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Views and Practice

Vitamin D and dermatology

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The role of vitamin D has been well-established in calcium homeostasis and bone health for decades and has recently gained its popularity regarding its potential role in human health issues including cancer, autoimmune or cardiovascular diseases with bursts of ongoing researches.[1,2]

Vitamin D is a fat-soluble prohormone and can be acquired by humans through cutaneous photosynthesis, diet or supplements. There are two forms of vitamin D from the above three sources: vitamin D_2 and vitamin D_3. Vitamin D_2 is naturally found in plants like sun-dried mushrooms (e.g. shiitake mushrooms), while vitamin D_3 is synthesised in human skin and is present in vitamin D-rich food of animal products (Figure 1).

The active vitamin D end product, 1,25-dihydroxyvitamin D ($1,25(OH)_2D$) is tightly regulated by parathyroid hormone, serum calcium and phosphate levels, hence, its serum level cannot reflect the total vitamin D store in our bodies. Therefore, 25-hydroxyvitamin D (25(OH)D) is commonly used to determine vitamin D status as it is the circulating form with the longest half-life (15 days to 3 weeks).

Because of its endocrine effect of serum calcium and phosphorus homeostasis, vitamin D deficiency can cause rickets in children and osteomalacia and osteoporosis in adults. Serum 25(OH)D level below 25 nmol/L is widely acknowledged as the threshold defining the risk of rickets and osteomalacia.

Vitamin D also has autocrine effects depending on genetic transcription unique to the type of cell expressing nuclear vitamin D receptors, e.g. keratinocytes, to promote cell differentiation and apoptosis, and to inhibit cell proliferation. This autocrine effect explains the mechanism of topical vitamin D analogue used in the treatment of psoriasis. In addition, vitamin D has roles in immune system functioning and cardiovascular systems, e.g. inhibition of macrophage activation and regulation of macrophage phagocytosis.

Source of vitamin D

Human can acquire vitamin D through sunlight exposure (endogenous), diet and vitamin D supplements (exogenous). It was noted that serum 25(OH)D levels attain a plateau from cutaneous photosynthesis, but this is not observed if vitamin D is obtained via diet and supplements.

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The United Kingdom Food Standards Agency-funded studies showed that UVB exposure (i.e. seasonal difference) was the major contributor to changes in the serum 25(OH)D levels. This finding was consistent in two Caucasian women groups in the north and south of the United Kingdom (UK), while it was less apparent in the group of South Asian origin living in the south of the UK. Besides, those studies also suggested that the typical daily vitamin D intake from food contributed less than UVB exposure to average year-round 25(OH)D levels in both Caucasian and Asian women.[3]

Sun exposure

Sun exposure is the dominant natural source of vitamin D. Vitamin D_3 (cholecalciferol) synthesis via previtamin D_3 from the precursor 7-dehydrocholesterol in the keratinocytes and fibroblasts is an ultraviolet (UV) light-dependent reaction. The optimal UV action spectrum is UVB of around 300 nm, however, this spectrum for vitamin D cutaneous synthesis is also the same as that responsible for sunburn and photocarcinogenesis. Use of tanning beds (group 1 carcinogenic to humans) to obtain vitamin D should be discouraged as the major emission spectra of tanning lamps is in the UVA range (320-400 nm) rather than the UVB action spectrum of vitamin D biosynthesis.

The height of the sun in the sky, expressed as the solar zenith angle (SZA), also needs to be considered in formulating advice about sun exposure. There are also other environmental factors affecting the ground-level UV intensity (Table 1). There is a seasonal variation in circulating 25(OH)D demonstrated in people residing in high latitude region, for example, with concentrations falling below 25 nmol/L in winter and spring in up to 10% and over 20% of the population in the south and north of Britain (latitude 49°N to 60°N) respectively.

