Estimates of beneficial and harmful sun exposure times during the year for major Australian population centres

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ABSTRACT

Objective: To examine the influence of geographical and seasonal factors on duration of solar ultraviolet (UV) radiation exposure of skin to produce recommended vitamin D levels without producing erythema.

Design and setting: An ecological study using daily Ultraviolet Index (UVI) data collected in major population centres across Australia for 1 year (1 January – 31 December 2001) to calculate sun exposure times for recommended vitamin D production and erythema.

Main outcome measures: Sun exposure times to produce either serum vitamin D concentrations equivalent to an oral intake of 200–600 IU/day or erythema for people aged 19–50 years with fair skin (Fitzpatrick type II skin) exposing 15% of the body.

Results: In January, across Australia, 2–14 minutes of sun three to four times per week at 12:00 is sufficient to ensure recommended vitamin D production in fair-skinned people with 15% of the body exposed. However, erythema can occur in as little as 8 minutes. By contrast, at 10:00 and 15:00, there is a greater difference between exposure time to produce erythema and that to produce recommended vitamin D levels, thereby reducing the risk of sunburn from overexposure. From October to March, around 10–15 minutes of sun exposure at around 10:00 or 15:00 three to four times per week should be enough for fair-skinned people across Australia to produce recommended vitamin D levels. Longer exposure times are needed from April to September, particularly in southern regions of Australia.

Conclusion: Our study reinforces the importance of existing sun protection messages for the summer months throughout Australia. However, fair-skinned people should be able to obtain sufficient vitamin D from short periods of unprotected sun exposure of the face, arms and hands outside of the peak UV period (10:00–15:00) throughout Australia for most of the year. The greater variability in sun exposure times during winter, means that optimal sun exposure advice should be tailored to each location.

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Despite the fact that skin cancer is largely preventable, about half of all Australians will be diagnosed with skin cancer during their lifetime.[1] There is strong evidence that ultraviolet (UV) radiation exposure increases the risk of developing skin cancer, and UV radiation has been classified as a carcinogen by the International Agency for Research on Cancer.[2,3] In Australia, it is estimated that up to 95% of cutaneous melanomas, and 99% of squamous and basal cell carcinomas, are caused by solar UV radiation.[4] Solar UV radiation can also cause serious eye damage, including cataracts, pterygium and cancer of the conjunctiva and cornea.[5]

Whereas overexposure to UV radiation may lead to skin cancer, inadequate exposure (in particular to UVB) results in vitamin D deficiency.[6] Exposing the skin to UVB radiation from the sun produces about 90% of the vitamin D_3 (cholecalciferol) that is bioavailable in the body.[7] Some foods also contain vitamin D; however, for most people, adequate vitamin D intake cannot be achieved from the diet alone.[7]

Insufficient levels of vitamin D contribute to the development of osteoporosis, which in Australia costs more than $1.9 billion a year in direct medical costs and, for affected individuals, more than 25 700 disability adjusted life-years are lost each year.[8] Suboptimal vitamin D levels have also been linked, although not conclusively, with several health conditions unrelated to bone, including multiple sclerosis, type 1 diabetes, bowel cancer, breast cancer, prostate cancer and non-Hodgkin's lymphoma.[6,9]

Recent research indicates that a significant number of Australians have at least marginal vitamin D deficiency, with two studies showing rates of 43% in young women and 23% in the general adult population.[10,11] Other groups within the Australian population, such as people with dark skin pigmentation, housebound or bedridden elderly people, and those who cover their skin for cultural or religious reasons, are more susceptible to vitamin D deficiency and have even greater levels of both marginal and frank vitamin D deficiency.[7]

Given the risks and benefits of sun exposure, there is an urgent need for appropriate health messages regarding adequate levels of sun exposure in Australia. Previous public health messages have sought to encourage people to reduce their UV radiation exposure by limiting their time in the sun when UV levels are highest, or by practising basic sun protection behaviours (use of shade, hats, clothing, sunglasses and sunscreen) if they do need to be outside.[12] In this context, the pragmatic question is: "How much sun exposure is enough to provide adequate vitamin D levels without compromising skin and eye health?".

METHODS

Ultraviolet radiation readings

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) routinely collects data on UV surface radiation levels at a number of centres in Australia. This information is reported using the Global Solar UV Index (UVI), which can be converted into a minimal erythemal dose (MED) — the time taken in minutes for UV radiation to cause a slight erythema of the skin but not sunburn.[13]

We obtained the daily UVI readings from ARPANSA for 1 January to 31 December 2001 for Adelaide, Brisbane, Perth, Melbourne, Sydney and Townsville. UVI readings for Hobart were from 1991, as reliable and comparable data for 2001 were not available.

