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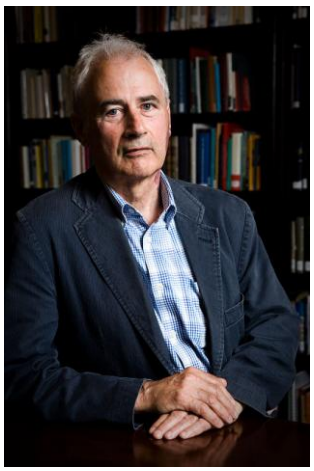
Commentary. Vitamin D

Let the sun shine on you



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Introduction

The Waorani people from Ecuador. Clothes are not necessary for brown-skinned people living in a tropical climate. This however is not our situation

Most people in northern industrial countries, such as the UK where I come from, have an inadequate level of vitamin D in their bodies, especially in winter. These low levels are now known to be associated with a wide spectrum of serious diseases, many of which lead on to disability and premature death. The diseases associated with D deficiency include more than a dozen types of cancer, multiple sclerosis, diabetes type 1, heart disease, high blood pressure, and schizophrenia, as well as the classic bone diseases – rickets, osteoporosis and osteomalacia. Evidence that these diseases are caused, at least in part, by a deficiency of sunlight and vitamin D has accumulated at an accelerating pace over the last ten years, but is not yet well known.

The effects of deficiency go way beyond the diseases of the bone that have long been known to be linked with vitamin D. But this new evidence is unfamiliar to most doctors and scientists, and quite rightly they are sceptical. At first sight it seems unlikely that vitamin D deficiency could be a causal factor in so many entirely different diseases. And we still have little idea how D deficiency acts, together with other risk factors, to cause one disease in one person and other diseases in other people. However the accumulated evidence linking D deficiency to chronic disease is

extensive and consistent. So it has great strength as a coherent body of work. It is reasonable to conclude even on present evidence, that if an optimal level of vitamin D is maintained throughout life, many diseases that presently destroy lives may be prevented.

Box 1

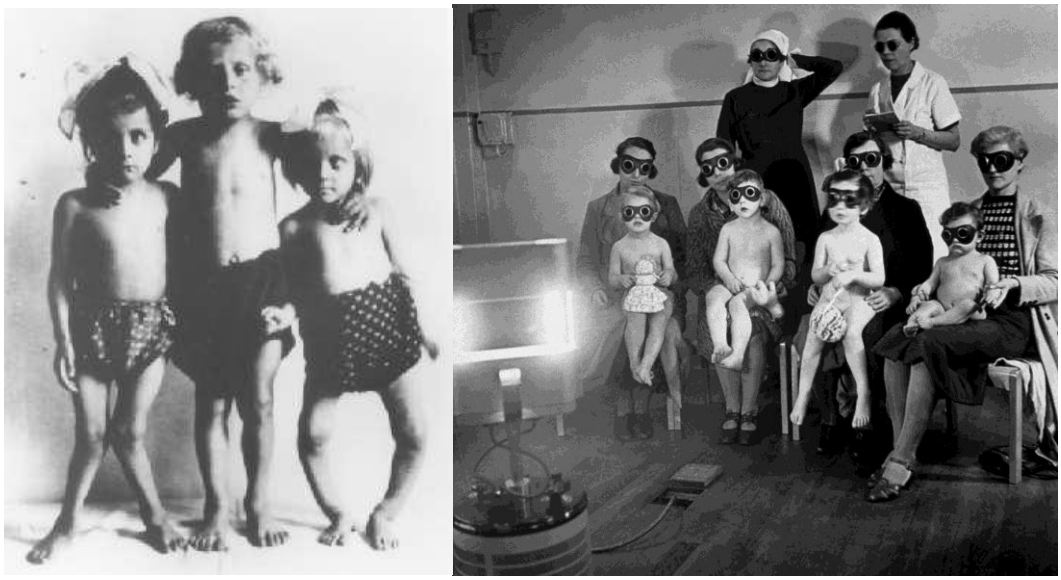
A personal note

I am a former medical correspondent of the UK national newspaper *The Sunday Times* and former health editor of *The Independent*. As a scientist and writer I have won 17 awards. Most recently I was elected health champion of the year by the Medical Journalists' Association for the campaign to inform the public and professionals about vitamin D insufficiency disease.

Over the last seven years my main work has been to research and to pass on information about vitamin D insufficiency to scientists, doctors, and journalists, and to lobby government and organisations such as Cancer Research UK for a rational evidence-based public health policy on sunlight and vitamin D. I am collaborating with Professor Julian Peto of the London School of Hygiene and Tropical Medicine in the development of scientific trials of vitamin D.

One of my main concerns is that cancer charities all over the world have used the slogan 'There is no such thing as a healthy tan'. This has played a major role in scaring people away from the sun, but has no sound scientific basis.

Skin and bone, and many body systems



'Classic' vitamin D deficiency in dark sunless Northern countries, and one of its cures: children with rickets, and being treated with ultra-violet rays

Ultra-violet radiation and the vitamin D it generates produced the first cures of tuberculosis of the skin in 1903. The results were seen as miraculous and earned the Danish physician Niels Finsen the Nobel Prize. Soon afterwards, rickets, a common disease causing devastating deformity, was also being cured with ultra-violet radiation. Within a few years, food supplements such as cod liver oil, very rich in vitamin D, were being used to cure rickets. Again the results seemed miraculous.

But now, a century later, a hundred or more diseases are now known to be, may be, or might be, causally associated with low levels of vitamin D. The very large number is enough to arouse scepticism in the minds of many scientists. Nevertheless, there is compelling evidence that insufficient vitamin D causes 36 of these diseases or is at least a major risk factor for them, while there is moderately strong evidence that insufficient vitamin D is likely to cause another 27 (see Box 2). Further preliminary observations indicate that another 40 or so diseases are associated with insufficient vitamin D.

Box 2

Diseases caused by or associated with deficiency of vitamin D

A review using Austin Bradford Hill's criteria for causality has found strong evidence that vitamin D is a risk factor for 36 diseases, and moderate evidence linking to another 27 diseases. The lists below are taken from Grant W: Review of 100 diseases and their association with vitamin D insufficiency. http://www.vitamindcouncil.org/health-conditions.