It has been measured that full body exposure of fair-skinned individuals to 10 to 15 minutes of midday sun in summer is equivalent to one minimal erythema dose (MED) and it results in the synthesis of approximately 15000 IU/d of vitamin D_3. Besides, the concentration of previtamin D_3 reaches maximal levels after less than one MED UV radiation and further exposure merely results in the production of inactive metabolites and increased risk of skin cancers. Hence, one should avoid erythema from excessive sun exposure to aim for more vitamin D production.

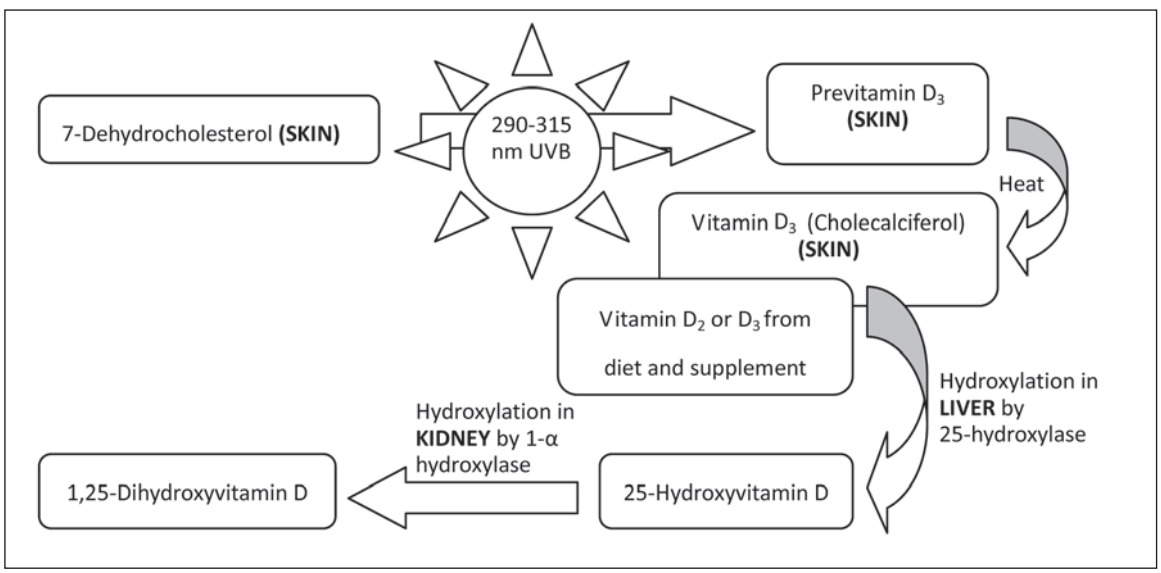

Figure 1. Vitamin D synthesis through sun exposure, diet and vitamin D supplements.

Terushkin et al[4] estimated that exposure of 25.5% of body surface of an individual with type III skin to sunlight at noon for 3 to 8 minutes generates about 400 IU of vitamin D in the summer in Boston (latitude 42°22'N), whereas this is possible during the entire year in Miami (latitude 25°47'N) for 3 to 6 minutes of sun exposure at noon. Hong Kong has a similar latitude to Miami at 22°15'N, and the majority of Hong Kong people have type III and type IV skin phototypes. According to the Hong Kong Observatory, 333 days of the 1-year period (91.2% of annual days) from July 2013 to June 2014 had daily maximal ultraviolet index (15-minute average, usually in the midday) of 3 or above, at which level vitamin D photosynthesis can be effectively carried out. Generally, a short incidental sun exposure without sunscreen (e.g. <10 minutes) in the midday should be enough for vitamin D cutaneous synthesis in Hong Kong.

Furthermore, the cutaneous production of vitamin D_3 is also affected by host factors including age, skin pigmentation and sun avoidance behaviours (e.g. sunscreen use). Individuals with darker skin synthesise less vitamin D_3 from sunlight since melanin pigment competes for absorption of the UV photons, while cutaneous vitamin D_3 precursors decrease with age in addition to a decreased cutaneous function to synthesise vitamin D from sunlight.

