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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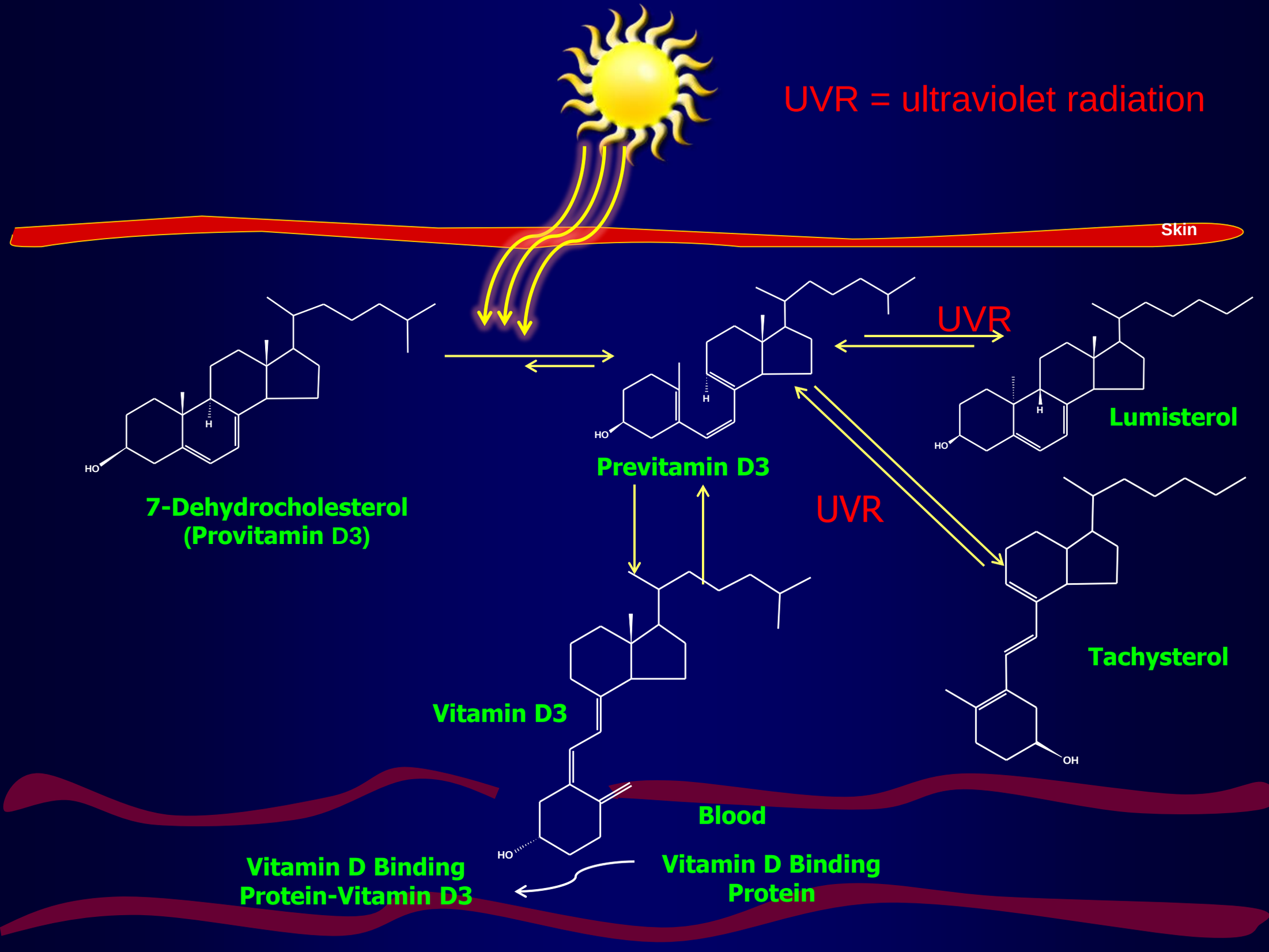

UVR = ultraviolet radiation
Skin
UVR
Lumisterol
Previtamin D3
7-Dehydrocholesterol
(Provitamin D3)
UVR
Tachysterol
Vitamin D3
Blood
Vitamin D Binding
Protein-Vitamin D3
Vitamin D Binding
Protein

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

Munns CF, Simm PJ, Rodda CP *et al* (2012)
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

Jones G, Strugnell, SA, DeLuca HF (1998)
Current understanding of the molecular actions of vitamin D
Physiol Rev
78:1193-1231