Strong evidence

Anaemia
Arthritis (osteo)
Atherosclerosis
Cancer:
- bladder
- breast
- colorectum
- endometrium
- gallbladder
- Hodgkin disease
- kidney
- non-Hodgkin lymphoma
- oesophagus
- ovary
- stomach
- vulva

Cardiovascular disease
Chronic kidney failure
Coronary heart disease
Dental caries
Diabetes type 2
Fractures
Falls
Fibromyalgia
Inflammatory bowel diseases
Influenza
Insulin resistance
Meningococcal disease, meningitis
Multiple sclerosis
Osteoporosis
Pneumonia
Polycystic ovary syndrome
Pre-eclampsia
Rickets
Sepsis/septicaemia
Tuberculosis
Vaginosis, bacterial

Moderate evidence

Anaphylaxis
Asthma
Atopic dermatitis, eczema
Autism
Autoimmune disease
Cancer:
- leukaemia
- lung
- melanoma
- pancreas
- prostate

Chronic obstructive pulmonary disease
Cognitive impairment
Common cold
Congestive heart failure
Depression
Diabetes type 1
HIV/AIDS
Hypertension
Paget's disease
Parkinson's disease
Periodontal disease
Peripheral vascular disease
Psoriasis, psoriatic arthritis
Schizophrenia
Stroke
Tonsillitis
Turner syndrome

No other risk factor has been recognised which has so many known and suspected adverse consequences for health, not even smoking. Vitamin D insufficiency has emerged suddenly in the last seven years as being a much more important problem than anyone realised. It is now identified as a risk factor for the two major killer diseases: heart disease (1-3) and cancer (4,5), and as crucial for healthy function of bone (6,7), muscle (8,9), and the immune system (10,11). Insufficiency is also linked to high mortality, and extra years of life may be gained by taking a vitamin D supplement (12-15).

Not just a vitamin

As indicated above, a century ago it was shown that rickets, a bone disease of children, could be cured by an 'accessory factor' in food (15). About the same time it was shown that ultra violet light from a mercury arc lamp could cure the disease (16). Confusion continued for some time, while experts disagreed on whether rickets and other bone diseases were caused by lack of sunshine or by diet. The argument was eventually settled when it was shown that vitamin D is made by the action of ultra violet light on skin (17).

Nevertheless confusion continued for many years, perhaps because there was no single discipline that 'owned' vitamin D. It is not just a nutrient, the province of nutritionists and dietitians. It is also generated by sunlight, the province of physicists and physiologists, while medically it became the province of endocrinologists.

Over the last 30 years the essential health role of sunlight has been neglected and misunderstood. Even so vitamin D is known as the sunshine vitamin, but equally it could be called the orphan vitamin because its parenthood is uncertain and, more a hormone than a vitamin, it stood aside from its fellows.

Classic studies of vitamin D showed its importance for prevention of bone disease. Now we know there is much more. Vitamin D plays a vital role in regulating six different physiological systems of the body (18). It does this in at least two different ways: by controlling a thousand or more genes, and by direct physiological action on and in several organ systems. Study of vitamin D has brought a new understanding of the way in which environment and genome interact which means we must reinterpret old ideas of nature and nurture.

The purging of dogma

Today, new knowledge of vitamin D is once more challenging established dogma. Nutritionists, midwives, paediatricians, and dermatologists, are being confronted with uncomfortable facts which force a re-examination of long held beliefs.

Diet is inadequate

It only takes a small regular dose of vitamin D, as found in a teaspoon of cod liver oil, to prevent and treat rickets. But in the last 5 to 10 years scientists have shown that much larger doses are needed for optimal health and that typical diets can only supply a small part, often less than 5 per cent, of our optimal vitamin D requirement (19). Except for Eskimo (Inuit) who get plenty of vitamin D from their traditional marine diet, the sun is our major source of vitamin D. It is impossible to get enough vitamin D for health only from a modern diet. This has confronted nutritionists with a serious challenge to their dogma that a varied or balanced diet will provide populations with all the nutrients they need. Vitamin D is an exception to their rule.

Low levels of vitamin D can be corrected by taking a supplement, but this again challenges the assumption of many nutritionists that supplements are unnecessary if people are eating varied diets. We are omnivores – a varied diet is a natural part of the hunter-gatherer way of life, as is sunshine. But now, most people in industrial countries are far from any rural roots, and long ago departed from natural ways of life. Today diets may be varied or balanced while ways of living remain distinctly unbalanced and totally unnatural. City life, houses, and daily work have kept most us out of the sun for several generations. Now television, computers, and air conditioning give us even more cause to stay indoors. Clothing fashions and cosmetics containing sun-block remove us further from natural living.

The risk to babies and children

Breastfeeding is of course natural, but our knowledge of vitamin D brings an alarming challenge to doctors and midwives who dogmatically believe that breast is best – always. Most women living modern urban lives get little exposure to the sun and so secrete little vitamin D in their breastmilk (20,21). So breastfed babies, particularly those born in spring or early summer – April and May in the northern hemisphere – may get too little vitamin D, whereas bottle-fed babies get vitamin D from their formula which is fortified.

Babies born in May at high latitudes have been found to have a greater risk of certain diseases occurring later in life, particularly multiple sclerosis, but also anorexia

nervosa, autism, schizophrenia and diabetes type 1 (22-26). Deficiency of vitamin D in pregnancy may seriously damage growth and development of the baby in other ways and in the extreme may lead to heart failure (27). These risks are easily overcome by giving babies a vitamin D supplement, but some passionate proponents of breastfeeding are unwilling to recommend vitamin D to nursing mothers because it means acknowledging that breastmilk is less than perfect.

Box 3

Dietary sources of vitamin D

Eskimos (Inuit) such as the hunter above, live in darkness for some eight months of the year and so get relatively little vitamin D from the sun. But their traditional diet of fish, seal and whale, which includes the liver and viscera of these creatures, is rich in vitamin D and so deficiency is not a problem. Some Eskimos who live inland in western Canada live largely by hunting caribou and get less vitamin D from their mostly meat diet. However they prize fish oil rich in vitamin D which they trade with Eskimos living on the coast.

Outside polar regions and neighbouring high latitudes, sun is the major source of vitamin D, and unfortified diets by themselves never supply enough. A mere 5 per cent of the optimal level of vitamin D may come from conventional modern diets. Few common foods naturally contain vitamin D. These include butter and cheese, and eggs (especially when the chickens are fed supplements). The best common source is oily fish. The liver of some fish is exceedingly rich in vitamin D.

Vitamin D is also contained in fortified foods such as margarine. In some countries, for example the US, most milk is fortified with vitamin D, and in Canada milk must be fortified by law. In other countries such as the UK milk is not fortified. Breakfast cereals are often fortified but generally only with very small amounts of vitamin D.

