Mini Review

Vitamin D status and food security in North-East Asia

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The functions of vitamin D are pleiotropic affecting all body organs and systems in some way. Its adequacy depends principally on sunshine for UV light to stimulate its synthesis in skin and on foods which contain it, either animal-derived or obtained from fungi or mushrooms, with the UV-responsive substrates dehydrocholesterol for vitamin D-3 or ergosterol for vitamin D-2, respectively. Thus, vitamin D health is very environmentally dependent. With ecosytem degradation, whether by atmospheric pollution or food systems which do not derive UV irradiation, as with fish farming or mushroom processing, then this nutrient input into human biology may falter. Vitamin D deficiency is now common and widespread in North-East Asia as elsewhere. When discovered early in the 20th century it was linked to rickets in children and osteomalacia in adults and, for a generation or so, children were given fish, usually cod, liver oil to prevent bone disease. Now cod as a species and many edible fish are threatened. Over-exposure to sun-light increases the risk of skin cancer. We may tackle this problem by vitamin D supplementation with an alternative to fish liver. But the demographic pressures of population size and ageing (when the skin is less UV responsive) make the clinical and public health decisions and strategies demanding. Vitamin D health has become indicative of food security whose usual indicator is food diversity; such diversity may allow lesser concentrations to be more effective in organ and system function, but we have little evidence to support this at present.

Key Words: vitamin D, climate change, health, pleiotropic functions

PLEOTROPIC FUNCTIONS OF VITAMIN D

Whereas once vitamin D was seen as a nutrient with actions principally in bone, its spectrum of activity is now known to be endocrine, autocrine and paracrine and to embrace probably every organ or tissue and every major body function[1,2] and throughout the life-cycle.[3-6] These actions range from cellular differentiation and risk for neoplastic disease,[7,8] to energy regulation and adiposity, locomotion (muscle and bone), cardiorespiratory,[9,10] renal,[11] gut,[12] integument (skin),[13] cognitive [4] and central nervous system,[14] the special senses,[15,16] male and female reproduction,[17,18] other endocrine (including pancreatic and diabetes),[19] immune system[20-24] and inflammatory responses.[1,20] The morbidity and threats to life of vitamin D deficiency extend well beyond the original recognition of its contribution to rickets in children [25,26] and to osteomalacia and osteoporosis in adult.[1]

SOURCES

What is, therefore, most interesting is how dependent its status is on sun exposure and on food which was worked out by a number of investigators and eventually named vitamin D by McCollum in the 1920s.[27] The problem with foods as a source is that those that contain it are few, mainly animal-derived where dehydrocholesterol (cholesterol is only found in animals) is the precursor or fungi like mushrooms which contain the precursor ergosterol. In both cases, exposure to ultraviolet light is required to produce, respectively, vitamin D-3 or vitamin D-2. For most people, skin exposure to sunlight is the principal source unless the winters are long and dark and where seafood is abundant (as in the arctic regions).

Sunlight

Dependence on sunlight for vitamin D has become difficult for many since the risk of skin cancer through actinic damage has become a public health priority, especially where the ozone layer has been depleted through atmospheric contamination. Added to this is atmospheric pollution which obscures the sun, as in many urban precincts in North-East (NE) Asia, and where people spend more and more time indoors or in cars.

Food

In NE Asia, the main food sources of vitamin D are fish, meat, dairy (if fortified or irradiated with UV), eggs and mushrooms (where they have been dried in the sun). The

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skin of animals like chicken can be a source if the chickens have been raised with sunlight exposure.[3] Liver can be an important source, but its popularity is waning among younger people and because people fear that it might contain accumulated toxicants.

Increasing dependence on food which is vitamin D poor exacerbates the problem of limited sun exposure. This is occurring for several reasons. One is that there has been a concerted public health program in cardiovascular disease prevention to discourage animal-derived foods that happen to contain vitamin D because they are cholesterol-rich like eggs, organ meats (which include liver, brain, 'sweet-breads'). Another is that, for many, their dietary diversity is narrow, particularly through the work-aday week when short-cuts to meal preparation and cheaper food choices are made.[28] Dairy is a useful source if fortified, but liquid milk itself is not a particularly good source of vitamin D.[29] In NE Asia, elderly people tend to use imported milk powder as a dairy source and this is usually fortified with vitamin D.[3] Food intake itself rarely provided the DRIs (Dietary Recommended Intakes) for vitamin D, and supplements are used to meet a gap which could be met with sun-light exposure, if it were not for the constraints mentioned above.[3]

RISK FACTORS FOR DEFICIENCY

Environment, season, diet and skin pigmentation are major risk factors for vitamin D deficiency and its related health outcomes. Being male is a notable risk in Chinese men compared with women.[30] Physical activity and not smoking are favourable. There are also several other individual sociocultural and behavioural risk factors. These include hats and clothing, parasol usage, kind of recreation such as swimming, use of sunscreen use, occupational conditions, outdoor activities, travel by bicycle or car or public transport, and vitamin supplement usage.[31]