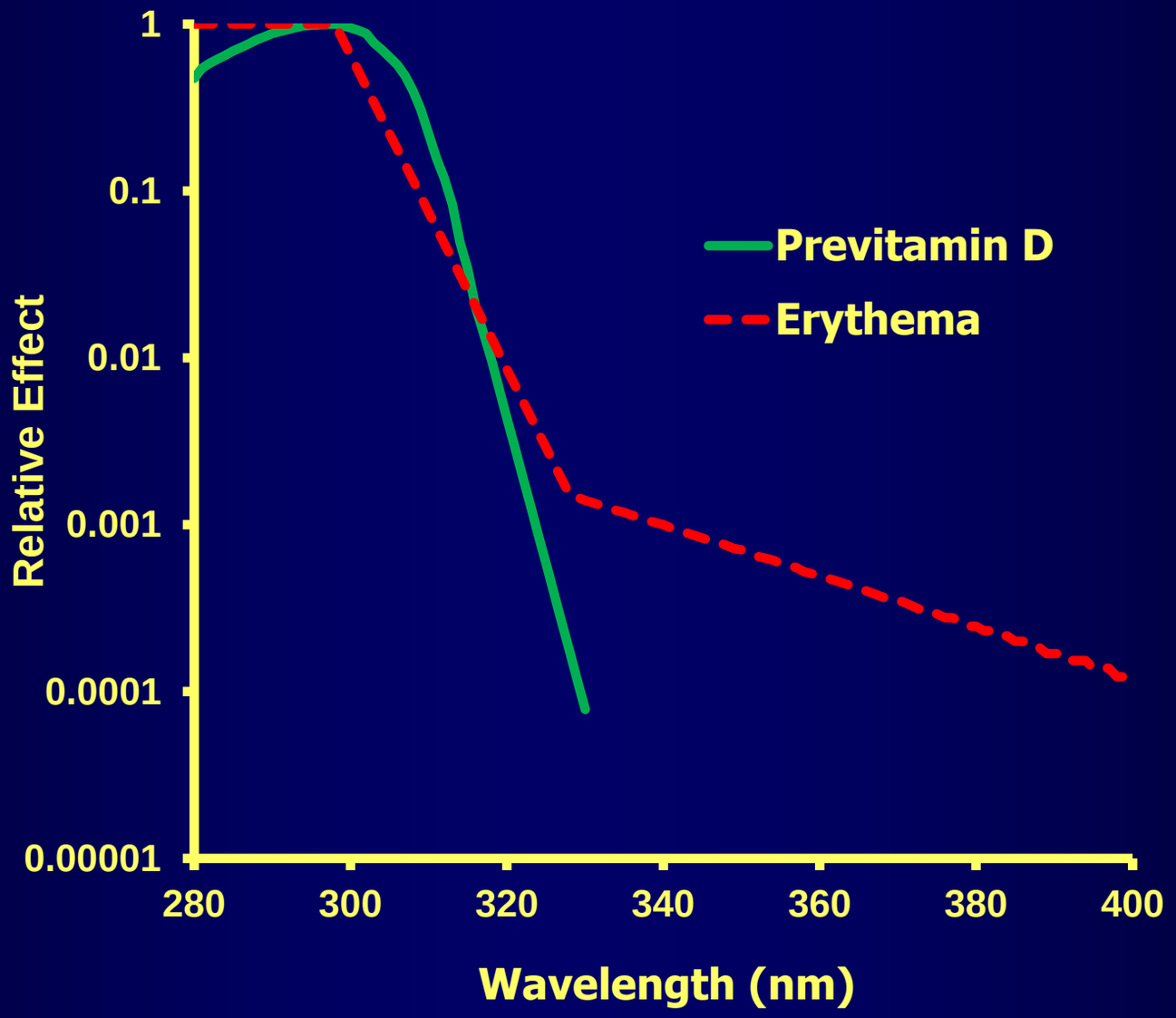
⌘ Wavelengths inducing skin DNA damage, sunburn, ageing, cancer and vitamin D production very similar in UVB region

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

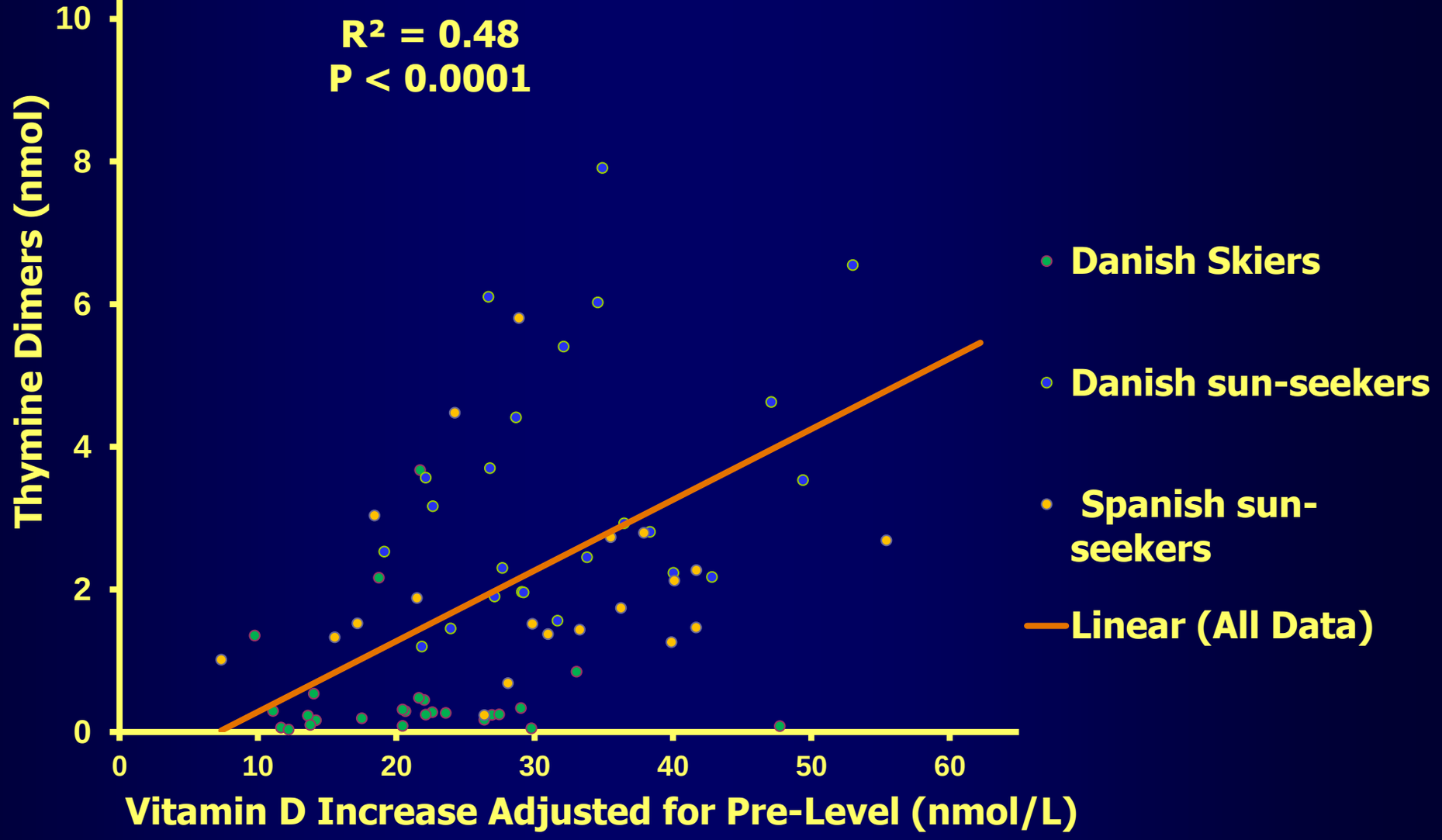
⌘ Effect of sunscreen use on vitamin D production needs clarification

