A study of UV and vitamin D in Melbourne adults

Research summary

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Introduction

Solar ultraviolet radiation (UVR) provides a valuable source of vitamin D and is also the major cause of skin cancer. For our population in sunny Australia, there is a fine line in balancing these beneficial and harmful effects of sunlight (UVR) exposure. With this in mind, Australian public health guidelines have been developed and refined over time to provide recommendations of personal sun exposure; for vitamin D adequacy (defined as a 25 hydroxyvitamin D (25(OH)D concentration of 50nmol/L or above) while still acknowledging the risks (SunSmart 2014a, 2014b).

In Australia the guidelines recommend that in the summer, when levels of UVR are consistently high to extreme between 10am and 3pm, the amount of UVR exposure needed to maintain vitamin D adequacy equates to having the face, hands, and arms exposed for a few minutes during mid-morning or mid-afternoon (The Australian and New Zealand Bone and Mineral Society et al. 2007). In winter, the amount of UVR exposure needed varies by location (Holick 2002). At latitudes further from the equator such as Melbourne, Australia, two to three hours per week of exposure to as much bare skin as feasible may be required (Nowson et al. 2012, The Australian and New Zealand Bone and Mineral Society et al. 2007). Other factors such as skin colour may also affect vitamin D production (Webb & Engelsen 2006), and people with highly pigmented skin are recommended to achieve between three and six times the exposure recommended for fair to moderate skin types (Clemens et al. 1982).

While specific sun exposure guidelines have been developed, there has been minimal evaluation of whether these guidelines, if followed, will maintain adequate levels of vitamin D. Given the mounting evidence of many health protective effects of vitamin D adequacy, but acknowledging the high incidence of skin cancers under extreme levels of ambient UVR in Australia, it is important that the efficacy of sun exposure guidelines is investigated.

Objectives

This pilot study aimed to determine whether the current sun exposure recommendations of 2–3 hours of weekly sun exposure in winter, and only a few minutes of sun exposure per day to face, arms and hands (or equivalent area of skin) at mid-morning or mid-afternoon in summer (three to six times this amount in people with dark skin), would maintain vitamin D at adequate levels in a population of Melbourne adults.

Accordingly, this study investigated the vitamin D status of a group of indoor workers from Melbourne who were provided with the current Australian guidelines on personal sun exposure for vitamin D adequacy in summer and winter. Population vitamin D status was examined after 14 days of following the sun exposure guidelines, to determine if vitamin D adequacy was maintained. By extension, the attainment throughout the year of the amount of sun exposure recommended in the guidelines should maintain overall yearly vitamin D adequacy (Rhodes et al. 2010, Webb AR & Engelsen O 2006). We planned to test this hypothesis in this study.

Methodology and recruitment

This study was approved by the Human Research Ethics Committees of the Queensland University of Technology (# 1200000490) and Cancer Council Victoria (# 1218).

Volunteer indoor workers were recruited in January 2013 from three large workplaces in the central business district of Melbourne, Australia. The participant sample was restricted to indoor workers due to their regular structured hours indoors, lower opportunity for incidental or deliberate sun exposure during weekdays and higher risk of vitamin D deficiency/insufficiency. Thus the recommendations for sun exposure for vitamin D adequacy could be considered as being particularly relevant to this group.

All workers were sent a detailed study information sheet and invited to participate. Participants were required to be aged 18 years or over, literate in English, taking no more than 400 International Units (IU) per day of oral vitamin D supplements (the amount contained in most multivitamins), and able to attend two on-site data collection interviews in summer (February/March) and winter (August) 2013. Additional recruits for the winter study were obtained from the same workplaces as used in the summer study, to compensate for the natural loss of participants over time and also for the exclusion/withdrawal of summer study participants due to use of high dose vitamin D supplementation during winter.

Data collection

All participants provided written informed consent before data collection began. Participants attended two on-site data collection interviews each season, conducted during 19–21 February and 6–8 March (end of summer), and during 6–8 August and 28–30 August (end of winter). At their first interview each season, participants completed an online questionnaire on factors relevant to vitamin D status, including demographics (age, sex, ethnicity, education), past medical history, consumption of alcohol or tobacco, recent sun exposure and sun protection, sensitivity of skin to the sun, dietary intake of vitamin D, and use of oral vitamin D supplements. Measures were made of participants' height and weight. Participants then self-selected, and were provided with, the season-specific sun exposure guidelines for vitamin D adequacy appropriate for their skin colour (fair-to-olive skin, or dark skin). The guidelines recommend sun exposure to at least the face, arms, and hands (or equivalent area of skin) for the following times:

- September to April (high UVR months): a few minutes at mid-morning or mid-afternoon on most days of the week (3–6 times this amount for dark skin).
- May to August (low UVR months): 2–3 hours around midday and spread across the week (3–6 times this amount for dark skin).

