun exposure
- **Ageing**
- **Obesity**
- **Pregnancy**
- **Smoking**
- **Malabsorption** e.g. cystic fibrosis, coeliac disease, Crohn’s disease
- **Liver disease** (impaired conversion of vitamin D to 25-hydroxy vitamin D)
- **Kidney failure** (impaired conversion of 25-hydroxy vitamin D to 1,25-dihydroxy vitamin D)
- **Calcium deficiency** - results in increased 25-hydroxy vitamin D inactivation in the liver
- **Some drugs** – statins, anticonvulsants, cholestyramine, colestipol, orlistat, ketoconazole
- **Vitamin A excess** – may antagonize the actions of vitamin D
Burn injury
Psychiatric disorders
Genetic variability – accounts for 25-50% of the variation of vitamin D levels

What are the consequences of lack of vitamin D?

Vitamin D deficiency (hypovitaminosis D) is associated with numerous health problems, including:

- Increased inflammation (elevated CRP)
- Muscle weakness and pain - hypovitaminosis D myopathy (HDM)
- Rotator cuff muscle degeneration
- Poor physical performance
- Loss of muscle mass with ageing (sarcopenia)
- Falls in the elderly
- Aches and pains, non-specific musculoskeletal pain
- Fibromyalgia (vitamin D deficiency is often misdiagnosed as fibromyalgia)
- Fatigue
- Chronic low back pain
- Osteomalacia bone pain; tenderness on pressing sternum, shinbone, or forearm bone
- Sensitive, aching or ‘throbbing’ teeth
- Rickets
- Osteopaenia, osteoporosis
- Osteoarthritis
- Sweaty head as child
- ‘Hurting hair’ during childhood (pain in the scalp when hair is brushed or combed)
- Easily tired legs a child
- Growing pains in childhood
- Periodontal disease, gingivitis
- Dental decay (caries)
- Anxiety
- Depression
- Seasonal affective disorder (SAD)
- Bipolar disorder
- Schizophrenia
- Insulin resistance (syndrome X, metabolic syndrome)
- Insulin deficiency
- Pre-diabetes (impaired glucose tolerance)
- Diabetes – type 1 and type 2
- Diabetic retinopathy
- Obesity
- Polycystic ovary syndrome (PCOS)
- Premenstrual syndrome
- Pelvic floor disorders / urinary incontinence in women
- Infertility (in men and women)
- Pre-eclampsia
- Low-birth weight
- Seizures in newborns
- Hypocalcaemia (low blood calcium)
- Auto-immune diseases, including multiple sclerosis, type 1 diabetes, rheumatoid arthritis, Sjogren’s syndrome, lupus, Graves’ disease, Hashimoto’s disease, Crohn’s disease, autoimmune prostatitis
- Increased susceptibility to infection
- Influenza, swine flu
- Methicillin-resistant Staphylococcus aureus (MRSA) nasal carriage
- HIV disease progression
- Psoriasis
- Rosacea
- Atopic dermatitis
- Hair loss (alopecia)
- High blood pressure (hypertension)
- Peripheral arterial disease
- Heart attack (myocardial infarction)
- Left ventricular hypertrophy
- Congestive heart failure
- Cardiomyopathy
- Stroke
- Asthma
- Chronic obstructive pulmonary disease (COPD)
- Cystic fibrosis
- Renal disease
- Multiple sclerosis
- Parkinson’s disease
- Impaired cognitive function in elderly
- Alzheimer’s disease
- Motor neurone disease
- Migraine
- Cluster headaches
- Tension headache
- Retinitis pigmentosa, cataracts, myopia, keratoconus
- Hearing loss, otosclerosis, cochlear deafness
- Age-related macular degeneration
- Increased risk of 17 types of cancer, including breast, prostate, colon, ovarian, endometrial, oesophageal, Hodgkin’s and non-Hodgkin’s lymphoma, bladder, gallbladder, gastric, pancreatic, rectal, renal, testicular, vulvar, and skin
What should my vitamin D level be?

A blood level of 25-hydroxyvitamin D (25OHD) is the best indicator of vitamin D status.

25OHD level (nmol/L):
- <100 = Deficient 😞
- 100-200 = Ideal 😊
- 135-225 = Normal in sunny countries
- >250 = Excessive 😞
- 500+ = Potentially toxic 😞

Your level on....../....../2011 was.......... 

Treatment of vitamin D deficiency

Adequate sun (UVB) exposure (20 minutes/day, without sunscreen)

Diet: increase consumption of oily fish

Vitamin D supplementation:

Vitamin D3 (cholecalciferol) is the natural form of vitamin D in humans and animals.

To correct a deficiency, 4,000-15,000 IU of D3 a day for 3 months, may be required; thereafter, 2,000-10,000 IU/day will generally be sufficient as a maintenance dose (depending on sun exposure). Maintenance vitamin D supplementation may be taken as a single weekly dose.

Toxicity

Vitamin D toxicity is also known as hypervitaminosis D. All known poisonings with vitamin D3 reflect misuse on an industrial scale. All reports of iatrogenic (doctor-caused) vitamin D intoxication of adults have involved large doses of vitamin D2 or calcitriol.

- Safe level (25OHD) < 250 nmol/L
- Potentially toxic level (25OHD) 500+ nmol/L [requires a sustained daily intake >/= 40,000 IU]

Resources / further reading

www.vitamindcouncil.org
www.thevitamindcure.com
www.vitamindrevolution.com