⌘ 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



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 (28ºN) 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/cm^2 concentration throughout exposure

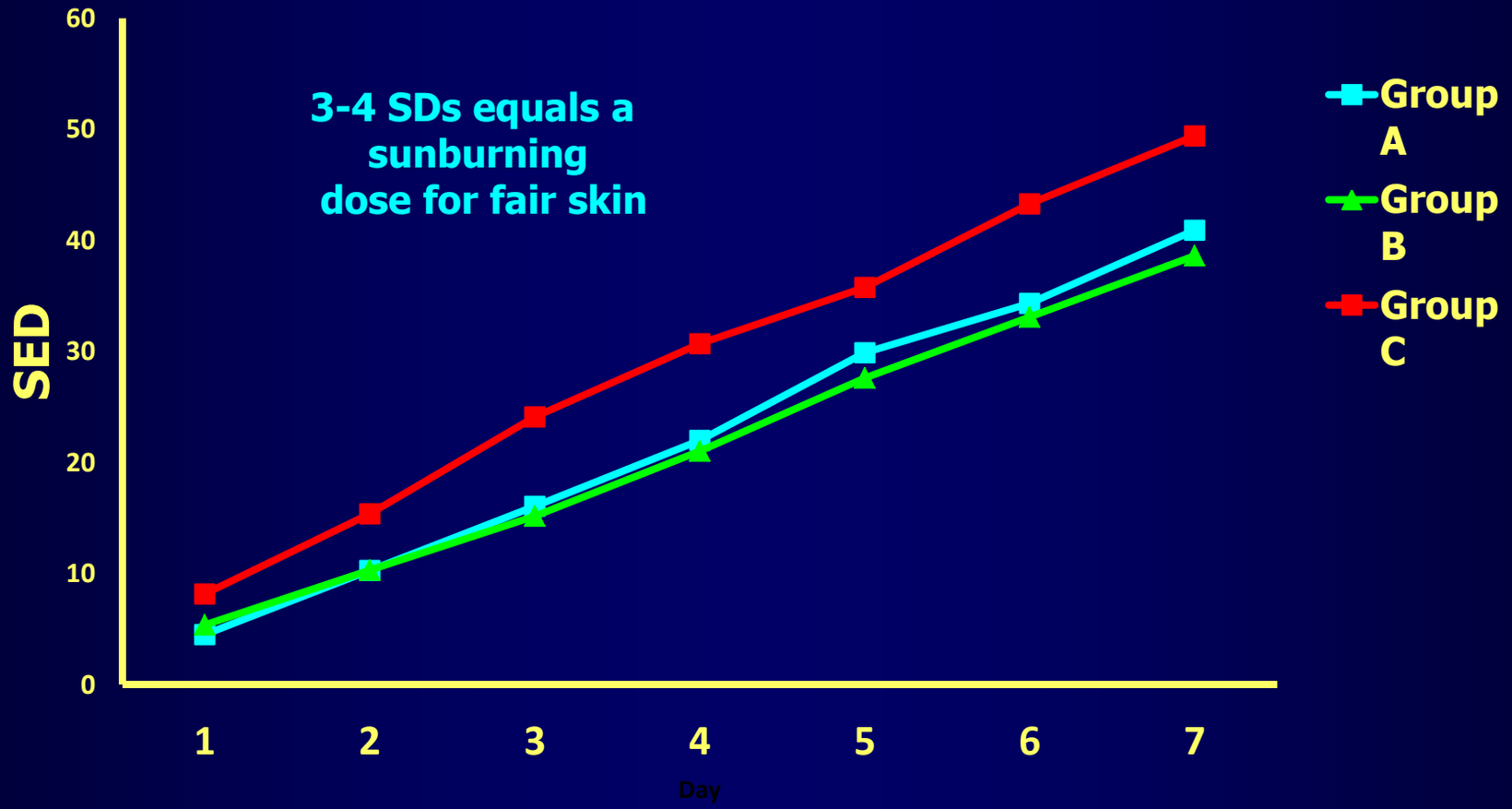
⌘ 17 control volunteers remained in wintry Lodz in Poland

