Vitamin D and sun exposure: to bare all or cover up?

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"…questions have been raised as to whether sun protection advice could in fact be contributing to the prevalence of vitamin D deficiency."

Vitamin D has been branded as the new 'wonder' vitamin. Emerging qualities range from its established role in bone protection to the novel association in reducing all cause mortality [1]. Vitamin D deficiency is an endemic problem of global proportions, with a quarter of the UK's population and an estimated one billion people worldwide deficient [101, 2]. In February of this year, the Chief Medical Officers of the UK wrote to every community health professional urging awareness and intervention for this issue [101].

Defining vitamin D deficiency is complicated by no formal internationally recognized definition. Most researchers define deficiency as serum levels of 25-hydroxyvitamin D3 of less than 50 nmol/l; however, levels as high as 75 nmol/l may be needed to obtain optimal benefits [3]. This is the level that vitamin D levels plateau after prolonged ultraviolet radiation (UVR) exposure [4].

Vitamin D can be obtained from both cutaneous exposure to UVR and orally through diet; although diet alone is generally insufficient to meet the recommended intake [5]. Methods to increase serum levels include increasing sunlight exposure, food fortification, oral supplementation or intramuscular injections.

There is debate concerning what constitutes a desired daily intake. The Institute of Medicine recently increased its recommended daily intake to 600 IU, with a maximum of 4000 IU/day [6]. This level can be reached by exposing a Caucasian's face, arms and hands to sunlight for 10–15 min for 4–6 days per week [7]. As deficiency is linked to reduced UVR exposure, questions have been raised as to whether sun protection advice could in fact be contributing to the prevalence of vitamin D deficiency.

Other than vitamin D deficiency's infamous causation of rickets and osteomalacia, there has been increasing research into its effect on extraskeletal health. Various studies have suggested that deficiency is associated with reduced immunity to infections, reduced fertility and increased mortality secondary to cardiovascular disease, inflammatory bowel disease and falls [8]. It has also been implicated in numerous cancers, as well as a potential trigger for autoimmune diseases [9]. It should however be noted that these are association studies.

Aside from pathological etiologies of vitamin D deficiency, significant factors which affect vitamin D status on a population level include dietary intake and those reducing skin synthesis. These include skin pigmentation, season, latitude, time-of-day, age and sun protection behavior [2].

The approach to sun protection should be multifaceted and encompass avoidance behaviors, covering up and applying sunscreen. The impact of this advice on vitamin D status is not fully known and is again dependent on many factors. It is clear however that when used appropriately, sunscreens do not suppress serum vitamin D levels [10], and that sun

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protection behavior can be maintained in a subtropical climate without affecting vitamin D status [11].

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An optimum level of sun exposure that maintains vitamin D status without causing skin damage is ideal. However, as discussed, this is dependent on many factors, and even when these are taken into consideration, we are still uncertain exactly what an optimum exposure should be. In excess, solar radiation is harmful: it is a risk factor for every type of skin cancer and a WHO-classified carcinogen. However, the overzealous campaigns that public health departments have implemented in order to modify public attitudes in the face of a conflicting message from tanning and fashion industries may have had an overly negative impact on vitamin D status. In the UK, recommendations for routine sunscreen use recently doubled to SPF 30 in response to inadequate public adherence to application instructions [12]. Some authors argue that this campaign has been successful and we should now reconsider this one-sided approach; advising the public to spend more time in the sun. We would argue against this. The incidence of melanoma continues to rise [102], beach holidays are becoming more accessible and the majority of people still fail to use any form of sun protection [13].