Advice on cancer prevention is wrong

Perhaps the most alarming challenge to dogma is being faced by cancer charities which until recently had a monopoly of advice on sunshine (28,29). Encouraged by the dermatology industry, they have exaggerated the risks of skin cancer and the danger of excessive sun exposure while ignoring the benefits of sunshine (30). These sunshine deniers have condemned sun-bathing as an unhealthy cosmetic procedure aimed solely at providing a tan. In doing so they have failed to recognise that we have a physiological requirement for sun exposure, and that tanning is a natural process that is not known to cause disease of any kind. Used to occupying the moral high ground, cancer charities have been shocked to be told that they have put lives at risk by telling people to cover up and hide from the sun, to stay in the shade in the middle of the day and to use sun-cream whenever outdoors. They promoted the assumption, which had no scientific basis, that exposure of only hands and face to the sun provided sufficient vitamin D. They believed, in effect, that what you got is what you need (30). Now there is, happily, a move away from this mistaken view: see Box 3.

Box 4

Sunbathing is healthy

Since 1994 the government of my country, the UK, backed by a number of cancer charities and other organisations, has warned against exposure to sunlight in order to prevent skin cancer. This policy, also followed in many other countries, was originally based on a model developed in tropical and sub-tropical Australia. It gives advice to cover the body with clothes or sun-cream, wear a hat, seek shade between 11am and 3pm, and to avoid tanning. The policy cautions the public to avoid exposure to the sun, while making no reference or concessions to the health benefits of sunlight.

Any benefit derived by this policy in prevention of skin cancer is greatly outweighed by the disease deficits incurred by the loss of vitamin D. UK government policy on sunlight, in common with that of other temperate countries, advocates ways of life particularly unsuited to climates in which sunny days are intermittent and sunshine is relatively weak. It is unnatural, and is recognised as such by a large section of the public who have rejected it. Following such recommendations can only increase vitamin D deficiency and so lead to an increase in ill health and premature death.

New public health policies on sunlight and vitamin D are needed, throughout the world. They should include a recommendation for regular exposure to or sunbathing in strong sunlight. Certainly it is also essential to avoid baking or burning – for example, in strong sun men with thin hair or who are bald should wear

a hat. But given that baking or burning are avoided, there is no sound scientific basis for alleging that a tan is ever unhealthy. The slogan 'There is no such thing as a healthy tan' should be publicly stated to be wrong, and should be dropped. People enjoy sunbathing. It is the normal and natural way to obtain vitamin D. Sunlight costs nothing and has very great health benefits. A wise policy on sunlight should encourage sunbathing while advising people how best to sunbathe safely.

Some cancer charities have now acknowledged that their previous advice was wrong and have in effect admitted that it is likely to have put lives at risk through deficiency of vitamin D (31,32). Cancer Research UK, for example, has made a U-turn and now advises the public to spend some time in the sun in the middle of the day. In Australia the SunSmart programme promoted uncompromising advice on sun avoidance for many years with its 'slip, slap, slop' slogan. Now Australian cancer charities have issued new advice. This calibrates recommended sun exposure to the intensity of radiation in different parts of Australia according to season and latitude (33,34).

Impact on many body systems

An exciting new story of the sunshine vitamin, the orphan vitamin, the hormone vitamin, and now the gene transcription factor, is emerging The classic story tells us that vitamin D is made in the skin and from there is absorbed into the blood stream which carries it to the liver where it is converted into 25-hydroxyvitamin D (17). It then travels to the kidney where it is converted into the steroid hormone 1α,25-hydroxyvitamin D. In the 1970s this hormone-vitamin (D-hormone) was shown to control absorption of calcium in the intestine and the deposition of calcium in bone. This is the classic story that every medical student and every student of biology learns (17).

Impact on five body systems

However the classic story is just part of a much larger encyclopaedia of actions that we are now beginning to understand in some detail. Over the last five years or so the pieces have all come together, and the sum is far greater than its parts. We now know that receptors for the D hormone are found in at least 38 different tissues or organs of the body (18), not just bone and intestine. Furthermore many of these organs are not dependent on the kidney for their supply of D hormone, but convert the upstream molecule, 25-hydroxyvitamin D, into its hormone form within the organ itself. In this way D hormone is secreted within the organ (18), where it is able to act in an intimate and individual manner under local control.

Laboratory and clinical research shows that vitamin D acts on five physiological

systems other than bone (18). These are the immune system, the heart and blood vessels, the muscles, the brain, and the pancreas which controls metabolism of sugar and fat. In addition vitamin D has been shown to be essential for normal differentiation of cells into mature tissues and for normal death of cells that have completed their functions, a process known as apoptosis. These cellular processes are crucial for growth and development of the baby in the womb and early life and for control of rogue cells that might otherwise become malignant.

Another burst of growth occurs with puberty, and plenty of vitamin D at that time is also needed for normal growth of breast and prostate cells. Insufficient vitamin D bringing failure of normal growth and multiplication of cells at puberty may allow deviant cells to survive only to re-emerge in malignant form much later in life (4). Understanding the way these tissues are influenced by vitamin D as well as by sex hormones is bringing a new understanding of breast and prostate cancer (35).

Our capacity to explain disease based on actions of vitamin D known from the laboratory has raced ahead of evidence proving that vitamin D causes or exacerbates individual diseases (36,37). Evidence from clinical trials, the gold standard of evidence, is still scarce and so many scientists remain sceptical (38,39). The effect of vitamin D in correcting rickets in children is so dramatic that no formal clinical trial was needed (40). Equally dramatic is the effect of vitamin D in correcting heart failure in babies suffering from extreme vitamin D deficiency, although this is less well known (27). Clinical trials show that vitamin D given to older adults reduces the risk of fractures in those who take the supplement and/or those in whom blood levels of vitamin D are raised (6,7).

Vitamin D has also been shown to reduce the risk of falls, which are a separate effect of insufficient vitamin D reaching the nervous system (41).There have been many trials, many meta-analyses and much dispute about the benefit of vitamin D in preventing fractures and falls. Some trials have failed to find a benefit, while others have. Trials conducted in institutions where subjects are supervised taking their medication produce positive results, whereas results from trials in the community are more variable (42). This seems to be because subjects may fail to take supplements consistently in long trials if they are not supervised.

Gradually evidence is accumulating to show the vital role of vitamin D insufficiency in diseases such as type 1 and type 2 diabetes, and the related condition, metabolic syndrome (43). Yet other studies show vitamin D has a role in regulation of the renin angiotensin system which controls blood pressure while further work shows the vitamin has an important influence on blood coagulation (44).