Diet

There are only a few natural sources of vitamin D as shown in Table 2. Sources of dietary vitamin D are mostly from fish (25%), followed by fortified cereal, meat and eggs (15-20% each), milk (6-7%) and fat spreads (2-6%) in the Western diet. Given the paucity of vitamin D in the natural diet, selected foods including infant formulae are fortified with vitamin D (usually D_3).[1] Two Irish randomised controlled trials showed that the daily requirement for vitamin D needs to be about 9 μg/day (1 μg=40 IU) to ensure that 97.5% of the population maintain their wintertime serum 25(OH)D concentration above 25 nmol/L. In fact, the mean habitual daily intake of vitamin D from food in a UK representative population was only between 2 and 4 μg/day.[3]

In the traditional Chinese diet, vitamin D amount is even lesser than those in the Western diet. Sun-dried shiitake mushrooms may be one of the richest sources of vitamin D in the Chinese food. However, they are expensive and may not be a good source for those with gouty arthritis. Nowadays, we consume more fortified foods and vitamin D-rich fish like salmon in the westernised diet and catfish which is commonly served in Cantonese restaurants (e.g. fillets of fish in sweet corn sauce 粟米斑塊).

Table 1. Environmental influences on UV intensity at the Earth's surface

Factors	Influences
Position of the sun	Varies with time of the year, time of the day and the latitude. The higher up the sun in the sky, the stronger is the UV radiation.
Ozone layer in the atmosphere	Ozone absorbs UV radiation, hence, the more abundant the ozone layer, the less UV radiation reaches the ground.
Clouds, rain, fog and haze	UV radiation is both absorbed and scattered by them.
Ground reflection	Most natural surfaces such as soil, grass and water reflect less than 10% of UV radiation, while sand and fresh snow reflects 10-25% and around 80% of UV radiation respectively.
Altitude above the sea level	The higher the altitude, the higher the UV intensity and the atmosphere becomes thinner as we go up and absorbs less UV.

Table 2. Dietary sources of vitamin D

Source	Serving size	Vitamin D form	Amount (IU)
Natural			
Herring, cooked	100 g	D_3	1627
Shiitake mushrooms			
Sun-dried	100 g	D_2	1613
Fresh	100 g	D_2	101
Cod liver oil	1 tablespoon (15 ml)	D_3	1360
Salmon			
Wild	100 g	D_3	1008
Farmed	100 g	D_3	302
Sardines, canned	100 g	D_3	518
Catfish, cooked	100 g	D_3	500
Mackerel, canned	100 g	D_3	348
Tuna, canned	100 g	D_3	235
Eel, cooked	100 g	D_3	202
Egg yolk	100 g	D_3	71
Fortified foods*			
Margarine	100 g	D_3	400
Cheese	100 g	D_3	118
Butter	100 g	D_3	50
Orange juice	100 ml	D_3	44-66
Milk	100 ml	D_3	44
Yogurt	100 ml	D_3	44
Breakfast cereal	100 g	D_3	18

*may vary, please refer to the nutritional information of the specific product

Vitamin D supplements

Nowadays, nutritional supplement industries had a fast-growing market and many inexpensive supplemental vitamin D (in the forms of D_2 or D_3) are readily available over the counter with or without calcium.

A clinical practice guideline in 2011 titled "Evaluation, Treatment and Prevention of Vitamin D Deficiency: an Endocrine Society Clinical Practice Guideline" suggests either vitamin D_2 or D_3 for the treatment and prevention of vitamin D deficiency.[5] Vitamin D_2 (ergocalciferol) is only obtained by diet and supplement, and its biological activity is likely equivalent to that of vitamin D_3. Furthermore, vitamin D_2 supplement is a good option in case of the unacceptability of the animal source of vitamin D_3 to strict vegetarians.

In 2011, the Institute of Medicine (IOM) in the United States updated the recommended dietary allowance (RDA) of vitamin D (Table 3) after reviewing of nearly 1000 scientific studies.[6-8] The RDA for vitamin D represents a daily intake sufficient to maintain the bone health and normal calcium metabolism in healthy people disregarding other sources of vitamin D, e.g. sun exposure. The RDAs for ages older than 1 year corresponding to a serum 25(OH)D level of at least 20 ng/ml (50 nmol/liter) meet the requirements of at least 97.5% of the population according to IOM.