Advice that encourages the public to increase sun exposure has the potential to undermine the work done by health agencies over the past 50 years. We should ultimately aim for targeted sun exposure plans, based on individual factors such as skin pigmentation, UV dosimeter readings and serum vitamin D levels. Blanket advice however, encouraging sun exposure, is likely to conflict with sun protection messages. Current recommendations, such as the Drug and Therapeutic Bulletin's that '(those) with fair skin (should expose their) hands, arms, face or back to suberythemal doses of sunlight in the UK from April to September for 15 minutes, two to three times a week' is complex and hard to communicate to the public [14]. Additionally, the evidence for this advice is based on the minimal erythema dosing method, whereby skin is exposed to sunlight until just before sunburn. This is potentially harmful, as DNA damage has been shown to occur at radiation levels far less than those causing sunburn [15].

We suggest that instead of sending conflicting public health messages, potentially giving rise to a new generation of complacency, tanning binges and increased use of sun beds; a safer alternative would be to optimize oral intake together with advice to spend more time outside, while continuing to heed sun protection guidance.

Considering very few foods naturally contain vitamin D, there are three options to raise the population's serum levels: the 'test and treat method', multivitamin supplementation and food fortification.

The 'test and treat' method is currently used to target 'at risk' groups [16], but would be unrealistic and expensive to implement on a population scale. The second proposed method is dietary supplementation. In their assessment, Yetley showed that the maximum population compliance with multivitamin supplements was 40% and consequently, relying on the public to take these is unlikely to be successful [16]. The third, and possibly most practical way to optimize vitamin D status, is food fortification. When considering subjecting an entire population to a lifetime drug exposure, questions concerning the long-term efficacy, safety and benefits must be comprehensively addressed.

Food fortification has been instrumental in tackling micronutrient deficiencies with resulting health benefits. Vitamin A was first added to margarine on a voluntary basis in 1927, which was subsequently made compulsory, along with vitamin D, during the period of rationing. Newer additions to the list include folic acid, with the aim of reducing neural tube defects among others [17].

Food fortification clearly works. It has been shown to increase vitamin D levels by 19.4 nmol/l when fortifying foodstuffs in the US (on a mandatory basis), with higher treatment effects where baseline levels were <50 nmol/l [17]. Although this may lead to a multitude of health benefits, current research has only shown a significant increase in bone mineral density and glycemic control in Type 2 diabetics [17].

Potential intoxication is the clear downside of oral replacement, as there is no risk of toxicity with excessive sun exposure [2]. Traditionally, toxicity has been attributed to hypercalcemia, occurring at serum levels greater than 374 nmol/l, with oral intakes of more than 50,000 IU daily [2]. However, newer concerns focus on the cumulative effects of chronic exposure and other forms of toxicity that may occur at lower doses.

There is little research that specifically evaluates the safety of long-term vitamin D use and the upper tolerable dose. The maximum level of 4000 IU is not intended to avoid acute intoxication, but to create a safe level for chronic intake. Unfortunately, due to limited evidence largely relating to short-term consumption, extrapolation to a life-time of exposure is potentially unreliable [101].

Adequate circulating levels of vitamin D have been shown to reduce all-cause mortality; however, somewhat perplexingly it is a 'reverse-J-shaped' curve, whereby mortality starts to reduce at higher circulating vitamin D levels [1]. Observational studies have also shown an association between vitamin D supplementation and pancreatic cancer. A further concern, rather incongruently, is the emerging (albeit limited) evidence that higher doses of vitamin D administration to those at high fracture risk actually increased the risk of falls and fractures [6]. These adverse effects are largely reported at levels of 75–120 nmol/l, which would allow for food fortification easily within therapeutic but not toxic limits [6].

Clearly, there are ethical implications with regard to mandatory food fortification. For this reason, many of the successful historical campaigns began with voluntary additions, which gives choice and the added benefit of long-term efficacy and safety data before mandatory legislation is imposed. Other considerations need to be given to cost, which would likely be passed on to the consumer at a time of rising food prices in an economic recession.

Before we jump to change the advice on sun protection and risk giving conflicting messages to the public, we propose optimising vitamin D intake. On a population scale, food fortification is the best method to do so. Although more evidence is needed to assess the potential toxicities and benefits of long-term supplementation, considering the scale of the problem we should act quickly to do so.

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