ABSTRACT

Objective: To examine the feasibility of balancing sunlight exposure to meet vitamin D requirements with sun protection guidelines.

Design and setting: We used standard erythemal dose and Ultraviolet Index (UVI) data for 1 June 1996 to 30 December 2005 for seven Australian cities to estimate duration of sun exposure required for fair-skinned individuals to synthesise 1000 IU (25 μg) of vitamin D, with 11% and 17% body exposure, for each season and hour of the day. Periods were classified according to whether the UVI was < 3 or ≥ 3 (when sun protection measures are recommended), and whether required duration of exposure was ≤ 30 min, 31–60 min, or > 60 min.

Main outcome measure: Duration of sunlight exposure required to achieve 1000 IU of vitamin D synthesis.

Results: Duration of sunlight exposure required to synthesise 1000 IU of vitamin D varied by time of day, season, and city. Although peak UVI periods are typically promoted as between 10 am and 3 pm, UVI was often ≥ 3 before 10 am or after 3 pm. When the UVI was < 3, there were few opportunities to synthesise 1000 IU of vitamin D within 30 min, with either 11% or 17% body exposure.

Conclusion: There is a delicate line between balancing the beneficial effects of sunlight exposure while avoiding its damaging effects. Physiological and geographical factors may reduce vitamin D synthesis, and supplementation may be necessary to achieve adequate vitamin D status for individuals at risk of deficiency.

MJA 2011; 194: 345–348
times a week.\textsuperscript{13,16} Excluding the face equates to 11% body exposure, which would reportedly produce 7331 IU of vitamin D.\textsuperscript{22} We calculated that when hands, arms and neck on one side of the body (11% of the body) are exposed to the sun, a dose of 0.455 MED is required for fair-skinned individuals to achieve 1000 IU of vitamin D, whereas including one side of the lower legs (17% of the body) decreases the required dose to 0.294 MED (Box 1). We then determined the duration of sun exposure required to achieve each of these MEDs for each hour of daylight between 6 am and 5 pm, by season and city.

Average monthly SEDs for each hour of daylight during January, April, July and October were used to represent summer, autumn, winter and spring, respectively. Periods when the average UVI (UVI\textsubscript{av}) was < 3 were recorded in tabular format as green if synthesis of 1000 IU could be achieved in \( \leq 30 \) min, and blue if it could be achieved in 31–60 min. Periods when the UVI\textsubscript{av} was \( \geq 3 \) were coded red to reflect sun protection guidelines. Periods when it was impossible to achieve 1000 IU of vitamin D synthesis within 1 hour were recorded as grey.

### RESULTS

Our data showed it was possible for fair-skinned individuals to obtain 1000 IU of vitamin D within 30 min of exposure of 11\% (Box 2) or 17\% (Box 3) of the skin to the sun, but there were few occasions when this could be achieved at times not excluded by sun protection guidelines. More opportunities to achieve synthesis of 1000 IU in \( \leq 30 \) min occurred, and required duration was shorter, when 17\% of the body was exposed to the sun, relative to 11\%, as seen by the greater number of green cells in Box 3 relative to Box 2.

UVI\textsubscript{av} often reached 3 outside the publicised peak UVI period of 10 am–3 pm (Box 2, Box 3). In summer, the UVI\textsubscript{av} was \( \geq 3 \) between 8 am and 5 pm in all cities except Townsville and Sydney (8 am–9 pm) and Darwin (9 am–5 pm). In winter in Darwin, Townsville, and Brisbane, the UVI\textsubscript{av} was \( \geq 3 \) from 10 am until 4 pm, 3 pm and 2 pm, respectively. In contrast, in winter in Sydney,
Adelaide, and Melbourne, the UVI\textsubscript{av} remained < 3 throughout the day, allowing exposure without protection during the warmer parts of the day.

UVI\textsubscript{av} and duration of sun exposure required to achieve 1000 IU of vitamin D synthesis varied according to time of day, season and city (Box 2, Box 3). Opportunities when this could be achieved within 30 min when the UVI was < 3 were limited.

With 11% body exposure, there were no opportunities in winter and spring to achieve 1000 IU of vitamin D synthesis in ≦ 30 min except Townsville in summer, whereas during winter and spring there were some opportunities in most cities (Box 2).

When lower legs were included in exposure, 1000 IU synthesis could be achieved within 30 min on at least one occasion each day for almost all seasons (with the exceptions of Adelaide, Perth and Melbourne in summer, Townsville in spring; and Darwin and Sydney in autumn) (Box 3). As the UVI was < 3 during the middle part of the day in winter in Perth (except at midday), Sydney, Adelaide and Melbourne, sun exposure of ≦ 30 min during the middle of the day could achieve 1000 IU of vitamin D synthesis.