⌘ 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

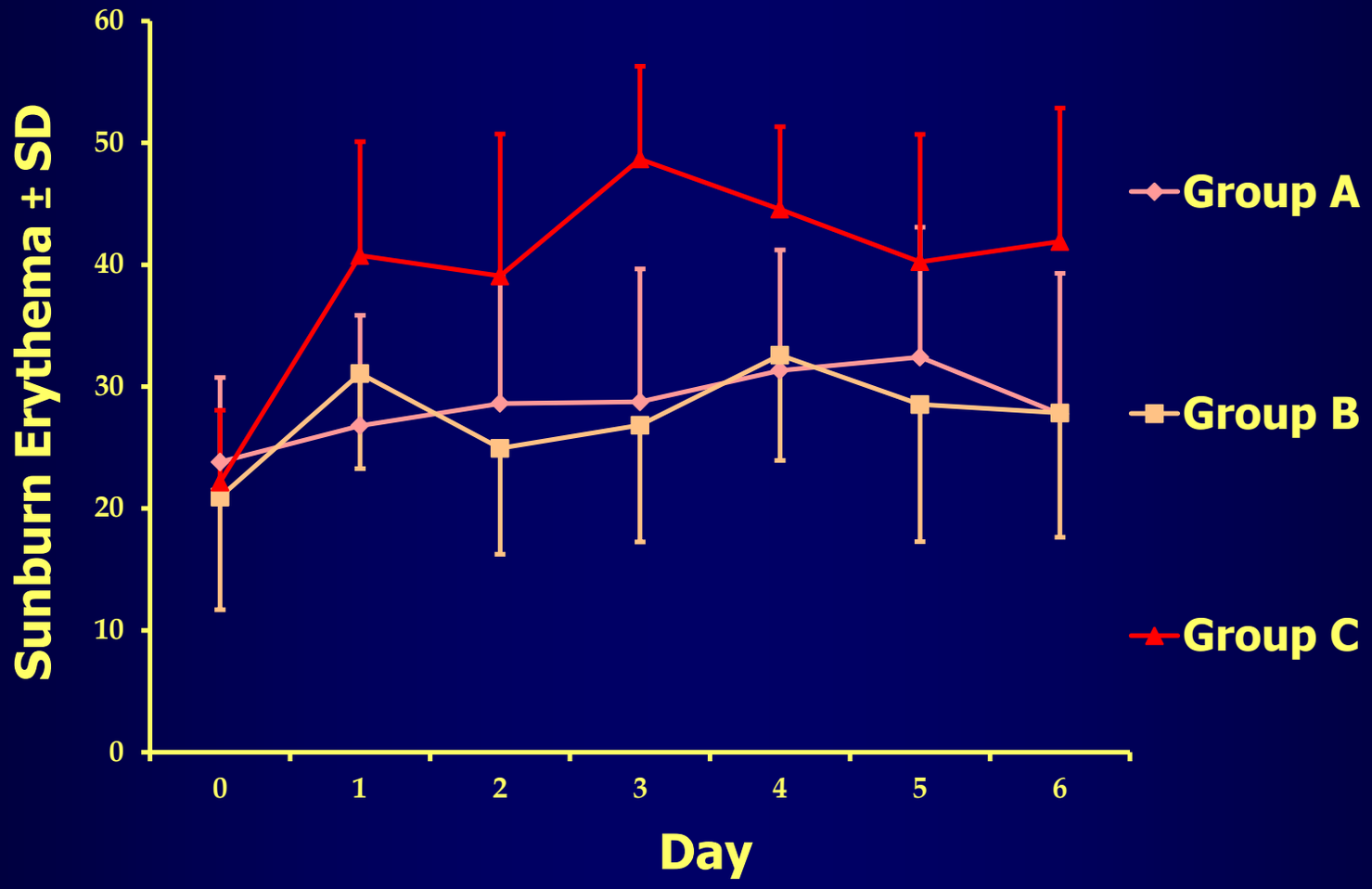
Comparison Between UVR Incident on Non-Interventional Group C (In One Hotel) and Sunscreen Groups A and B (In Another Hotel)