Impact on immunity

For a century it has been known that sunshine or cod liver oil, the richest natural source of vitamin D, can help people to overcome diseases such as tuberculosis of

the lungs (40). And for almost as long, it has been known that sunshine or UV radiation can cure tuberculosis of the skin, known medically as *lupus vulgaris*. Now it has been proved in clinical trials that this is because vitamin D promotes our immune defence against infection (45,46). Trials have shown that vitamin D boosts immunity to tuberculosis, influenza and pneumonia (46-48). Laboratory work suggests that this is the result of action of vitamin D stimulating the innate immune system (49).

Vitamin D, or the lack of it, has other profound effects on the immune system. When people have insufficient vitamin D they are more prone to autoimmune diseases such as type 1 diabetes, multiple sclerosis, inflammatory bowel disease (for example, Crohn's) and psoriasis. These are diseases in which the body is attacked by its own immune system. There are 80 or more autoimmune diseases including some relatively common ones such as coeliac disease, rheumatoid arthritis, biliary cirrhosis, and certain thyroid diseases. Experiments with autoimmune diseases in mice have shown that vitamin D plays a crucial role in them (50). This together with other evidence from epidemiological studies is enough to make vitamin D insufficiency a prime suspect in investigations of these diseases (49).

It takes a long time for a new treatment to become known to doctors when there is no drug company to push it. So the hopeful message that vitamin D may modulate autoimmune disease (11) has reached few of those who suffer from one of the many rare autoimmune diseases of which Goodpasture's, Addison's, Cogan's, Sjogren's and Behçet's diseases are only a few.

Correction of vitamin D insufficiency should be a primary consideration for people with any autoimmune condition. Vitamin D has no serious side-effects and is very cheap, so it makes no sense to wait for a clinical trial which may never be done. Provided there are no contra-indications to taking a vitamin D supplement it may be begun right away and, when optimal levels are confirmed by a blood test, each patient can judge for themselves whether or not there is any benefit. Treatment with a vitamin D supplement at a suitable dose may halt progress of a disease but is unlikely to reverse it if there are already pathological changes. Nevertheless for someone who is very deficient there may be immediate benefit in a greater sense of well being.

The link with multiple sclerosis

Research on multiple sclerosis (51) shows how the disease may be triggered by insufficient vitamin D during pregnancy or any time up to the teenage years. Symptoms of multiple sclerosis itself generally do not occur until later, after the age of 20. The most vulnerable times for the initial insult seem to be when there is rapid growth, as in early life and during the pubertal years (52). People who get multiple sclerosis are more likely to have had an infection with Epstein-Barr virus at one of these life stages when their immune system is probably not functioning optimally

(53). Epstein-Barr virus, best known as the cause of glandular fever or infectious mononucleosis, is very common. The vast majority of people suffer no lasting effects after infection. Current thinking suggests that, in the absence of sufficient vitamin D, infection (54) with the Epstein-Barr virus sets in train an autoimmune reaction which involves the nervous system, eventually causing the familiar damage of multiple sclerosis (55,56).

Studies by a team at Oxford University have shown that the risk of multiple sclerosis may be transmitted in a way that defies the classic teaching of genetics enshrined in Mendel's laws and in the classic biochemistry of DNA (57). The Oxford team has found that some genes, instead of being handed down unchanged, seem to defy dogma and become modified by environmental factors. The team, led by George Ebers and Julian Knight, has shown that a gene called HLA-DRB1 which determines susceptibility to MS can be switched on or off by vitamin D in laboratory experiments (58). Once initiated by insufficient vitamin D, risk of the disease may be transmitted by modified genes that persist for a number of generations, before perhaps changing back again as a result of another environmental stimulus (59).

Epigenetics and Lamarck

The detailed scientific evidence from the Oxford team includes studies of families over three or more generations. These are pioneering studies in the new science of epigenetics, which explains how genes may be modified by methylation or other means and then transmitted in their modified form to offspring (57). Their work confirms well established studies by others using different methods which suggest that multiple sclerosis is caused primarily by insufficient exposure to sunlight and insufficient vitamin D in pregnancy or youth.

Using the same method, the Oxford team has gone on to find that other disease genes are controlled in a similar way by vitamin D (60). These are genes for type 1 diabetes, Crohn's disease, rheumatoid arthritis, chronic lymphocytic leukaemia, colorectal cancer, and systemic lupus erythematosus, a horrible disease which causes inflammation of the skin, joints, kidneys and other organs. These laboratory findings confirm completely separate evidence from a variety of epidemiological studies which suggest that, like multiple sclerosis, these diseases are caused by insufficient sunshine and/or insufficient vitamin D (61-66).

These are extraordinary findings which once more challenge cherished dogma. They show that the environment, in this case a lack of sunshine, can have an effect not just on our present health and our health in later life, but on future generations. The lack of vitamin D is recorded in the genome, and this record may then be passed on to our grandchildren. It seems possible, even likely, that effects of insufficient vitamin D may accumulate in the genome from generation to generation when an adverse environment with little sunshine is experienced by successive family members.

Eminent people have endlessly discussed the rival effects of nature versus nurture and Lamarckism, the theory that acquired characteristics can be inherited, versus Mendelism, the inheritance of well-defined genes. For more than 100 years Mendel's laws have been pre-eminent, bolstered by our knowledge of DNA and how it divides. Today, as a result of the most advanced biochemistry we can begin to understand what Lamarck glimpsed, and what animal breeders and acute observers of the human condition have long suspected. The environment now may have an effect on later generations.

Most people now are sun-deficient

Most people living a modern life in all parts of the world, have sub-optimal levels of vitamin D (67). The sun is our major source of the vitamin and it is not strong enough at high latitudes, north or south, to provide optimal vitamin D year round. When the sun is below an angle of 45°, nearly all of the UVB, the part of the spectrum that makes vitamin D, is absorbed by the atmosphere (68).

So people living in Europe and northern Asia need to obtain enough sun exposure in summer to provide them with vitamin D to last through the winter. This is not at all easy in northern Europe, where cloudy weather frequently blocks out the sun (30, 69).). People in the southern hemisphere, in Tasmania, New Zealand, southern Argentina and Chile also have a winter period when the sun is not strong enough to make vitamin D in skin and people in these regions need to get extra sun exposure, or take a supplement, in winter to keep their vitamin D levels optimal.

