Achieving Adequate Sun Protection With Adequate Vitamin D Status

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to include results of recent work directed by

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Skin

Blood

Vitamin D Binding Protein

7-Dehydrocholesterol (Provitamin D3)

Previtamin D3

Vitamin D3

Tachysterol

Lumisterol

UVR = ultraviolet radiation

Vitamin D Binding Protein-Vitamin D3
Vitamin D, really a steroid, vital for bone health, with suggested recent rickets increases, other health issues, from deficiency from sun avoidance

Incidence of vitamin D deficiency rickets among Australian children: an Australian Paediatric Surveillance Unit study
Med J Aust
196:466-468

Two vitamin D sources, solar UVB (295 - 315nm) for most, and oral, both effective if dietary calcium and parathormone, calcitonin function normal

Current understanding of the molecular actions of vitamin D
Physiol Rev
78:1193-1231

Wavelengths inducing skin DNA damage, sunburn, ageing, cancer and vitamin D production very similar in UVB region

Relationship between sun exposure, DNA damage, vitamin D status needs clarification, as advantage and disadvantage from same source illogical

Effect of sunscreen use on vitamin D production needs clarification

Effect of skin pigmentation on vitamin D production needs clarification
CIE Action Spectra for Production of Sunburn Erythema and Previtamin D
Relationship Between DNA Damage as Assessed by Thymine Dimer Production and Vitamin D Levels

$R^2 = 0.48$

$P < 0.0001$

High UVR exposure to obtain vitamin D increases risk of skin sunburn, ageing, cancer, not ideal in evolutionary terms, so what may be explanation?
62 Polish volunteers offered free week’s vacation in cloudless Tenerife (28°N) in March 2011, sunbathed daily round hotel pool, wore wrist UVR meter

20 group A volunteers used high UVA protection sunscreen of SPF 18.9±2.8

20 in group B used low UVA protection UVB sunscreen of SPF 17.7±2.7

Spectrally different sunscreens (both nominally SPF 15) used to see if vitamin D responses varied

22 in non-interventional group C in different hotel sunbathed at will

Precisely quantified thrice daily sunscreen use in groups A and B ensured all subjects maintained 2mg/cm² concentration throughout exposure

17 control volunteers remained in wintry Lodz in Poland

Sunburn erythema quantified by reflectance spectroscopy

Blood taken before, after exposure, serum 25 (OH) vitamin D assessed by mass spectrometry in two separate laboratories to improve reliability
Comparison Between UVR Incident on Non-Interventional Group C (In One Hotel) and Sunscreen Groups A and B (In Another Hotel)

Daily Accumulating UVR Dose Received Over Week

Sunscreen users received a little less UVR exposure than non-interventional group (probably because in less sun-exposed hotel)
Sunscreens A and B Prevented Sunburn Erythema as Assessed by Reflectance Spectroscopy on Volunteer Chests

Sunscreen users did not sunburn but non-interventional group did.
Change in 25(OH) Vitamin D Levels in Sunscreen Groups A and B and Non-Interventional Group C (similar results from both laboratories)

All exposed groups developed 25(OH) vitamin D increases, with careful sunscreen users only moderately less than non-users, with broad-spectrum sunscreen apparently better than mostly UVB sunscreen.
Similar type of result to previous work where lower 3 SED UVB to much smaller 25% body area three times weekly with SPF 8 sunscreen maintained vitamin D levels when applied in 2mg/cm$^2$ concentration

The relation between sunscreen layer thickness and vitamin D production after ultraviolet B exposure: a randomized clinical trial

*Br J Dermatol*

67:391-5

Very careful, very high SPF sunscreen use therefore seems likely to prevent vitamin D production

Usual sunscreen use in normal subjects achieves only one third of stated SPF, strongly suggesting this does not happen, SPF 50 seeming safe

Norval M, Wulf HC (2009)
Does chronic sunscreen use reduce vitamin D production to insufficient levels?

*Br J Dermatol*

161:732-736
Effect of Skin Melanin of Any Depth of Colour on Vitamin D Production
Protocol for Assessment of Vitamin D Synthesis in Melanin Study

Blood draw to measure baseline vitamin D level

2 SED irradiation by Arimed B solar simulator (whole body apart from underwear)

3 or 4 day interval

Follow-up blood draw to assess vitamin D levels immediately followed by 2 SED irradiation, repeated four more times
Comparison of Spectra of London Summer (22 June 2001) Noon and Arimed B Solar Simulator

![Graph comparing Solar Spectrum and ARIMED B Spectrum](image-url)
Data Excluding Two Outliers in Type IV-V Indian Sub-Continent Group

Serum 25(OH)D (nmol/L)

SEDs

ISC= Indian Sub-Continental
SEEA=South East Asian and East
V/VI

Same vitamin D increases for same UVR doses for all skin types, though different initial levels, very possibly from reduced sun exposure

Lifestyle factors including less cutaneous sun exposure contribute to starkly lower vitamin D levels in U.K. South Asians compared with the white population

Br J Dermatol
169:1272-1278
Vitamin D Increase After Total 10 SED UVR Exposure (Two to Three Sunburning Doses for Fair Skins)

- Fair, brown, black skins all achieved essentially same 25(OH) vitamin D increases after same UVR exposure to same skin areas
- This replicates previous findings

Bogh MK, Schmedes AV, Philipsen PA, Thieden E, Wulf HC (2010)
Vitamin D production after UVB exposure depends on baseline vitamin D and total cholesterol but not on skin pigmentation

*J Invest Dermatol*
30:546-553
Significant vitamin D rises for sunscreens A, B without sunburning (mean increase = 16nmol/L), with A rise greater than B (19, 13 respectively), not significant, but broad spectrum sunscreens may be better for vitamin D.