Daily Accumulating UVR Dose Received Over Week



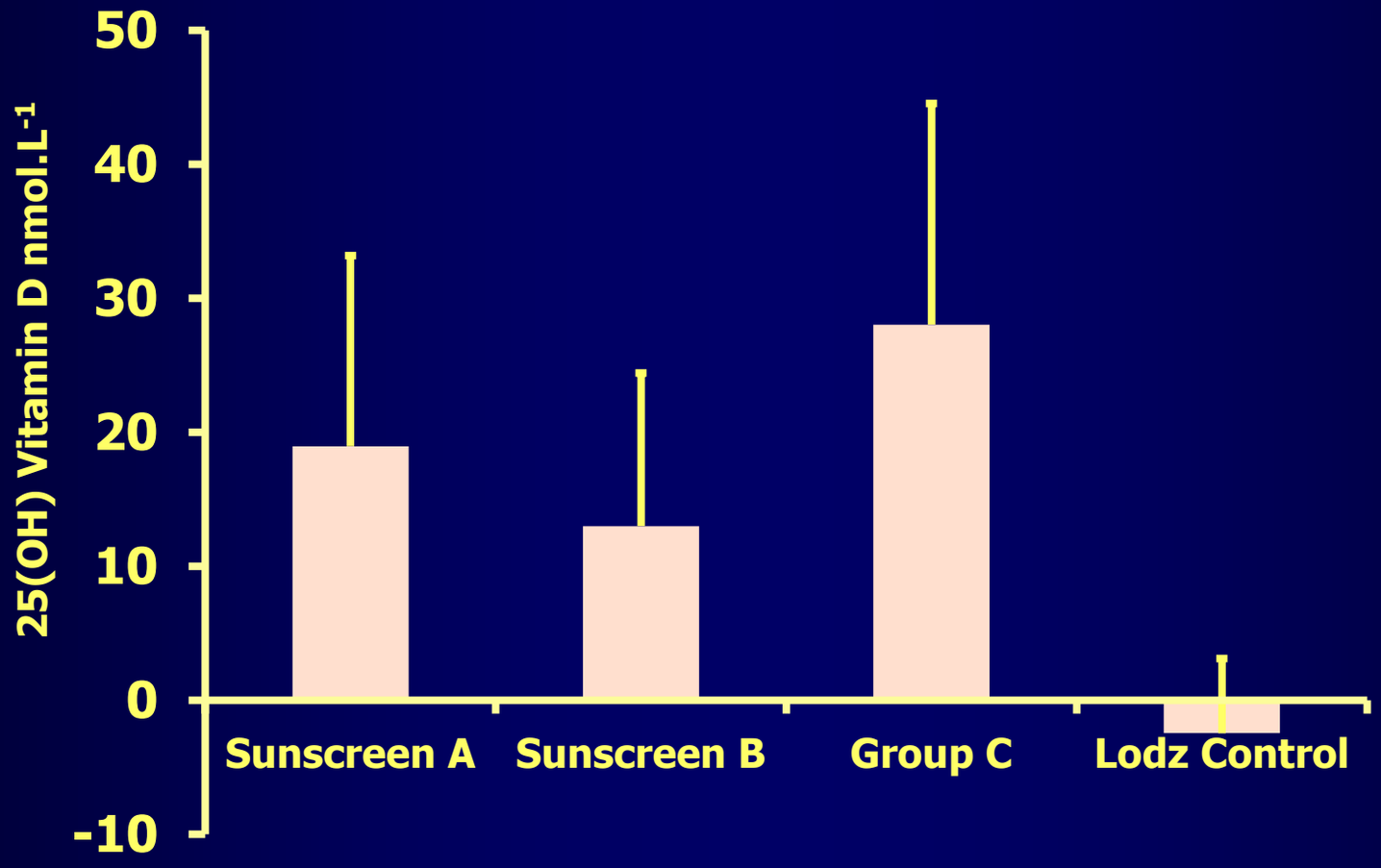
Sunscreen users received a little less UVR exposure than non-interventional group (probably because in less sun-exposed hotel)

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

Faurschou A, Beyer DM, Schmedes A, Bogh MK, Philipsen PA, Wulf HC (2012)
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

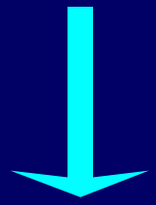
⌘ Usual sunscreen use in normal subjects achieves only one third of stated SPF, strongly suggesting this does not happen, SPF 50 seeming safe

Norval M, Wulf HC (2009)
Does chronic sunscreen use reduce vitamin D production to insufficient levels?
Br J Dermatol
161 :732-736

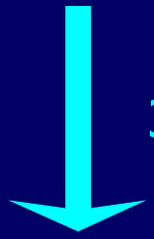
Effect of Skin Melanin of Any Depth of Colour on Vitamin D Production