In Europe only a few people who lead outdoor lives are likely to get enough vitamin D without deliberate sunbathing (30). These people include gardeners, sports teachers, and some builders, but even farmers nowadays have comfortable cabs on their tractors that block out the sun. In hot countries many people become deficient in vitamin D because they deliberately avoid the sun. It is too hot for much of the day to spend any length of time outside, although only a few minutes with little clothing could be enough to provide all the vitamin D they need.

In many regions where there is plenty of sun religious and social custom insists that men and women wear clothing that blocks out the sun (70-72). This puts them at risk of getting insufficient vitamin D which becomes acute with changes in housing. In the past, veiled women were generally able to remove their veils and some of their clothing in inner courtyards restricted for use by women and children. Today more and more families are living in western style flats that do not allow that possibility, putting women at greater risk of vitamin D deficiency. Vitamin D deficiency has been found to be a serious problem in Muslim countries despite strong sun all the year round.

Box 5

Survival of the palest

Enjoying the springtime rays at the Peter and Paul fortress, St Petersburg, Russia. People who live in Northern Europe need all the sun they can get

Northern Europe, where I come from, is not a natural environment for humans. Recent studies of human DNA tell us that humans evolved in central Africa where the tropical sun provides plentiful ultra-violet light for vitamin D synthesis in the skin every day of the year. Lack of sunlight resulting from a northern location, and a maritime climate, makes countries like the British Isles extreme habitats compared with the tropical regions where human beings first evolved.

Some 50,000 years ago small bands of people, almost certainly dark skinned, moved into Europe probably by way of Turkey. The virgin territory of Europe provided plentiful food in summer. However in winter not only was food in short supply, but also low levels of vitamin D must have increased the susceptibility of these pioneering bands of people to disease and reduced their fertility. Vitamin D deficiency causes infertility, and during pregnancy and lactation stunts the growth of the brain and other organs in the fetus and newborn. How this occurs, causing common diseases such as schizophrenia, is only now beginning to be understood.

Why women are paler

Egyptian painted statues from around 2500 BCE, showing the paler faces of noblewomen that better absorbed vitamin D, protecting their children

A pale skin exposed to the sun makes vitamin D six times faster than a dark skin and so pale skin has an important advantage in northern countries. Natural selection, powered by infertility and disease, took its toll on the migrants heading north. Human skin colour changed by genetic mutation over a period of thousands of years to a lighter shade. These changes in skin colour occurred several times in different human races in various parts of the globe. Not only do native peoples everywhere have paler skins the further they live from the equator, women and children always have paler skins than mature men of the same tribe, a neat adaptation to provide the maximum vitamin D that is needed for fertility of women and growth of children

The first Europeans probably spread along coasts and rivers where fish provided an important supplementary source of vitamin D. But as the pioneers pushed further into the interior of Northern Europe those with paler skins were more likely to survive and contribute to the following generation. The British Isles and Scandinavia were the end of the trail, further north than human beings had ever lived before. The cloudy maritime climate of the region often blocks out sunlight even in high summer adding to selection pressure for a pale skin.

This evolutionary story helps us to understand our needs today. The pale European skin enables the first weak rays of spring sun to be used to make vitamin D and the last weak rays of autumn to be utilised before winter comes. This extends the period during which vitamin D may be synthesised and so must have extended the period of optimal health and fertility providing important survival advantages. Children with British ancestry are often initially blond and then their hair becomes darker, an adaptation allowing maximum uptake of weak spring and autumn sun at an early age.

We need to bathe in sun

Sunbathing to take advantage of the sunniest times of day and the earliest and latest sun of the season is a natural and necessary activity for human beings who have evolved to survive in this northern environment. Tanning also provides a benefit. Pale skin in spring gives a maximum response to the weak spring sunlight. As spring turns into summer and the sun gradually becomes stronger, pigment is deposited in the skin providing some protection from the harsh midsummer sun and allowing longer exposure without burning. This process involves the death of skin cells but there is no reason to believe that this should be alarming or anything other than a wholly natural process.

Sunlight is the primary source of vitamin D for people everywhere except for communities living within the Arctic Circle who obtain the vitamin from oily fish and other marine animals. Now that we live in cities and spend little time in the open air many people suffer from serious deficiency of vitamin D caused by insufficient exposure to sunlight. This has been exacerbated by a fear of skin cancer which has dominated public health policy on sunlight.

Food fortification, and supplements

The problem of insufficient vitamin D has been and remains partially addressed by fortification of food, which reduces the number of people with the lowest uptake of the vitamin (73, 74). In the US nearly all milk is fortified, as is some orange juice and cereals. In Canada fortification of milk is required by law as it is now in Finland and Israel. In Ireland a voluntary scheme of fortification of milk has been introduced and in Jordan bread is now being fortified.

While milk is a particularly suitable vehicle, because vitamin D is fat soluble, many populations do not drink milk, either because it is not customary or because they are lactose sensitive. In Europe fortification varies from country to country. In the UK, for example, margarine and some breakfast cereals are fortified but with such small amounts of vitamin D that it does not make a significant contribution to the daily requirement.

In Arab countries vitamin D deficiency is recognised as a major problem because of clothing which women in particular are required to wear. In traditional Arab houses women could often get some sun privately in inner courtyards but this is not possible in much modern housing, particularly flats, in which many Arab people live today. The risk to health and to future generations is now being recognised in the Arab world and the government of Jordan is leading the way with fortification of bread with vitamin D.

Any attempt by government to make fortification of milk, bread or any other food stuff compulsory would be sure to be bitterly opposed by those who are against any compulsory government action of this kind. However governments could do much to develop voluntary fortification of foods by encouraging use of health claims. The European Union now allows several health claims for foods fortified with vitamin D (75). These cover benefits to bones and teeth, muscles, the immune system and healthy cell growth. This enables companies to develop fortified products they can sell at a premium but as yet these possibilities have been little exploited (30).

For most people living in cities, taking a supplement is the easiest way to keep their vitamin D level optimal. Until recently the recommended dose of supplement, which is derived from the amount of vitamin D in a teaspoon of cod liver oil (400 IUs, 10 micrograms), was very low. Now the US Institute of Medicine has cautiously ruled that a dose of up to 4,000 IUs (100 micrograms) per day is safe and can be taken indefinitely (76,77).