Significant and greater vitamin D rises in non-interventional group C but with marked sunburning (increase in 25(OH)D = 28nmol/L).

Sunscreens at 2mg/cm² for quoted SPF therefore did reduce vitamin D production but still enabled significant increases without sunburn.

As sunscreens usually poorly applied to give a third of SPF, SPF 50 sunscreens should generally permit same, adequate vitamin D response.

Constant, very obsessive, very high SPF sunscreen use may well prevent adequate vitamin D production.

Melanin does not affect vitamin D synthesis, however dark the skin.
Further evidence that good sun protection does not prevent adequate vitamin D production is normal hair-covered cows make adequate vitamin D.


Response reduced if hide partly covered, showing hide area responsible, as in man.

Normal cows do not suffer skin sunburn, cancers under hair despite constant sun exposure.


Human hair gives solar UVR protection factor between 5 and 17, more for short hair, allowing only 0.75-1.4 SED/hour then to scalp when sun high.


Strongly further suggests mild UVR exposure maintains adequate vitamin D.
Further, mean vitamin D similar from 25° to 70° N, whatever UVR strength,

Best explained by internal bodily regulation, long two-month vitamin D half
life, small exposures raising low levels rapidly, high only a little more

Levels not greatly dependent on heavy sun exposure, being slightly higher in summer, lower in winter everywhere, at 40 to 80nmol/L


Bogh MK *et al.* (2011) Vitamin D production depends on ultraviolet-B dose but not on dose rate *Exp Dermatol* 20:14-8
Vitamin D deficiency risk is increased though with constant extensive clothing cover, liberal high protection sunscreen use, sun avoidance because of prior skin cancer, photodermatoses or photosensitising medications, poor diet, liver, renal disease, medication affecting vitamin D levels.

Oral vitamin D not needed in normals, but at risk groups need 600 IU/day (15μg) in adults, 800 if over 70, 4000 maximum, but not in hypercalcaemia, hypervitaminosis D, renal osteodystrophy with hyperphosphphataemia, and given with care in atherosclerosis, impaired cardiac, renal function, vitamin D sensitivity, sarcoidosis, when mild sun exposure preferred.

1. Consensus Statement on Vitamin D and Sun Exposure, 2012
   New Zealand Ministry of Health
2. Report 2010
   US and Canadian Institute of Medicine

Incidence of vitamin D deficiency rickets among Australian children: an Australian Paediatric Surveillance Unit study
*Med J Aust*
196:466-468
In summary, vitamin D levels worldwide similar in summer, winter, and only minor ultraviolet B exposure seems needed for satisfactory levels

Recommended summer sunlight exposure levels can produce sufficient (> or =20 ng ml(-1)) but not the proposed optimal (> or =32 ng ml(-1)) 25(OH)D levels at UK latitudes

*J Invest Dermatol*
130 :1411-1418

Low vitamin D goes up with mild, high goes up little with strong, exposure

Bogh MK, Schmedes AV, Philipsen PA, Thieden E, Wulf HC (2010)
Vitamin D production after UVB exposure depends on baseline vitamin D and total cholesterol but not on skin pigmentation

*J Invest Dermatol*
30:546-553

1.5 SED over 0.6% body surface area raises levels, 0.75 SED over 24%

Bogh MK, Schmedes AV, Philipsen PA, Thieden E, Wulf HC (2011)
Interdependence between body surface area and ultraviolet B dose in vitamin D production: a randomized controlled trial

*Br J Dermatol*
164 :163-169

Sunscreens and animal coats have little effect

Pigmentation has no effect

Low vitamin D associated just with poor diet, heavy clothing in Australian study

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No good evidence that lower vitamin D levels in winter important
Suggests only small exposures needed for vitamin D production in normals and that no specific exposure time should be advocated, particularly as solar ultraviolet levels vary hugely and cannot be judged.

This is situation in very sun- and vitamin D-conscious Denmark, where sun is less intense than here (Hans Christian Wulf, personal communication).

This contention fits into seeming mammalian need for **very moderate, largely harmless** sun exposure as evolutionary advantage, not drawback:

1. To avoid constant delayed type hypersensitivity reactions causing the sun rash, polymorphic light eruption, and constant allergic contact dermatitis by suppression of adaptive immunity
   
   
   Ultraviolet radiation-induced upregulation of antimicrobial proteins in health and disease
   
   *Photochem Photobiol Sci* 12:29-36

2. To induce bactericidal defensins by activating innate immunity, to prevent skin infection with reduced adaptive immunity
   
   
   UV-B radiation induces the expression of antimicrobial peptides in human keratinocytes in vitro and in vivo
   
   *J Allergy Clin Immunol* 123 :1117-1123

3. To avoid vitamin D deficiency