Protocol for Assessment of Vitamin D Synthesis in Melanin Study

Blood draw to
measure baseline
vitamin D level



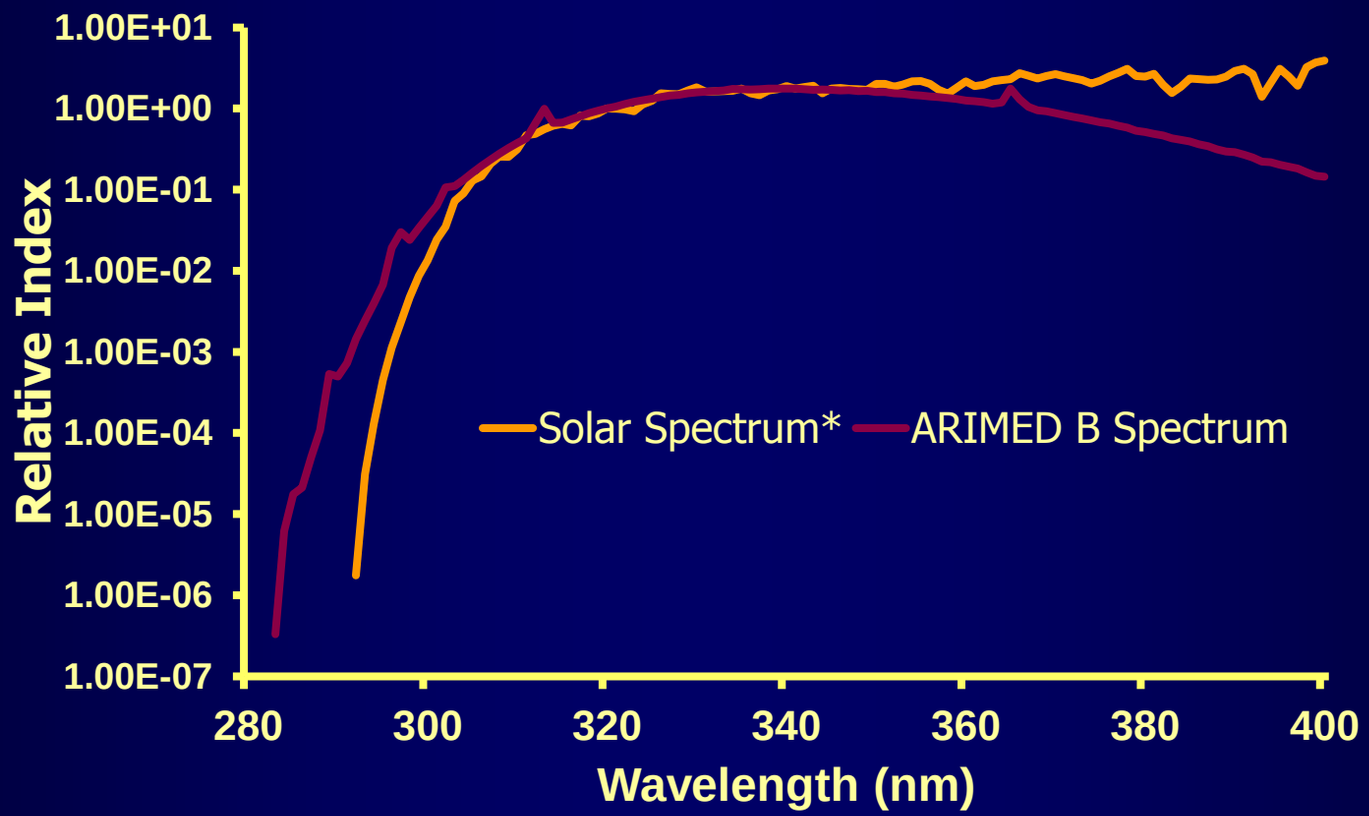
2 SED irradiation by Arimed B solar simulator
(whole body apart from underwear)