Recommended doses for adults vary from 1000 to 4000 IUs per day, and 2000 IUs per day is adequate for many but not all people. A few people may require doses as high as 8-10,000 IUs per day to achieve an optimal level (78). Evidence suggests that up to 10,000 IUs per day, an amount that is made in a few minutes exposure to strong sunshine, is safe (79). Infants can be given 400 IUs per day from the first week of life, going up to 1000 IUs per day after one year. The aim is to get the blood level of 25(OH)D, the vitamin D metabolite that is measured in blood, above the minimum for optimal action, that is more than 75 nmols per litre (30ng/ml).

Special needs

Anyone with a low level of vitamin D will benefit from optimising their level, but some people are particularly at risk because of established disease (19). An international team of experts (80) has recommended that blood levels of vitamin D should be corrected in all hospital patients, all cancer patients under treatment, in patients with cardiovascular diseases and a number of other categories. It is not always necessary to do an initial blood test before prescribing, but in those patients who have a therapeutic indication for a vitamin D supplement it is a good idea to check blood levels after two or three months to see if an optimal level has been reached.

A very few people with certain conditions are sensitive to vitamin D and should only take it under medical supervision. The most common indication for caution is a skin condition called sarcoidosis. Others are tuberculosis, lymphoma, and kidney stones, which may be caused by raised calcium in blood (hypercalcaemia). Vitamin D may aid cure of tuberculosis and prolong the life of people with lymphoma but with these diseases it must only be taken under medical supervision. This is because pathological tissue develops in these diseases which may produce an excessive amount of the active hormone form of vitamin D.

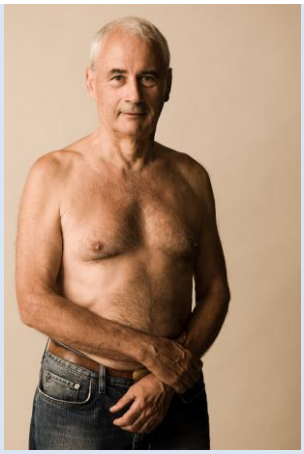
Conclusion

I conclude with the SunSafe (30,81) advice:

Box 6

The SunSafe advice

1. Sunbathe safely without burning – every day if you can.
2. The middle of the day is a good time for sunbathing in high latitudes because UVB, which generates vitamin D in skin, is most intense at this time.
3. Remove as many clothes as you can. Start by sunbathing for 2–3 min each side. Gradually increase from day to day to a maximum of half an hour *per side* in high latitudes, less elsewhere.
4. Be cautious. Remember intensity of sun varies with season, time of day and cloud, and allow for differences between individuals in skin tone. Never bake.
5. Do not use sunscreen creams while aiming to boost vitamin D.
6. If feeling hot or uncomfortable expose a different area, cover up, or move into the shade. If continued exposure cannot be avoided, as in some sports, use sunscreen cream.
7. The face is easily over-exposed so it makes sense to wear a hat when sunbathing.
8. Be very cautious under intense sun such as tropical, sub-tropical and Mediterranean summer conditions, or similar. Expose your body for much shorter times until you find out how much is safe. A few minutes in direct midsummer sun will be sufficient to begin with.
9. In intense sun wear a hat and use sun-cream to protect the top of the feet which easily burn because they present their surface perpendicular to the sun. Sensitive people will need to wear long sleeved shirts and long trousers when going out in the middle of the day but these parts are less at risk because they do not present a perpendicular surface to the sun.
10. Children benefit from sun exposure, but need guidance



I am proud of my tan. People enjoy sunbathing. A 'good colour' from the sun shows that their vitamin D level is likely to be better than normal.

11 A tan is natural and is generally associated with good health

References

1 Zittermann A, Koerfer R. Vitamin D in the prevention and treatment of coronary heart disease. *Curr Opin Clin Nutr Metab Care* 2008;**11**(6)**:**752-7.

2 Wang L, Manson JE, Song Y, Sesso HD. Systematic review: Vitamin D and calcium supplementation in prevention of cardiovascular events. *Ann Intern Med* 2010;**152**(5)**:**315-23.

3 Parker J, Hashmi O, Dutton D, et al. Levels of vitamin D and cardiometabolic disorders: systematic review and meta-analysis. *Maturitas* 2010;**65**(3)**:**225-36.

4 Garland CF, Gorham ED, Mohr SB, Garland FC. Vitamin D for cancer prevention: global perspective. *Ann Epidemiol* 2009;**19**(7)**:**468-83.

5 Giovannucci E. Vitamin D and cancer incidence in the Harvard cohorts. *Ann Epidemiol* 2009;**19**(2)**:**84-8.

6 Bischoff-Ferrari HA, Willett WC, Wong JB, Giovannucci E, Dietrich T, Dawson-Hughes B. Fracture prevention with vitamin D supplementation: a meta-analysis of randomized controlled trials. *Jama* 2005;**293**(18)**:**2257-64.

7 Bischoff-Ferrari HA, Willett WC, Wong JB, et al. Prevention of nonvertebral fractures with oral vitamin D and dose dependency: a meta-analysis of randomized controlled trials. *Arch Intern Med* 2009;**169**(6)**:**551-61.

8 Bischoff-Ferrari HA, Orav EJ, Dawson-Hughes B. Effect of cholecalciferol plus calcium on falling in ambulatory older men and women: a 3-year randomized controlled trial. *Arch Intern Med* 2006;**166**(4)**:**424-30.

9 Ward KA, Das G, Berry JL, et al. Vitamin D status and muscle function in post-menarchal adolescent girls. *J Clin Endocrinol Metab* 2009;**94**(2)**:**559-63.