For the subsequent 14 days starting on the day after their interview, participants were requested to obtain the recommended daily amount of sun and skin exposure as specified in their guidelines. They were also asked not to change their normal sun protection habits. Participants also completed a 14-day sun diary in which they recorded ('Yes'/'No') whether they achieved at least the minimum recommended sun exposure that day. Participants who answered 'Yes' then recorded the start and finish of all times during that day when they spent time outdoors with the recommended amount of skin exposed, as well as their use of sunscreen. In winter, participants were also asked to record any difficulties that they faced in obtaining the recommended amount of the sun exposure.

Participants' completed diaries were collected at a follow-up interview (three weeks after the first interview) and a sample of blood was taken for analysis of post-exposure 25(OH)D concentration. Blood was processed within four hours of collection and serum samples stored locally at -80°C. At the completion of the study all stored sera were transported to Brisbane for analysis of 25(OH)D concentration using the DiaSorin® Liaison semi-automated chemiluminescence assay II.

Study findings

137 participants enrolled in the summer study and 121 enrolled in the winter study: 33 and 23 participants were excluded from the summer and winter analyses respectively, as they either did not attend their second interview and hence did not have 25(OH)D results, their choice of guidelines was not recorded, their sun diary was incomplete, or they were taking oral supplements containing over 400 International Units of vitamin D. Eighty-nine people participated in both the summer and winter studies.

Summer Study

104 participants (average age 38.4 years) completed the summer study: 74% were female, 71.2% were Australian born, and 87.5% were in full-time employment. Almost all were non-smokers. Most participants self-reported as having fair or medium skin, and almost half had brown hair. The average 25(OH)D concentration of the sample was 65.9 nmol/L (range from 19.0 to 147 nmol/L), which is considered adequate. 25(OH)D concentration was significantly higher in participants who were female, Australian-born, , and who wore sunscreen. There was no association between adequate vitamin D levels and the following participant characteristics; age, education, employment, smoking or health status, skin, hair or eye colour, body mass index, dietary intake of vitamin D from oily fish, or consumption of low dose vitamin D supplements.

Summer sun exposure guidelines for Vitamin D (25(OH)D concentration)

Participants were considered to have met the minimum summer sun exposure requirements if they completed the following, over the 14 day period:

- For fair-to-olive skin: spent at least a few minutes outdoors with their face, arms and hands (or equivalent) exposed, on 8 or more days in 14.
- For dark skin: as above, plus a daily average outdoor time of 20 minutes or more.

Using these criteria, 94.2% of summer study participants met or exceeded the sun exposure recommendations over the 14-day data collection period – this included 77.9% of fair-to-olive-skinned participants and 100% of dark-skinned participants. The average 25(OH)D concentration of the group who met or exceeded the recommended amount of sun exposure was 67.3 nmol/L. Participants who *did not* meet at least the minimum sun exposure recommendations were significantly more likely to be male, non-Australian-born, to rate themselves as having less than excellent health, or to have a body mass index greater than 30. Overall 25(OH)D concentration was significantly higher in participants who were Australian-born, who had blonde or red hair, and who wore sunscreen.

Winter Study

Ninety-nine participants (average age 37.8 years) completed the winter study. As most participants participated in both summer and winter studies, the characteristics of the groups were similar. The average 25(OH)D concentration of the winter sample was 38.9 nmol/L (range from 11.1 nmol/L to 109 nmol/L), which is considered inadequate. 25(OH)D concentration was significantly higher in participants, who had fair-to-olive skin, who had brown or blonde hair, and who were taking low dose vitamin D supplements. The average 25(OH)D concentration was lowest overall in participants with dark skin and black hair.

25(OH)D concentration was not associated with age, country of birth, education, employment, smoking or health status, eye colour, dietary intake of vitamin D from oily fish, body mass index, or use of sunscreen.

