Atmospheric Research

Balancing risks and benefits of UV radiation

Too much sun causes sunburn; too little results in a vitamin deficiency. ***Richard McKenzie,*** ***Ben Liley,*** *and* ***Paul Johnston*** *have run the numbers to find a happy balance.*

Getting the right exposure

- New Zealand is subject to high levels of UV radiation in summer, and protection is necessary to prevent sunburn.
- But avoiding the sun, especially in winter may compromise vitamin D production.
- A new study shows the optimal exposure time for summer is between 1 and 10 minutes.
- There should be sufficient UV in winter to keep up vitamin D levels, but only if more than just the hands and face are exposed for longer periods.

The health risks of excessive UV radiation are well known. New Zealanders have among the highest skin cancer mortality rates in the world, mainly from melanoma. Unlike more tropical climates, here we can comfortably sit outdoors in direct sunlight for long periods, and for those with paler skins especially, sunburn is still a common complaint.

Sunburn is a known risk factor for developing melanoma, and for many years we have been advised how to protect ourselves from sunburn during the summer, when UV intensities in New Zealand reach values that are 40% more than at corresponding northern latitudes. However, there is another side to the UV story.

When our skin is exposed to UV, our bodies synthesise vitamin D, a key component for good health. It turns out that during winter many New Zealanders have sub-optimal levels of vitamin D, which suggests that in winter our UV exposures may be too low. People in the south of the country and those with darker skins are at greater risk of having sub-optimal levels of vitamin D during the winter months.

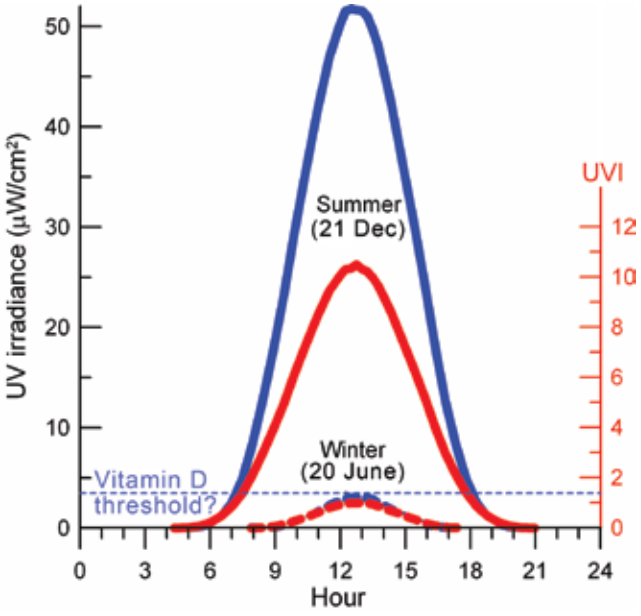
Seeking a healthy balance

So, how can we get enough UV without getting too much? To investigate the relation of sunburning UV radiation with vitamin D-producing UV, we compared measurements of the spectrum of UV radiation reaching the ground at Lauder, NIWA's Central Otago site. The results are in the graph below.

We found that in winter the peak sunburning UV is typically 10% of its summer value, while vitamin D-producing UV is only about 5% of its summer value (see graph below). Then we looked at physiological relationships to estimate the exposure times to sunlight that optimise human health, as a function of the widely used UV Index (UVI). The target we used for vitamin-D production was 1000 IU (international units).

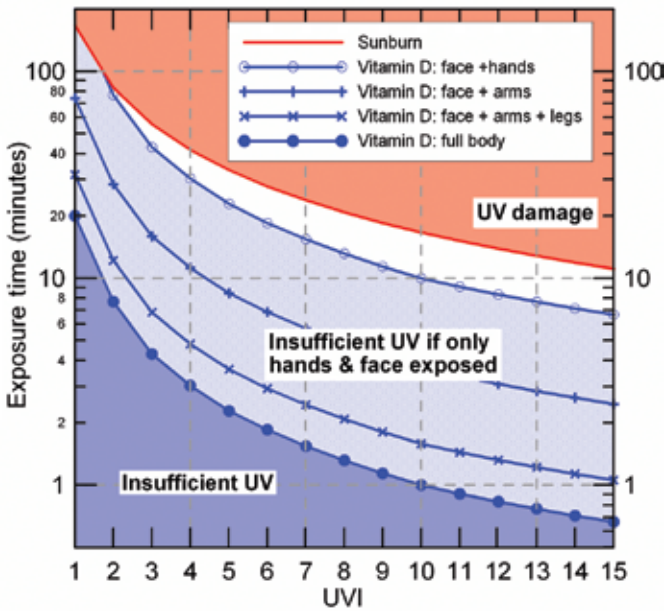
The optimal exposure times that we calculated are shown below. The red area gives times for each UVI value when exposed skin will sunburn. The darker blue area gives the times when there is insufficient UV to maintain optimal levels of vitamin D, even for full body exposure (for example, in swimwear). The other curves give the exposure times needed to maintain vitamin D for different amounts of exposed skin. For full body exposures, there's a wide window between the time for sufficient UV and the time for too much UV. As the fraction of our bodies that is exposed decreases, the window of optimum UV exposure times also decreases.

For lower UVI values, it becomes more and more difficult for our bodies to produce sufficient vitamin D without also suffering sunburn. It's hard to get enough UV from exposing the hands and face alone. During the winter, when cold temperatures discourage us from exposing large areas of



Left: Variation in vitamin D-producing UV (blue) and sunburning UV (red) on clear days at Lauder. Solid curves are summer measurements; dashed curves are in winter. Vertical axis on right shows the corresponding UV Index.