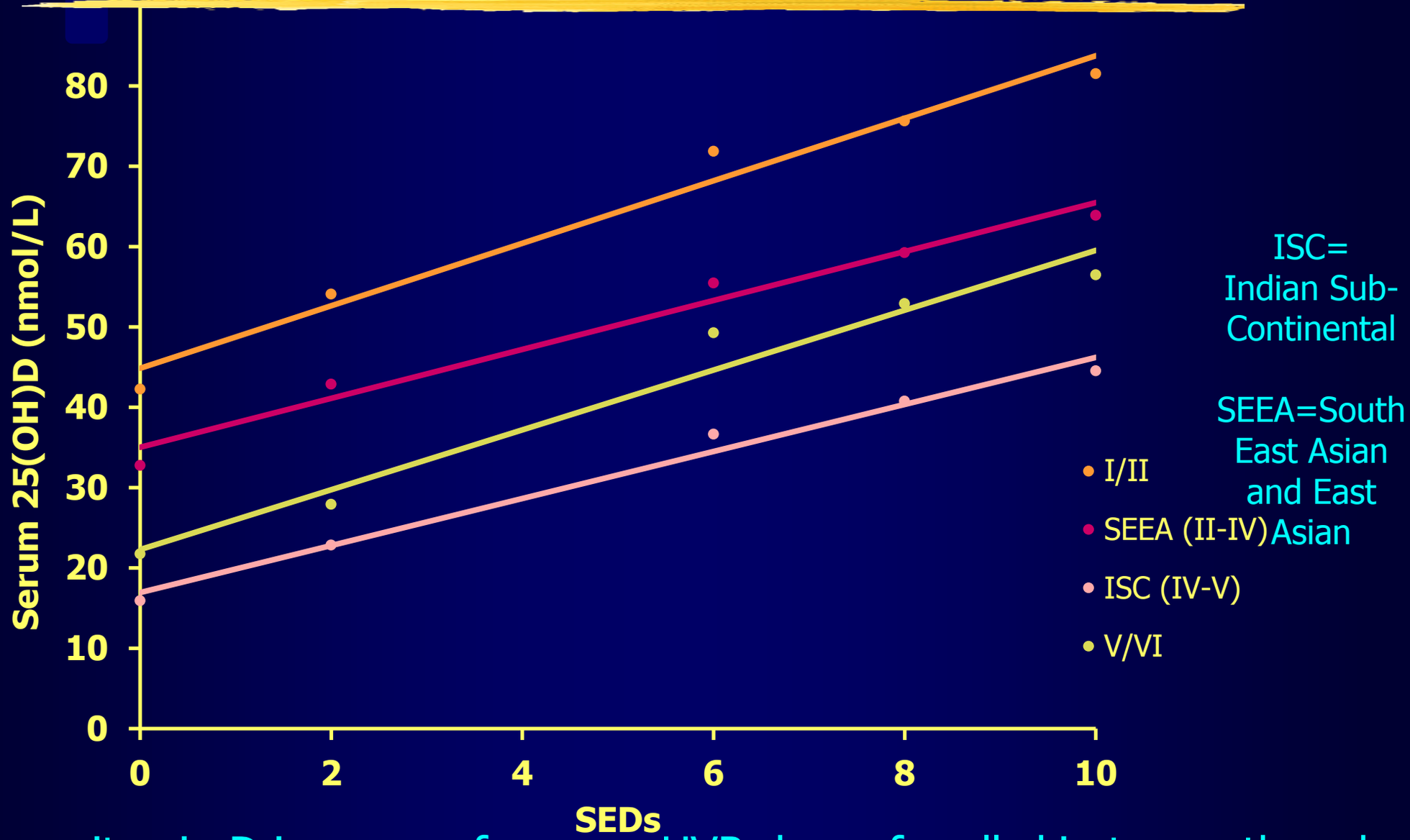
3 or 4 day interval

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



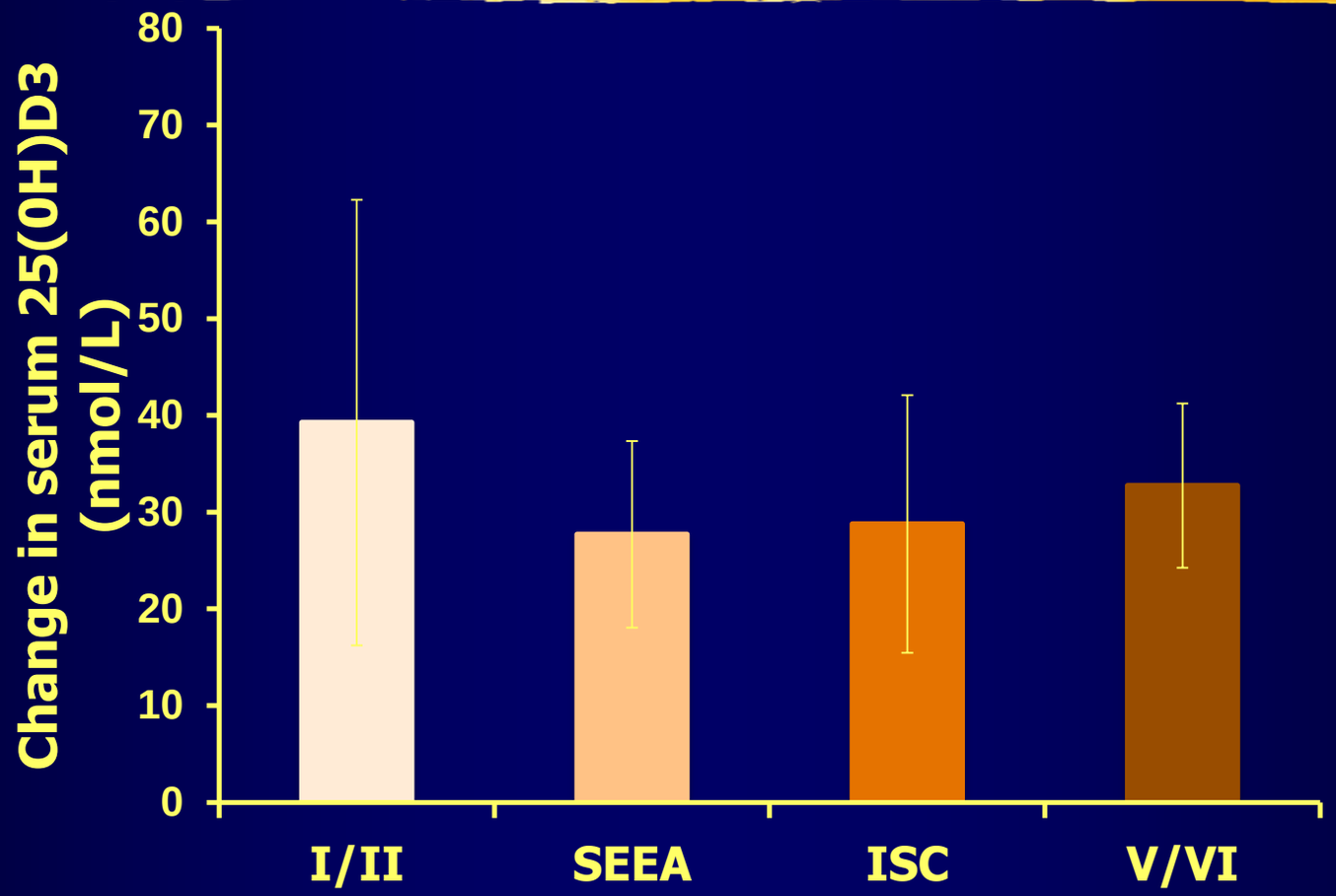
Data Excluding Two Outliers in Type IV-V Indian Sub-Continent Group



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

Kift R, Berry JL, Vail A, Durkin MT, Rhodes LE, Webb AR (2013)
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/cm^2 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

Hymøller L, Jensen SK (2010) Vitamin D(3) synthesis in the entire skin surface of dairy cows despite hair coverage *J Dairy Sci* 93: 2025-9