**DISCUSSION**

We found that duration of sunlight exposure required for fair-skinned individuals to achieve 1000 IU of vitamin D synthesis varied according to time of day, season and city.

Overall, when 11% of the body is exposed to the sun, there are few opportunities to synthesise 1000 IU of vitamin D within 30 min at times of day when sun exposure without protection is not discouraged. In nearly all cities during summer and autumn, there are no opportunities to achieve this, whereas there are more opportunities during winter and spring, particularly in southern cities such as Sydney and Melbourne. For exposure durations of 31–60 min, most cities have at least one opportunity each day to synthesise 1000 IU; however, as these periods mostly occur early and late in the day, we advise caution due to the potentially damaging effects of UVA light at these times.\(^{10}\) It may be preferable to instead increase the amount of skin exposed to the sun to reduce the required duration.

We consider 30 min as the maximum duration that individuals could feasibly spend in the sun each day on a regular basis. Formation of pre-vitamin D plateaus in fair-skinned individuals within 15–45 min of exposure to UVR, after which further exposure causes the breakdown of pre-vitamin D into biologically inactive lumisterol and tachysterol.\(^2\)

Our findings suggest that UVI\textsubscript{av} is often ≧ 3 at these times, and the risk of overexposure is therefore higher. We found that UVI\textsubscript{av} often reached 3 outside commonly promoted peak UVI periods, indicating sun protection behaviour should extend beyond these times.

Our UVI data cover a period of 10 years, and therefore are likely to be robust and based on “typical” cloud cover, although...
daily variation in cloud cover and pollution levels will alter the required exposure durations. As reported previously, we found that the UVI remains below 3 throughout the day in Sydney, Adelaide and Melbourne during winter, suggesting that there may be a wider safety margin to allow sufficient sunlight exposure to achieve adequate vitamin D synthesis in winter in these cities.

Our recommendations take into account Australian guidelines that suggest sun protection is not required when the UVI is below 3. Our suggested doses of 0.455 and 0.294 MED are unlikely to cause sunburn, as 1 MED produces only a faint pinkness in fair-skinned individuals. We recommend individuals check real-time UVI data, as the actual level may vary from the long-term average.

A limitation of our study is our inability to take into account physiological factors that contribute to vitamin D deficiency, such as increased age, increased skin pigmentation, fat malabsorption, and obesity, and as such our recommendations are likely to be an underestimate for individuals affected by these factors. It could be argued that the recommendation of avoiding sunlight exposure when the UVI is 3 could be more nuanced, as skin is damaged relative to the total exposure, which is dependent on both UVR intensity and duration of exposure. Although brief exposure when the UVI is 3 could be identical to longer exposure during periods of low UVI in terms of both vitamin D synthesis and skin damage, exposure during high UVI periods requires careful timing to avoid overexposure. Additionally, the achievements made in educating the public about the dangers of high UVI could be lost if alternative recommendations were to be made.

Australians should be aware of methods to obtain sufficient vitamin D while minimizing skin damage. Given the difficulty of achieving adequate vitamin D synthesis in some individuals, increasing oral intake with daily supplementation or consuming food naturally containing or fortified with vitamin D may be required.

Elizabeth L Salisbury, MB BS(Hons), FRCPA, FFOP, Tissue Pathologist
Colin R Dunstan, PhD(Med), MSc, BSc(Hons), Animal Biologist
Stuart I Henderson, BSc, PhD(Applied Physics), Scientist
Peter L Talbot, BSc, PostgradDipNutrDiet, MSc, Head Dietitian
1 Westmead Breast Cancer Institute, University of Sydney, Sydney, NSW.
2 Biomedical Engineering, School of Aerospace, Mechanical and Machatronic Engineering, University of Sydney, Sydney, NSW.
3 Non-ionising Radiation Branch, Australian Radiation Protection and Nuclear Safety Agency, Yallambie, VIC.
4 Department of Dietetics and Nutrition, Westmead Hospital, Sydney, NSW.

Correspondence: Kellie.Bilinski@bci.org.au

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COMPETING INTERESTS
None identified.

AUTHOR DETAILS
Kellie L Stalgis-Bilinski, BSc, MNutrDiet, APD, Oncology Dietitian
John Boyages, MB BS(Hons), FRACR, PhD, Executive Director and Radiation Oncologist