Right: Exposure times required for optimal UV. The times given are for light skin. Double these times for dark skin (Māori or Polynesian), and for black skin multiply by 5.



skin, it may not be possible to get adequate UV. If we expose only our hands and face, there's only a small margin of error between getting sufficient UV for vitamin D production and getting burned; when the UVI is less than 2, it's impossible to get sufficient UV for vitamin D without inducing sunburn.

They said, we said

In magazine articles and in the scientific literature, it's often stated that it is not possible to synthesise vitamin D in the winter (when UV is below the dotted threshold line in the first graph). Our results, however, suggest that sufficient vitamin D can be produced in about 20 minutes of daily full-body exposure. For darker skins, or exposure of smaller areas, the exposure time required would be longer.

The exposure times reported here are very approximate, and it's questionable whether people would be prepared to expose a large enough area of their bodies at low winter temperatures. Also, we need to remember that on winter days, there is only a brief period around noon when the UVI remains close to its maximum value. We already know that many New Zealanders do not receive sufficient UV to maintain optimal vitamin D during the winter. This may be in part because of our modern lifestyles, where outdoor exposure is not common, even in the summer months.

Working it out for yourself

To estimate your optimal exposure time, you first need to know the UVI. NIWA provides daily forecasts of UVI, but currently the media passes these on to the public in summer only. Daily UVI forecasts that include the effects of cloud are available year-round on the NIWA website.

In the absence of any specific UVI information, you can use your shadow to estimate appropriate exposure times, as shown in the table and the illustration below. But for high altitudes, or snow-covered surfaces (such as ski fields), UVI values can be about 30% greater, so exposure times are correspondingly shorter.

Resolving the inconsistencies

In summer, when the UVI is greater than 10, our bodies can produce optimal vitamin D from a few minutes of sun exposure to the face and hands (and about a minute for full body exposure). But exposure times should be less than about 15 minutes to avoid sunburn. When the UVI equals 3, skin damage occurs after about an hour, but optimal vitamin D can still be produced in a few minutes if at least the face, arms, and legs are exposed. Even during winter in southern New Zealand (when UVI reaches only 1 at midday) there should be sufficient UV radiation available to maintain vitamin D, though we'd need to expose larger areas than hands and face alone.

There's an inconsistency between these findings and previous studies which imply that no vitamin D is produced in winter sunlight. Currently we're collaborating with the colleagues at the University of Auckland and the University of Otago to investigate the relationships between measured personal UV exposure and production of vitamin D. The findings of this study should help to resolve this inconsistency. W&A

Useful link and further reading

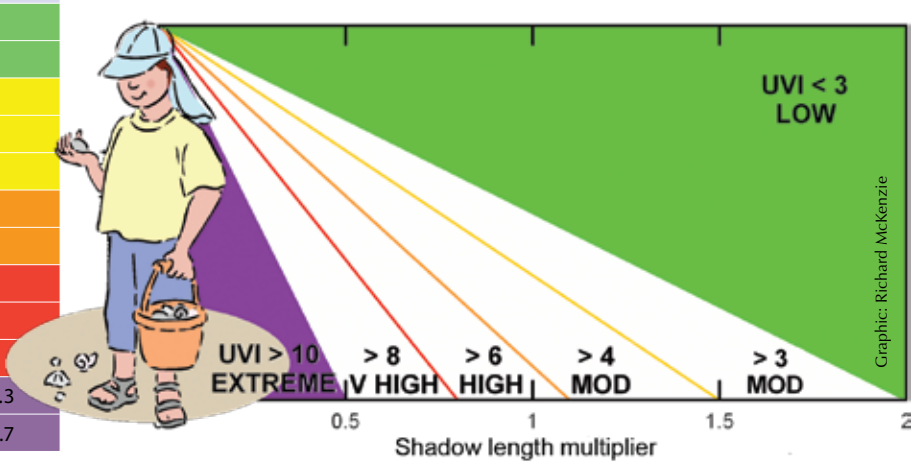
Daily UVI forecast: www.niwa.co.nz/services/free/uvozone

McKenzie, R.L.; Liley, J.B.; Björn, L.O. (2009). UV radiation: balancing risks and benefits. *Photochemistry and Photobiology 85*: 88–98.

Dr Richard McKenzie, Ben Liley, and Paul Johnston are atmospheric scientists based at NIWA in Lauder. *Their current collaborative research is funded by the Health Research Council.*

Approx SZA (°)	UVI	Approx shadow multiplier	Time for sunburn (mins)	Time for 1000 IU Vit D (mins)	
				Full body (100%)	Face & hands (10%)
70	1	2.7	180	20	200
63	2	2.0	120	7.7	77
57	3	1.5	60	4.3	43
53	4	1.3	45	3.0	30
50	5	1.2	36	2.3	23
47	6	1.1	30	1.9	19
42	7	0.9	26	1.5	15
38	8	0.8	22	1.3	13
36	9	0.7	20	1.1	11
32	10	0.6	18	1.0	10
24	12	0.4	15	0.83	8.3
0	15	0.0	12	0.67	6.7

To use the table, start by estimating the solar zenith angle (SZA), which is 90° at sunrise or sunset and 0° for overhead sun. Exposure times are for light skin. For darker skin, multiply by 2 (for Māori/Polynesian) or by 5 for black skin



When your shadow length is twice as long as your body length, then no protection from UV radiation is required

When your shadow is shorter than your body (sun elevation > 45° above the horizon), skin damage can occur in less than 30 minutes

When shadow length is less than half body length, skin damage occurs in less than 15 minutes

Estimating UVI and safe exposures from your shadow length. The UVI is greater under broken clouds, and damage can still occur under overcast conditions when no shadow is visible.