Exposure times and vitamin D synthesis

Exposing the whole body to 1 MED produces serum vitamin D concentrations equivalent to an oral intake of between 10 000 and 25 000 IU.[6] Thus, exposing 15%

of the body, for example the face, arms and hands, to 1 MED would be equivalent to an oral dose of 1500–3750 IU of vitamin D. For those aged 19–50 years, 200–600 IU per day of vitamin D taken orally is recommended to prevent vitamin D deficiency.[14] The current Australian guidelines for recommended vitamin D intake for different age groups are 200 IU/day from birth to 50 years of age, 400 IU/day for people aged 51–70 years, and 600 IU/day for those over 71 years.[15] Therefore, 1/6 to 1/3 MED would be sufficient to provide this amount.

1 Fitzpatrick classification* of skin type[16]

Skin type	Description
I	Always burns, never tans (pale white skin)
II	*Always burns easily, tans minimally (white skin)*†
III	Burns moderately, tans uniformly (light brown skin)
IV	Burns minimally, always tans well (moderate brown skin)
V	Rarely burns, tans profusely (dark brown skin)
VI	Never burns (deeply pigmented dark brown to black skin)

* Source: <http://www.skincarephysicians.com/agingskinnet/photoaging.html>.
† Our calculations are for people with Fitzpatrick type II skin. ◆

Exposure times for adequate vitamin D synthesis in Australian cities

The Fitzpatrick classification (Box 1) gives skin type categories for sun reactivity.[16] All our calculations of solar UV exposure times for recommended vitamin D synthesis are for fair-skinned people (Fitzpatrick type II skin).

UVI data from each of the cities listed in Box 2 and Box 3 were used to determine how long a person needs to spend in the sun to receive 1/6 to 1/3 MED of UV radiation. We used the average monthly UVI data for available centres throughout Australia to calculate exposure periods required to obtain recommended levels of vitamin D from sun exposure at 12:00, 10:00 and 15:00. Calculations are based on exposing 15% of the body to UV radiation for people aged 19–50 years with Fitzpatrick type II skin. Exposure times for 1 MED (erythema) were also calculated.

RESULTS

Box 2 shows sun exposure times required for recommended vitamin D production (and erythema) at 12:00 when 15% of the body is exposed for people with type II skin. In all the cities in January, about 2–14 minutes of sun at 12:00 is sufficient to produce 1/6 to 1/3 MED, which would achieve recommended vitamin D production. However, as erythema can occur in as little as 8 minutes, exposure at 12:00 also increases the likelihood that people will be overexposed to UV radiation, thereby increasing their risk of skin cancer.

Gaining sun exposure further from 12:00 allows a greater margin for error between exposure to achieve recommended vitamin D production and exposure leading to erythema. Therefore, a range from the least to most time required at either 10:00 or 15:00 for sufficient sun exposure to produce vitamin D was also calculated (Box 3). The first figure provided is the time required to achieve 1/6 MED at 10:00 and the second figure is the time required to achieve 1/3 MED at 15:00. Throughout the year, there is wide variability between the higher and lower estimates for sun exposure for vitamin D synthesis at these times. The least possible amount of time for erythema to occur at either 10:00 or 15:00 is given in parentheses to highlight the risk of overexposure, especially during summer in northern Australian centres.

In Box 4, we give recommendations for sun exposure times at 12:00, as well as at 10:00 and 15:00, for people between the ages of 19 and 50 with Fitzpatrick type II skin and 15% of the body exposed. These times apply to people who have no other risk factors for skin cancer and are not using

2 Solar ultraviolet (UV) radiation exposure period (minutes) at 12:00 to produce 1/6 to 1/3 minimal erythemal dose (MED), sufficient for vitamin D production, and 1 MED (erythema; in parentheses*), for people with type II skin and 15% of the body exposed

	Exposure period (minutes)											
City†	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Townsville	2–5	3–6	2–5	3–6	3–7	5–10	4–8	3–6	3–5	2–4	2–4	2–4
	(10)	(10)	(10)	(14)	(16)	(22)	(19)	(14)	(12)	(10)	(10)	(9)
Brisbane	2–4	3–5	3–6	4–8	5–11	7–14	6–12	4–9	4–8	3–6	3–6	3–5
	(8)	(11)	(10)	(14)	(22)	(34)	(30)	(23)	(17)	(14)	(12)	(11)
Perth	2–4	2–4	3–5	4–8	7–15	9–17	9–17	6–12	5–10	3–6	2–5	2–5
	(10)	(11)	(13)	(19)	(30)	(42)	(38)	(25)	(20)	(14)	(12)	(11)
Sydney	3–6	2–5	4–8	5–9	8–16	10–19	11–22	7–14	5–9	3–7	3–7	3–6
	(11)	(11)	(14)	(20)	(30)	(48)	(40)	(30)	(19)	(16)	(12)	(11)
Adelaide	2–4	2–5	3–6	6–11	9–17	15–30	12–25	8–16	6–11	4–8	3–6	3–5
	(11)	(11)	(13)	(22)	(33)	(55)	(48)	(32)	(20)	(16)	(13)	(11)
Melbourne	3–6	2–5	4–8	6–13	11–22	17–34	17–34	11–23	7–13	5–10	4–8	3–6
	(10)	(10)	(15)	(23)	(38)	(70)	(51)	(37)	(23)	(19)	(14)	(12)
Hobart‡	7–14	7–14	11–22	18–36	28–56	37–75	55–110	26–53	16–33	10–30	9–18	7–15
	(27)	(30)	(41)	(60)	(95)	(150)	(150)	(96)	(62)	(41)	(31)	(31)