EXTENT OF DEFICIENCY IN NE ASIA

With major gradients in sunlight exposure in NE Asia, it would be expected that those who live nearer to the equator would have the better vitamin D biochemical status whatever the intakes. This is probably the case as reports from sub-tropical and tropical Taiwan suggest.[3,6] Certainly, in the further north, Korea[19,32] exhibits extensive biochemical and functional deficiency. The same is the case for China.[9,33,34] Japanese elderly have been found to have acceptable vitamin D intakes in excess of 7 μg per day, but low 25-hydroxy vitamin D status;[35] this situation underscores the likely ongoing life-long need for sun exposure although its inadequacy might be compensated for by food fortification or supplementation. But that would overlook the companion value and eco-nutritional dimensions of being outdoors.[36]

Notwithstanding the relatively satisfactory vitamin D intakes in Taiwanese women, at the lower end of intake vitamin D have a protective effect against breast cancer in premenopausal women of normal weight in subtropical Taiwan. Intakes less than 5 μg per day were a risk factor.[8] Lesser sunlight exposure was also a risk factor for breast cancer. A problem among Chinese women in this regard is sunlight avoidance with parasols and face masks in order to be pale (quite the reverse of European women in Australia who seek the sun and suffer increased skin cancer as a consequence). In the Asia pacific region an example of apparently favourable vitamin D status is that of Fijian and Indian-Fijian women, while dark-skinned, as judged by serum 25-hydroxy vitamin D.[37]

While vitamin D deficiency is associated with increased mortality in a meta-analysis,[38] in Linxiang, china , noted for its micronutrient deficiencies and a link between vitamin D deficiency and oesophageal cancer,[7] mortality has not been found associated with vitamin D status.[39] It is possible that this incongruous finding is related to competing risks for mortality.

The question of optimal vitamin D intakes is clearly dependent on a number of behavioural and environmental considerations.[40] But the optimal serum concentrations of active forms of vitamin D are found to be higher than commonly encountered in surveys or clinical practice. Insofar as mortality is concerned, Zittermann et al found that there was "a nonlinear decrease in mortality risk as circulating 25(OH)D increases, with optimal concentrations ~75-87.5 nmol/L".[38]

GENES AND ENVIRONMENT – ECOLOGICAL FACTORS AND SOLUTIONS

Genetic factors play a minor role in serum vitamin D variability although an exception may be Chinese men[30] and in winter with the residual serum concentrations after the more elevated summer values.[31]

Nevertheless, the expression of vitamin D related health outcomes for a particular intake and serum status may be considerably affected by vitamin D receptor polymorphisms.[41]

OPTIMAL STATUS: IS IT POSSIBLE TO MANAGE WITH LESS?

Food intake and nutritional status may affect vitamin D function in a number of ways and these may extend back to fetal life and epigenetic effects on vitamin D absorption or cutaneous synthesis, transport, conversion to the active forms, 25-hydroxy vitamin D and 1,25-dihydroxy vitamin D, as well as vitamin D receptor activity. Any of these considerations might allow people in some circumstances to have less sunlight exposure, consume safely or have lower serum status than otherwise possible.

Each of the fat soluble vitamins may interact with each other. Vitamins D and K both affect bone pathophysiology since osteocalcin is a vitamin K dependent bone protein.[1,3,35]

How much active vitamin D is required will also depend on the health outcome in question e.g., osteoporosis and fracture, CVD, and skin cancer where quite different associated risk profiles apply between them.

The environment to which an individual is exposed will also modulate the risk as previously enumerated.

ENVIRONMENTAL MATCH AND VITAMIN D NUTRITION AS A FOOD SECURITY ISSUE

In human evolution various adaptations have enabled us to live with a wide range of climates, seasonal changes and food systems. Skin colour is an example which allows more or less cutaneous vitamin D synthesis dependent on sun exposure and which has allowed for restricted dietary vitamin D intakes. As sun exposure, whether for public health reasons or inadvertently, lessens, so dependence on the food supply will increase. Vitamin D fortification of foods or supplements appears to be part of the solution, but this approach is contextually novel for our species and its full risk analysis incomplete. This emerging scenario of food and environmental insecurity requires a more ecological approach.[36,42-46]

AUTHOR DISCLOSURES

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東北亞的維生素 D 狀況與糧食安全

維生素 D 的功能是透過某些途徑，多效地影響全身器官及系統。足量的維生素 D，主要靠陽光中的紫外線刺激皮膚合成，及含有維生素 D 的食物，如來自動物或菇菌類中所含的維生素 D-3 與 D-2，分別由去氫膽固醇與麥角固醇合成。因此，體內維生素 D 的狀況易受到環境影響。隨著生態系統的衰落，不管是大氣污染或是因為養殖漁業、菇類加工，使這些食物無法保有經由紫外線輻射而產生的維生素 D，可能讓此營養素進入人體的機會隨之減少。目前東北亞維生素 D 缺乏的情形和他處一樣常見且普遍。在 20 世紀初，維生素 D 被發現與孩童佝僂症和成人的軟骨症有關，當時那一輩的孩童藉由給與魚肝油(通常是鱈魚)來防止骨疾病。然而現在，鱈魚及許多可食的魚類數量均銳減，過度暴露於陽光下則會增加皮膚癌的風險。為了解決此問題，也許應以維生素 D 補充劑來取代魚肝。但是人口增加及老化(此時皮膚對紫外線的反應降低)的壓力，使得臨床及公共衛生上的決策變得不可或缺。維生素 D 狀況已成為糧食安全的代言，常用的指標為食物多樣性；多樣性或許使得以較少的濃度，就能在器官和系統功能更有效率，但目前支持的證據尚不足。

關鍵字：維生素 D、氣候變遷、健康、多效作用