⌘ 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

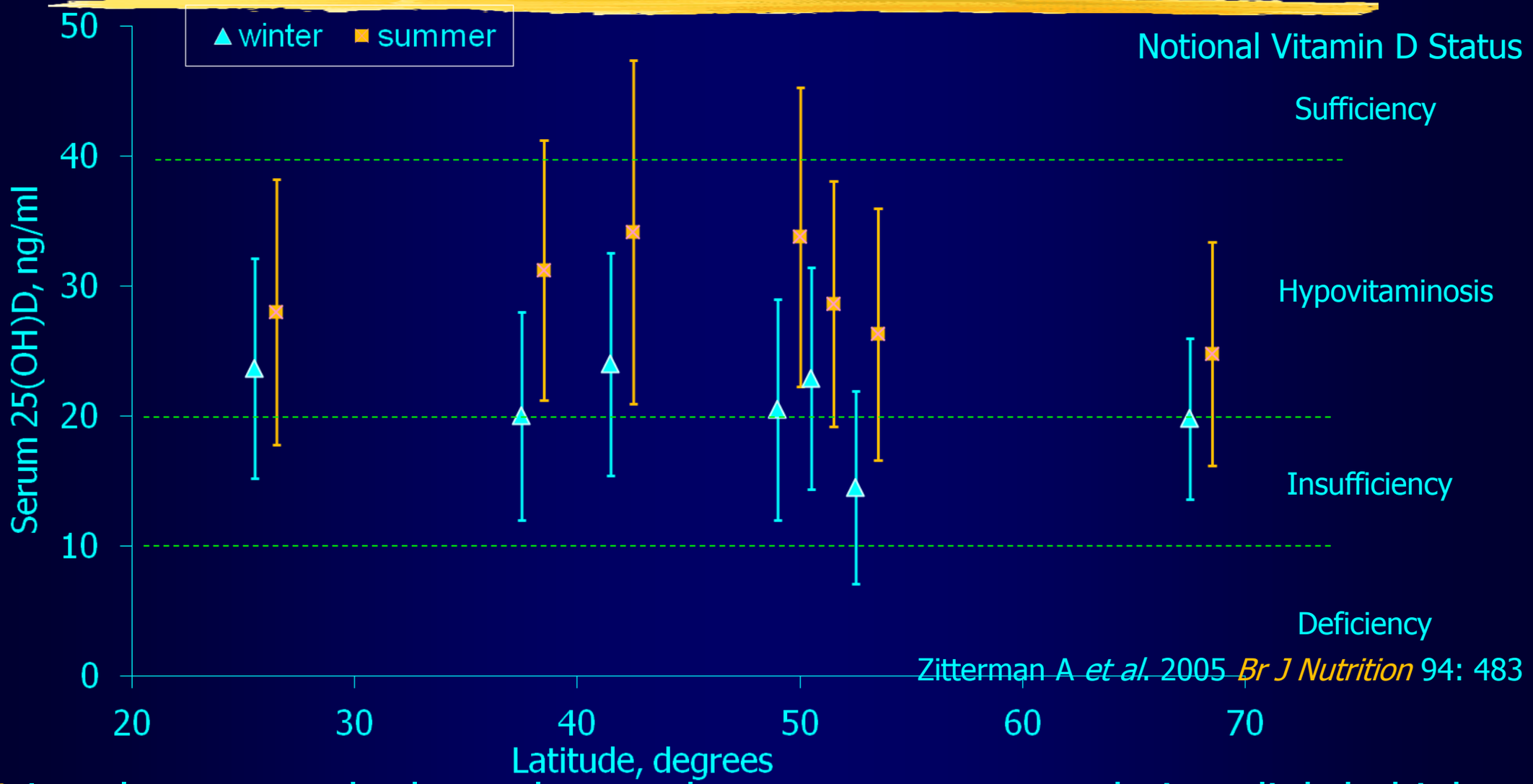
Spradbrow PB, Samuel JL, Kelly WR, Wood AL (1987) Skin cancer and papillomaviruses in cattle *J Comp Pathol* 97:469-79

⌘ 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

Parisi AV, Smith D, Schouten P, Turnbull DJ (2009) Solar ultraviolet protection provided by human head hair *Photochem Photobiol* 85 :250-254

⌘ Strongly further suggests mild UVR exposure maintains adequate vitamin D

⌘ Further, mean vitamin D similar from 25° to 70° N, whatever UVR strength



Zitterman A *et al.* 2005 *Br J Nutrition* 94: 483

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

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

Jones G (2008) Pharmacokinetics of vitamin D toxicity *Am J Clin Nutr* 88:582S-6S

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

Munns CF, Simm PJ, Rodda CP *et al* (2012)
Incidence of vitamin D deficiency rickets among Australian children: an Australian Paediatric Surveillance Unit study
Med J Aust
196:466-468

⌘ 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 hyperphosphataemia, 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

⌘ In summary, vitamin D levels worldwide similar in summer, winter, and only minor ultraviolet B exposure seems needed for satisfactory levels

Rhodes LE, Webb AR, Fraser HI, Kift R, Durkin MT, Allan D, O'Brien SJ, Vail, A, Berry JL (2010)
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

Munns CF, Simm PJ, Rodda CP *et al* (2012)
Incidence of vitamin D deficiency rickets among Australian children: an Australian Paediatric Surveillance Unit study
Med J Aust
196:466-468

⌘ 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

Felton S, Navid F, Schwarz A, Schwarz T, Glaser R, Rhodes LE (2013)
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

Glaser R, Navid F, Schuller W Jantschitsch C, Harder J, Schroder M, Schwarz A, Schwarz T (2009)
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