10 Szodoray P, Nakken B, Gaal J, R J, al e. Scandinavian Journal of Immunology *The complex role of vitamin D in autoimmune diseases* 2008;**68:**261–269.
11 Kamen DL, Tangpricha V. Vitamin D and molecular actions on the immune system: modulation of innate and autoimmunity. *J Mol Med*;**88**(5)**:**441-50.
12 Zittermann A, Gummert JF, Borgermann J. Vitamin D deficiency and mortality. *Curr Opin Clin Nutr Metab Care* 2009;**12**(6)**:**634-9.
13 Autier P, Gandini S. Vitamin D supplementation and total mortality: a meta-analysis of randomized controlled trials. *Arch Intern Med* 2007;**167**(16)**:**1730-7.
14 Melamed ML, Michos ED, Post W, Astor B. 25-hydroxyvitamin D levels and the risk of mortality in the general population. *Arch Intern Med* 2008;**168**(15)**:**1629-37.
15 Mellanby T. The part played by an "accessory factor" in the production of experimental rickets. *J. Physiol* 1918;**52:**11-4.
16 Huldschinsky K. Curing rickets by artificial UV radiation (in German). *Deutsche Med Wochenschr* 1919;**45:**712-3.
17 Holick MF. McCollum Award Lecture, 1994: vitamin D--new horizons for the 21st century. *Am J Clin Nutr* 1994;**60**(4)**:**619-30.
18 Norman AW, Bouillon R. Vitamin D nutritional policy needs a vision for the future. *Exp Biol Med (Maywood)* 2010;**235**(9)**:**1034-45.
19 Holick MF. Deficiency of sunlight and vitamin D. *BMJ* 2008;**336**(7657)**:**1318-9.
20 Wagner CL, Hulsey TC, Fanning D, Ebeling M, Hollis BW. High-dose vitamin D3 supplementation in a cohort of breastfeeding mothers and their infants: a 6-month follow-up pilot study. *Breastfeed Med* 2006;**1**(2)**:**59-70.
21 Wagner CL, Taylor SN, Hollis BW. Does vitamin D make the world go 'round'? *Breastfeed Med* 2008;**3**(4)**:**239-50.
22 Willer CJ, Dyment DA, Sadovnick AD, Rothwell PM, Murray TJ, Ebers GC. Timing of birth and risk of multiple sclerosis: population based study. *Bmj* 2005;**330**(7483)**:**120.
23 Disanto G, Handel AE, Para AE, Ramagopalan SV, Handunnetthi L. Season of birth and anorexia nervosa. *Br J Psychiatry* 2011.
24 Davies G, Welham J, Chant D, al e. A systematic review and meta-analysis of Northern Hemisphere season of birth studies in schizophrenia. *Schizophr Bull* 2003;**29:**587-93.
25 Castrogiovanni P, Iapichino S, Pacchierotti C, Pieraccini F. Season of birth in Psychiatry. A review. *Neuropsychobiology* 1998;**37:**175-81.
26 Rothwell PM, Staines A, Smail P, Wadsworth E, McKJinney P. Seasonality of birth of patients with childhood diabetes in Britain. *BMJ* BMJ;**312:**1456-57.
27 Maiya S, Sullivan I, Allgrove J, et al. Hypocalcaemia and vitamin D deficiency: an important, but preventable, cause of life-threatening infant heart failure. *Heart* 2008;**94**(5)**:**581-4.
28 Gillie O. Sunny D. *The Independent on Sunday, Sunday Review* 2004**:**8-12.

29 Gillie O. Sunlight Robbery: Health Benefits of sunlight are denied by current public health policy in the UK. *Health Research Forum Occasional Reports* 2004;**1:**1-42.

30 Gillie O. Sunlight robbery: A critique of public health policy on vitamin D in the UK. *Mol. Nutr. Food Res.* 2010;**54**(1-16).

31 Alleyne R. Sunbathing can be good for you, say health charities. *Telegraph* 2010.

32 Hope J. Mad dogs and Englishmen were right! We should go out in the midday sun say experts. *Daily Mail* 2010.

33 Lucas RM, Repacholi MH, McMichael AJ. Is the current public health message on UV exposure correct? *Bull World Health Organ* 2006;**84**(6)**:**485-91.

34 Lucas RM, Ponsonby AL. Considering the potential benefits as well as adverse effects of sun exposure: can all the potential benefits be provided by oral vitamin D supplementation? *Prog Biophys Mol Biol* 2006;**92**(1)**:**140-9.

35 Gorham E, Mohr, SB, Garland, FC, Garland, CF. Vitamin D for cancer prevention and survival *Clinic Rev Bone Miner Metab* 2009;**7**(2)**:**159-175.

36 Norman AW. Minireview: vitamin D receptor: new assignments for an already busy receptor. *Endocrinology* 2006;**147**(12)**:**5542-8.

37 Bouillon R, Carmeliet G, Verlinden L, et al. Vitamin D and human health: lessons from vitamin D receptor null mice. *Endocr Rev* 2008;**29**(6)**:**726-76.

38 Grant WB, Boucher BJ. Current impediments to acceptance of the ultraviolet-B-vitamin D-cancer hypothesis. *Anticancer Res* 2009;**29**(9)**:**3597-604.

39 Grant WB. How strong is the evidence that solar ultraviolet B and vitamin D reduce the risk of cancer?: An examination using Hill's criteria for causality. *Dermatoendocrinol* 2009; **1**(1)**:**17-24.

40 Mayer J. Armand Trouseau and the arrow of time. *Nutr Rev* 1957;**15:**321-3.

41 Bischoff-Ferrari HA, Dawson-Hughes B, Staehelin HB, et al. Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomised controlled trials. *BMJ* 2009;**339:**b3692.

42 Lips P, Bouillon R, van Schoor NM, et al. Reducing fracture risk with calcium and vitamin D. *Clin Endocrinol (Oxf)* 2009.

43 Boucher B. Vitamin D insufficiency and diabetes risks. *Current Drug Targets* 2011;**in press**.

44 Vaidya A, Forman JP. Vitamin D and hypertension: current evidence and future directions. *Hypertension* 2010;**56**(5)**:**774-9.

45 Martineau AR, Wilkinson RJ, Wilkinson KA, et al. A single dose of vitamin D enhances immunity to mycobacteria. *Am J Respir Crit Care Med* 2007;**176**(2)**:**208-13.

46 Martineau AR, Timms PM, Bothamley GH, et al. High-dose vitamin D(3) during intensive-phase antimicrobial treatment of pulmonary tuberculosis: a double-blind randomised controlled trial. *Lancet* 2010;**377**(9761)**:**242-50.

47 Urashima M, Segawa T, Okazaki M, Kurihara M, Wada Y, Ida H. Randomized trial of vitamin D supplementation to prevent seasonal influenza A in schoolchildren. *Am J Clin Nutr* 2010;**91**(5)**:**1255-60.

48 Manaseki-Holland S, Qader G, Isaq Masher M, et al. Effects of vitamin D supplementation to children diagnosed with pneumonia in Kabul: a randomised controlled trial. *Trop Med Int Health*;**15**(10)**:**1148-55.

49 Hewison M. Vitamin D and innate immunity. *Current Opinion in Investigational Drugs* 2008;**9**.

50 Hewison M. Vitamin D and the immune system: new perspectives on an old theme. *Endocrinol Metab Clin North Am* 2010;**39**(2)**:**365-79, table of contents.

51 Handel AE, Giovannoni G, Ebers GC, Ramagopalan SV. Environmental factors and their timing in adult-onset multiple sclerosis. *Nat Rev Neurol* 2010;**6**(3)**:**156-66.