* Exposure time to produce 1 MED (erythema) based on the maximal Ultraviolet Index (UVI) reading for that month is provided in parentheses.
† Data for cities other than Hobart are based on UVI readings recorded in 2001. ‡ UVI readings for Hobart were from 1991, as reliable and comparable data for 2001 were not available. ◆

sun protection measures. Based on previous recommendations, and given the high UV levels in Australia throughout much of the year, exposure three to four times a week should be more than adequate.

DISCUSSION

Our aim was to contribute to developing practical guidelines for sun exposure for different cities throughout Australia using available data on solar UV radiation levels. Our results indicate that fair-skinned people without any underlying medical condition should be able to obtain sufficient vitamin D from short periods of unprotected sun exposure of the face, arms and hands outside of the peak UV period (10:00–15:00) throughout Australia for most of the year.

Across Australia care is required with sun exposure from October to March at 12:00, as the data indicate little margin for error with respect to excess sun exposure. However, in the southern regions, including Melbourne and Hobart from April to September, and Sydney and Adelaide in June and July, some exposure during peak UV times may be warranted to obtain and maintain adequate vitamin D levels. The time taken to achieve 1 MED at 10:00 in some centres is equivalent to the time taken to achieve 1/3 MED at 15:00 in other centres. Thus, sun protection measures are needed when employing the recommendations in Box 4 to ensure that overexposure does not occur.

Care should be taken in extrapolating recommendations to locations other than those we studied because of the variability of UVI readings at differing altitudes and latitudes as well as with cloud variability.[13] Moreover, timing of readings was based on local times and so reflect UV exposure as influenced by daylight saving practices in each location.

For those at increased risk of vitamin D deficiency, such as housebound or bedridden elderly, it would be advisable to expose a greater body surface area than to increase the amount of time the skin is exposed. Oral vitamin D supplementation for these groups may be preferable to prolonged sun exposure, to reduce the risk of skin cancer. Moreover, the common practice of "sunning" housebound or bedridden people in front of closed windows will not significantly increase vitamin D synthesis as glass is a very effective UVB filter.

Our study has a number of limitations. Firstly, many researchers have suggested that optimal vitamin D intake has been underestimated and official recommendations are too low.[17-19] If optimal serum vitamin D levels are higher than those recommended by Australian and international guidelines, the sun exposure times given (Box 2, Box 3 and Box 4) may be too short for adequate vitamin D production.

Secondly, data reported here are based on UV readings over a single year, which may or may not be typical, and data were averaged for each month. All figures are point estimates and will vary depending on solar UVB levels, as only UVB induces vitamin D synthesis. The intensity of solar UV radiation is influenced by geographical and environmental factors including latitude, cloud cover and ozone levels, which will therefore influence exposure times.

Thirdly, numerous factors affect the ability of the body to synthesise vitamin D from UVB radiation. Many of these are related to disruptions to the UVB–vitamin D pathway, including reduced bioavailability of vitamin D in obese individuals, disorders of the skin, gastrointestinal tract and kidney, and ageing.[6] In addition, behaviours and certain characteristics that provide sun protection may compromise the ability of the body to synthesise vitamin D from UVB radiation. These include the use of sun protective clothing and sunscreen, as well as skin type.[20-23] Our recommendations only apply to fair-skinned people and do not take into account exposure needed for people with darker skin pigmentation. People with very dark skin (Fitzpatrick type VI) require around six times more exposure to UV radiation to produce as much vitamin D as someone with Fitzpatrick type II skin.[23] Based on our results, sunlight exposure during peak times is advisable for people with

3 Solar ultraviolet (UV) exposure times (minutes) to produce 1/6 and 1/3 minimal erythemal dose (MED) at 10:00 (1/6 MED) and 15:00 (1/3 MED), respectively, sufficient for vitamin D production, and 1 MED (erythema; in parentheses*), for people with type II skin and 15% of the body exposed