Winter sun exposure guidelines for vitamin D (25(OH)D concentration)

Participants were considered to have met the minimum winter sun exposure requirements if they completed the following, over the 14 day period:

- For fair-to-olive skin: spent time outdoors at least one day per week with face, arms, and hands (or equivalent) exposed, with an accumulated outdoor time between 10am and 3pm of 4 hours or more over 14 days.
- For dark skin: as above, with an accumulated outdoor time between 10am and 3pm of 12 hours or more over 14 days (3–6 times the time required for fair-to-olive skin).

Based on these criteria, only 47.5% of winter study participants met or exceeded the winter sun exposure guidelines. There was no significant difference in characteristics between those participants who did and those who did not meet the sun exposure recommendations. The average 25(OH)D concentration of the participants who met or exceeded the recommended guidelines was 41.9 nmol/L, which is considered inadequate. There was no significant difference in 25(OH)D concentration based on participant characteristics, with the exception that brown-haired participants had a higher 25(OH)D concentration than black-haired participants. In the total participant group, there was a large and significant difference in average 25(OH)D concentration in participants taking multivitamins compared with those not taking multivitamins. This difference in 25(OH)D concentration became smaller and non-significant when participants who met/exceeded the sun exposure recommendations were examined separately.

Following sun exposure guidelines and vitamin D adequacy

Ninety-eight participants achieved at least the minimum recommended ‘few minutes per day’ of summer sun exposure, with most receiving considerably more exposure time. 69.3% of participants who met or exceeded the recommended sun exposure guidelines were adequate in vitamin D (defined as having 50nmol/L or more of 25(OH)D). Most participants (83.3%) who *did not* meet the recommended exposure times in summer had inadequate levels of vitamin D (less than 50nmol/l of 25(OHD)).

The majority of participants in the winter study had *inadequate* levels of vitamin D, regardless of whether they met the sun exposure guidelines. Only 27.6% of winter participants who met or exceeded the sun exposure guidelines were 25(OH)D adequate.

Of those participants who met or exceeded the recommended summer guidelines, only 35% of those with dark skin and 46% of those who were non-Australian-born had an adequate 25(OH)D concentration. One summer participant was 25(OH)D adequate despite not meeting the sun exposure recommendations, while 62.4% of those who were not able to meet the recommendations were inadequate. 18% of winter participants who did not meet the guidelines had adequate levels of 25(OH)D.

Discussion

In this study, we assessed the impact of the current Australian sun exposure guidelines for maintaining vitamin D adequacy. Participants in Melbourne, Australia were asked to follow the current sun exposure guidelines over a two week period in summer and winter, after which we assessed 25(OH)D concentration through a blood sample. In each season we also collected information about demographic and other factors that might influence the production of vitamin D, and used these in our analyses.

We found that, in summer, obtaining at least the minimum recommended amount of sun exposure time for maintaining vitamin D adequacy (25(OH)D concentration of 50 nmol/L or greater) was easily achievable by almost all participants. As the majority of summer participants received considerably more than the required 'few minutes per day' of sun exposure, and it would be expected that a dose/response relationship exists between time outdoors and 25(OH)D concentration (the greater the time outdoors, the higher the 25(OH) concentration), it is difficult to draw conclusions about the effectiveness of the summer recommendations. Dark-skinned indoor workers were less likely to maintain vitamin D adequacy by following the summer sun exposure guidelines.

When compared with the summer group, winter participants were much less likely to achieve the recommended amount of sun exposure. Even if obtained, this exposure was unlikely to maintain adequate levels of vitamin D. Previous research has shown that, amongst other factors, seasonal changes in the angle of the sun can markedly affect the skin's ability to produce vitamin D, with little, if any, vitamin D produced in the skin in winter at latitudes above and below 35° (Webb, Kline & Holick 1988). Our findings support the notion of a decreased ability to synthesize vitamin D from winter sun exposure. Whether this is due to a lack of solar UV exposure, or a function of lack of outdoor time or decreased skin exposed in winter (due to the cold) is a question that remains unanswered – these latter two factors were reported as major impediments to sun exposure in almost all participants who were unable to meet the sun exposure recommendations in winter. Our findings thus raise an important question – should guidelines for sun exposure for winter vitamin D adequacy even be advocated, as the recommended amount of sun exposure is difficult to achieve and, importantly, does not appear to maintain vitamin D adequacy?