52 Ramagopalan SV, Valdar W, Criscuoli M, et al. Age of puberty and the risk of multiple sclerosis: a population based study. *Eur J Neurol* 2009;**16**(3)**:**342-7.

53 Ramagopalan SV, Dobson R, Meier UC, Giovannoni G. Multiple sclerosis: risk factors, prodromes, and potential causal pathways. *Lancet Neurol* 2010;**9**(7)**:**727-39.

54 Zwart SR, Mehta SK, Ploutz-Snyder R, et al. Response to Vitamin D Supplementation during Antarctic Winter Is Related to BMI, and Supplementation Can Mitigate Epstein-Barr Virus Reactivation. *The Journal of Nutrition* 2011;**published ahead of print**.

55 Handel AE, Williamson AJ, Disanto G, Handunnetthi L, Giovannoni G, Ramagopalan SV. An updated meta-analysis of risk of multiple sclerosis following infectious mononucleosis. *PLoS One*;**5**(9).

56 Ramagopalan SV, Sadovnick AD, Ebers GC, Giovannoni G. Effects of infectious mononucleosis and HLA-DRB1*15 in multiple sclerosis. *Mult Scler* 2010;**16**(1)**:**127-8.

57 Handel AE, Ebers GC, Ramagopalan SV. Epigenetics: molecular mechanisms and implications for disease. *Trends Mol Med* 2009.

58 Ramagopalan SV, Maugeri NJ, Handunnetthi L, et al. Expression of the multiple sclerosis-associated MHC class II Allele HLA-DRB1*1501 is regulated by vitamin D. *PLoS Genet* 2009;**5**(2)**:**e1000369.

59 Handel AE, Ramagopalan SV. Public health implications of epigenetics. *Genetics* 2009;**182**(4)**:**1397-8.

60 Ramagopalan SV, Heger A, Berlanga AJ, et al. A ChIP-seq defined genome-wide map of vitamin D receptor binding: Associations with disease and evolution. *Genome Res* 2010.

61 Handel AE, Handunnetthi L, Ebers GC, Ramagopalan SV. Type 1 diabetes mellitus and multiple sclerosis: common etiological features. *Nat Rev Endocrinol* 2009;**5**(12)**:**655-64.

62 Ebers GC, Sadovnick AD. The geographic distribution of multiple sclerosis: a review. *Neuroepidemiology* 1993;**12**(1)**:**1-5.

63 Ebers GC. MS and autoimmune disorders. *Neurogenetics* 2009;**10**(1)**:**1-3.

64 Lim WC, Hanauer SB, Li YC. Mechanisms of disease: vitamin D and inflammatory bowel disease. *Nat Clin Pract Gastroenterol Hepatol* 2005;**2**(7)**:**308-15.

65 Cutolo M, Otsa K, Paolino S, Yprus M, Veldi T, Seriolo B. Vitamin D involvement in rheumatoid arthritis and systemic lupus erythaematosus. *Ann Rheum Dis* 2009;**68**(3)**:**446-7.

66 Shanafelt TD, Drake MT, Maurer MJ, et al. Vitamin D insufficiency and prognosis in chronic lymphocytic leukemia. *Blood* 2011;**117**(5)**:**1492-8.

67 Lips P, Duong T, Oleksik A, et al. A global study of vitamin D status and parathyroid function in postmenopausal women with osteoporosis: baseline data from the multiple outcomes of raloxifene evaluation clinical trial. *J Clin Endocrinol Metab* 2001;**86**(3)**:**1212-21.

68 Godar DE. UV doses worldwide. *Photochem Photobiol* 2005;**81**(4)**:**736-49.

69 Macdonald HM, Mavroeidi A, Barr RJ, Black AJ, Fraser WD, Reid DM. Vitamin D status in postmenopausal women living at higher latitudes in the UK in relation to bone health, overweight, sunlight exposure and dietary vitamin D. *Bone* 2008;**42**(5)**:**996-1003.

70 Khan AH, Iqbal R. Vitamin d deficiency in an ample sunlight country. *J Coll Physicians Surg Pak* 2009;**19**(5)**:**267-8. .

71 Rajah J, Jubeh JA, Haq A, Shalash A, Parsons H. Nutritional rickets and z scores for height in the United Arab Emirates: to D or not to D? *Pediatr Int* 2008;**50**(4)**:**424-8.

72 Elsammak MY, Al-Wosaibi AA, Al-Howeish A, Alsaeed J. Vitamin d deficiency in Saudi Arabs. *Horm Metab Res*;**42**(5)**:**364-8.

73 Laaksi IT, Ruohola JP, Ylikomi TJ, et al. Vitamin D fortification as public health policy: significant improvement in vitamin D status in young Finnish men. *Eur J Clin Nutr* 2006;**60**(8)**:**1035-8.

74 O'Donnell S, Cranney A, Horsley T, et al. Efficacy of food fortification on serum 25-hydroxyvitamin D concentrations: systematic review. *Am J Clin Nutr* 2008;**88**(6)**:**1528-34.

75 EFSA. Scientific Opinion on the substantiation of health claims related to vitamin D. *EFSA Journal* 2010;**8(2)**(1468).

76 Institute of Medicine. Dietary reference intakes for Calcium and Vitamin D. Washington: National Academy of Sciences. 2010.

77 Gillie O. Blinded by science, pragmatism forgotten. *Public Health Nutr* 2011;**14**(4)**:**566-7.

78 Garland CF, French CB, Baggerly LL, Heaney RP. Vitamin d supplement doses and serum 25-hydroxyvitamin d in the range associated with cancer prevention. *Anticancer Res*;**31**(2)**:**607-11.

79 Xystrakis E, Kusumakar S, Boswell S, et al. Reversing the defective induction of IL-10-secreting regulatory cells in glucocorticoid-resistant asthma patients. *Journal of Clinical Investigation* 2005;**116**(1)**:**146-155.

80. Souberbielle JC, Lawson-Body E, Hammadi B, Sarfati E, Kahan A, Cormier C. The use in clinical practice of parathyroid hormone normative values

established in vitamin D-sufficient subjects. *J Clin Endocrinol Metab* 2003;**88**(8)**:**3501-4

81 Gandini S, Sera F, Cattaruzza M, et al. Meta-analysis of risk factors for cutaneous melanoma: II Sun exposure. *EJC* 2005;**41:**45-60.

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OG states: My thanks to Dan Tsantilis, who took the pictures of me. I have no conflicts of interest.

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