	Exposure time (minutes)											
City†	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Townsville	3, 7	4, 8	4, 8	5, 15	6, 16	8, 16	7, 16	5, 13	4, 10	3, 9	3, 8	3, 8
	(16)	(15)	(16)	(21)	(27)	(37)	(34)	(24)	(17)	(14)	(13)	(14)
Brisbane	3, 8	3, 9	4, 13	5, 22	7, 40	9, 49	9, 44	6, 29	5, 22	4, 18	3, 15	3, 11
	(12)	(15)	(16)	(23)	(31)	(46)	(46)	(32)	(20)	(16)	(14)	(12)
Perth	3, 6	3, 7	4, 9	7, 19	13, 37	16, 44	17, 37	11, 26	7, 20	4, 14	3, 10	3, 7
	(15)	(17)	(21)	(33)	(51)	(78)	(58)	(44)	(27)	(20)	(16)	(15)
Sydney	4, 10	4, 12	6, 15	7, 30	12, 56	19, 74	20, 74	11, 44	7, 28	4, 19	4, 17	4, 16
	(15)	(16)	(22)	(29)	(46)	(78)	(70)	(48)	(26)	(18)	(16)	(15)
Adelaide	3, 7	3, 7	5, 11	8, 21	17, 49	31, 74	25, 63	16, 37	9, 22	6, 16	4, 10	4, 8
	(17)	(18)	(22)	(38)	(61)	(111)	(83)	(53)	(33)	(22)	(18)	(16)
Melbourne	4, 8	4, 8	7, 14	11, 28	25, 49	44, 99	37, 89	37, 56	13, 26	8, 25	5, 13	5, 10
	(15)	(15)	(24)	(42)	(74)	(166)	(111)	(89)	(37)	(26)	(17)	(18)
Hobart‡	8, 16	8, 16	12, 23	24, 48	39, 78	58, 116	83, 166	37, 75	23, 46	13, 25	9, 18	8, 16
	(28)	(32)	(43)	(83)	(135)	(212)	(225)	(142)	(88)	(50)	(31)	(30)

* Least amount of exposure time to produce 1 MED (or erythema) based on the maximal Ultraviolet Index (UVI) reading for that month either at 10:00 or 15:00. † Data for cities other than Hobart are based on UVI readings recorded in 2001. ‡ UVI readings for Hobart were obtained for 1991, as reliable and comparable data for 2001 were not available. ◆

4 Recommended solar UV radiation exposure to 15% of the body at 12:00, 10:00 and 15:00, for fair-skinned people (Fitzpatrick type II) to produce vitamin D levels equivalent to current recommended intakes in Australia, if exposure occurs three to four times per week

Region	October to March	April to September
At 12:00		
Northern (Townsville and Cairns)	2–5 min with extreme care*	3–10 min with care†
Central (Brisbane and Perth)	2–6 min with extreme care*	4–17 min with care†
Southern (Adelaide, Sydney, Melbourne and Hobart)‡	2–10 min with extreme care*	5–34 min with care†
At 10:00 and 15:00		
Northern (Townsville and Cairns)	⩽ 10 min with care†	⩽ 16 min with care†
Central (Brisbane and Perth)	Around 10 min with care†	14–44 min with care† and extreme care in Brisbane*
Southern (Adelaide, Sydney, Melbourne and Hobart)‡	⩽ 15 min with extreme care*	21 min to ⩾ 1h with care*

* Extreme care: sun protection is highly recommended, as erythema can occur soon after the maximum exposure time is exceeded. † Care: sun protection is recommended if exposure is likely to exceed the maximum recommended time. ‡ Hobart exposure times will be higher (see Box 2 and Box 3). ◆

Fitzpatrick type V or VI skin in certain circumstances, especially in the southern region from April to September, and in the central region in June and July.

Fourthly, the aetiology of squamous cell carcinoma indicates that cumulative, or total, sun exposure is the major contributing factor.[2] It therefore seems inevitable that deliberately seeking sun exposure for vitamin D-related benefits may result in some increase in squamous cell carcinoma risk.

Our study illustrates the complexities of calculating UV exposure times and clearly indicates that it is impractical to generate a simple nationally uniform message that prescribes minutes of sun exposure to the general population, given the number of variables that need to be taken into consideration. Even so, across Australia, from Townsville to Hobart, summer UV levels are high enough that short exposure under most circumstances for most people should be enough to produce recommended vitamin D levels, whereas slightly longer exposure times will contribute to skin cancer risk. Therefore, in summer, minimising sun exposure is the key. By contrast, in winter, our individual circumstances including geography, skin type and age all need to be taken into consideration when determining the appropriate level of sun exposure for good health.

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COMPETING INTERESTS

None identified.

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