IOM concluded that there is clear evidence of skeletal but not extraskeletal benefit from vitamin D. Randomised clinical trial evidence for vitamin

Table 3. Recommended dietary allowance of vitamin D by the Institute of Medicine

Age	RDA (international unit, IU)
≤1	400
1-70	600
≥70	800

D benefit in conditions other than the bone health was limited and generally uninformative. It is inconclusive as to whether higher vitamin D intake can reduce the risk for cardiovascular, autoimmune and other chronic diseases or cancer. However, higher serum vitamin D values were not consistently associated with a greater benefit, and U-shaped associations were observed for some conditions with risks at both low and high levels.

Dermatology recommendation (Table 4)

There are well-known detrimental side effects of ultraviolet irradiation. Fortunately, malignant melanoma and non-melanoma skin cancers are less prevalent in Chinese comparing to Caucasians. Moreover, our skin types (III to IV) are more protective against UV radiation harmful effect from sunlight exposure. However, there are still lots of uncertainties about what levels qualify as "optimal" or "sufficient" sunlight exposure for individual people to achieve adequate level of vitamin D.

In conclusion, the short incidental sun exposure during daily outdoor activities in Hong Kong is likely adequate for vitamin D synthesis in healthy individuals, while oral supplementation remains the safest way for maintaining vitamin D status especially for those concerned with skin ageing or at risk of skin cancer (Table 5).

Table 4. Recommendation(s) from dermatology and other authorities

Authority	Recommendation(s) / Position statement
American Academy of Dermatology Position Statement on Vitamin D 2010[9]	• Getting vitamin D from a healthy diet, which includes naturally enriched vitamin D foods, fortified foods and beverages, and/or vitamin supplement, and practising sun protection offer a healthier and safer alternative to sun exposure (natural) or indoor tanning (artificial) in considering skin cancer risk from ultraviolet radiation.
British Association of Dermatology Vitamin D Consensus 2010[10]	• Sunlight is the most important source of vitamin D. • The time required to make sufficient vitamin D varies according to a number of environmental, physical and personal factors, but is typically short and less than the amount of time needed for skin to redden and burn to provide the benefits of vitamin D without unduly raising the risk of skin cancer. • Vitamin D supplements and specific foods can help to maintain sufficient levels of vitamin D, particularly in people at risk of deficiency. • However, there is still a lot of uncertainty around what levels qualify as "optimal" or "sufficient", how much sunlight different people need to achieve a given level of vitamin D, whether vitamin D protects against chronic diseases such as cancer, heart disease and diabetes, and the benefits and risks of widespread supplementation.

Table 5. Recommended advice for vitamin D and skin care in Chinese

香港是亞熱帶地區，一年四季都有充足陽光，一般人從日常的戶外生活，已能夠攝取充足陽光，在皮膚製造身體所需的維他命D份量。

根據現時大部份有限的溫帶白人數據，如果您長時間作全面防曬保護或甚少接觸陽光，可以考慮在每個晴天的正午時份，衣著露出頭頸及前臂，不塗防曬在戶外曬太陽五至十分鐘。此法不會顯著的增加皮膚癌之風險，但緊記適可而止，如皮膚感覺發紅或疼痛便要立即停止。

如果您擔心曬太陽會引起皮膚老化或皮膚癌的問題，則可考慮從其他途徑獲取維他命D，如食物或維他命D補充劑。一般食物中的維他命D份量較少，未必足夠每日所需；因此，口服維他命D是相對簡單及有效的補充方法。

戶外活動時，可隨身帶備防曬用品以備不時之需，尤其在較長時間的戶外活動，更應考慮穿戴闊邊帽或防紫外線的衣服，並尋找遮蔭的地方，更需每兩小時或在游水及流汗後，重覆塗抹防曬以免曬傷皮膚。如有皮膚問題時，應立即請教醫生，以免耽誤病情。

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