Also, in both summer and winter, participants who took multivitamin supplements containing low doses (less than 400 International Units) of vitamin D had a higher average 25(OH)D concentration than those who did not take multivitamin supplements. In the overall winter study sample, this difference between the multivitamin and no multivitamin groups was highly significant. It is possible that taking low dose vitamin D supplements, while not boosting 25(OH)D concentration, can function to maintain the stability of 25(OH)D concentration or to lessen the winter decline in 25(OH)D. High dose (1000 International Units or more) vitamin D supplements are likely to provide more benefit than multivitamins, although this was not assessed in our study.

Our study had a number of limitations. The majority of summer participants received considerably more than the required 'few minutes per day' of sun exposure, and it would be expected that a dose/response relationship exists between time outdoors and 25(OH)D concentration – the greater the time outdoors, the higher the 25(OH) concentration. This has not been investigated in this study. We also did not have a record of the specific amount of skin exposed while outdoors (other than it was at least face, arms and hands, or equivalent) and it is possible that the area of exposed skin varied between participants. Additionally, we could not determine if participants had the recommended amount of time outdoors, and it is possible that some participants may not have had the exposure that they stated. As two of the most important factors contributing to 25(OH)D concentration are the time spent outdoors and the amount of skin area exposed while outdoors (Kimlin et al. 2014), we may have underestimated the time in the sun required to produce 25(OH)D. This, however, is unlikely as even in summer not all those who followed the guidelines were 25(OH)D adequate. The study was also limited by a small sample size with very few dark-skinned participants, by the use of indoor workers only, and by the 14-day sun exposure assessment period. The sun exposure assessment period and the time at which blood was taken for analysis may not be optimal for producing and/or measuring changes in 25(OH)D concentration.

Nonetheless, our study has added to the evidence informing public health messages to minimise the risks of over-exposure to sunlight, while maintaining population vitamin D adequacy. Our study findings suggest that during the summer months, even in high latitude locations such as Melbourne, public health guidelines should focus on sun protection to minimise skin cancer risk, as the population is likely to receive more sun exposure than is required to maintain vitamin D adequacy. Sun exposure guidelines in winter may not be of value at high latitudes as the required level of exposure does not appear to maintain vitamin D adequacy. This finding, however, warrants further research.

Recommendations (for maintaining vitamin D adequacy)

Summer

From this study, we found that the majority of people in Victoria were serum 25(OH)D adequate over summer. In summer it was difficult for participants to obtain *only* the recommended amount of sun exposure ('a few minutes') as specified in the guidelines. The majority of summer participants received considerably more than this, making it difficult to accurately assess the effectiveness of the summer guidelines.

The key public health message in summer should therefore remain on sun protection while maintaining a balanced approach to sun exposure for vitamin D, given that the population is likely to receive more sun exposure than is required to maintain vitamin D adequacy.

Key public health message for summer:

- Use a daily sunscreen and seek shade during the middle of the day, to protect against sunburn and skin cancer risk.
- To assist with vitamin D production, aim to get some sunlight on the exposed skin of the face, hands and arms or legs for a few minutes before mid-morning or after mid-afternoon on most days of the week.
- Aim to have adequate levels of vitamin D at the end of summer.

Winter

During Winter, serum 25(OH)D levels naturally decrease in the majority of people due to the decreasing solar UVR. From our study we found that most people were not able to achieve the currently recommended amount of winter sun exposure for maintaining vitamin D adequacy. Moreover, most participants who did achieve at least the recommended amount of winter sun exposure *did not* maintain vitamin D adequacy.

From this we infer that the majority of Victorians will be unable to maintain vitamin D levels in winter through sun exposure alone, even if the currently recommended amount of sun exposure can be achieved.

Key public health message for winter:

- Ensure you have adequate vitamin D levels at the end of summer to accommodate for the seasonal decline in vitamin D during winter.
- Consider taking Vitamin D supplements, including multivitamins containing vitamin D, to assist with lessening the winter decline in vitamin D levels. Ask your medical practitioner for further information about these supplements.

It is important to note that these results should also be considered in context of the study design. This was a small, urban dwelling group of people, who may not represent the sun exposure patterns and behaviours of the rest of the Victorian community.

It is our strong recommendation that further studies are required using a modified study design where an intervention group is required to strictly comply with the summer recommendations (e.g., a few minutes of sun exposure per day). Further studies investigating other groups and regions within Victoria should also be conducted prior to the changing of public policy regarding sunlight exposure and vitamin D.

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