Seasonal Vitamin D

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Abstract. A fundamental assumption when undertaking studies into Vitamin D and populations is that the relative "ranking" of an individual remains constant with respect to time. That is, an individual with a low ranking (lowest percentile) of Vitamin D status in summer will also have a low ranking (lowest percentile) of Vitamin D in summer, even though the Vitamin D status may have increased from summer to winter. This work investigates if such relative ranking exists in populations and what impact this assumption has on epidemiological research

Introduction

Occurrence of many cancers, autoimmune diseases and infections varies geographically by latitude, as do levels of ambient ultraviolet radiation (UVR) (Holick, 2004a). There is some supportive animal experimental and laboratory evidence to suggest that vitamin D insufficiency, presumably over some sustained period, may be an important risk factor in the etiology of these conditions (Holick, 2004a). In their landmark 2008 report (WHO, 2008) the International Agency for Research on Cancer (IARC) further supported this vitamin D insufficiency – disease hypothesis by identifying Vitamin D as a possible cancer prevention agent.

In individual-level studies, which have provided mixed support for the vitamin D insufficiency - disease hypothesis, vitamin D status (measured as serum concentration of 25-hydroxyvitamin D (25(OH)D)), has usually been based on a single blood sample. In order to compare 25(OH)D levels from samples taken at different times in the year, studies attempt to statistically remove any background seasonal variation (due to changing UVR levels) by estimating each sample's deviation above or below the mean seasonal curve. This assumes that an individual maintains their position relative to the mean throughout the year. If this assumption is incorrect (and there is some preliminary evidence to suggest it is), a single 25(OH)D level may provide little information on "average" vitamin D status, with this measurement error resulting in null findings.

Based on seasonal variation in ambient UVR and in sun exposure behaviour, seasonal variation in 25(OH)D levels is expected. Indeed, at the population level, there is clear evidence that the population mean follows the expected pattern through the year (Webb et al., 1989, Holick, 2004b), however, the few studies that have examined individual vitamin D status across more than one time period suggest that there is substantial intra-individual variation in seasonal variability (e.g. in Japanese (Nakamura et al., 2000) (r=0.46) and Canadian (personal communication) (r=0.38) 10 women, there was a poor correlation between winter and summer 25(OH)D levels).

Most individual-level epidemiological studies examining vitamin D status in relation to disease risk measure serum 25(OH)D levels at a single time point, statistically "adjusting" for seasonal effects based on the mean seasonal variation in 25(OH)D levels in the whole sample. In longitudinal studies, more than one pre-existing blood sample may be used, but in comparing either intra-individually or inter-individually, adjustment for season is still usually required, as logistic considerations mean that samples are taken at different times of the year. However, if there is a poor correlation between winter and summer 25(OH)D levels (as noted above), then such adjustment, based on an individual maintaining their relationship to the mean, may not be valid.

Methods

The 25(OH)D levels of 60 healthy ambulatory adults (42 female) aged 18 to 87 (median 49) years, in southeast Queensland, Australia (27°S) were tracked from winter to summer. After informed consent, participants were administered a questionnaire surveying past (previous 30 days) sun exposure, timing of sun exposure, sun protection used and dietary Vitamin D intakes.

Serum 25(OH)D was measured at the Queensland University of Technology using a high throughput Diasorin Liaison competitive binding chemiluminescence system. This system was calibrated with control standards prior to use and participates in the DEQAS program (Vitamin D External Quality Assurance Scheme)

Data were analysed using the Statistical Package for Social Sciences (PASW) software package v18.0 (SPSS, 2005). Descriptive univariate and bivariate analyses of associations between serum 25(OH)D, personal characteristics, sun protection practices are reported.

The responses from the participants were used to identify potential explanatory variables for the variation in seasonal 25(OH)D, with a backwards elimination process in a univariate General Linear Model. For this model, the following independent variables were used: age, gender, education, BMI, PTH, self reported hair colour, self-reported skin colour, self reported eye colour, self reported burning tendency, self reported tanning tendency, self reported previous 30 day weekday (occupational) sun exposure, self reported previous 30 day weekday (occupational) sun exposure, self reported previous 30 day weekend (recreational) sun exposure, self reported previous 30 day sunscreen use, self reported previous 30 day hat wearing, self reported previous 30 day long-sleeved shirts and self reported previous 30 day long trousers, and the objective measures of inner upper arm L*, dorsum right hand L*, and mid-forehead L*.

Additional indicators of the previous 30-day intake of Vitamin D rich foods, such as oily fish and oral supplementation and fortified milk was used in this model (at least 4 times in the last month yes/no). Non-significant explanatory variables were sequentially removed if the lowest F-statistic was <4. The standardised residuals for this final model of 25(OH)D had a mean of zero and were within +/- 2 standard deviations of the mean.

Results

The blood serum 25(OH)D status of the participants in this study ranged from 17 to 128 nmol/L in winter (mean 59 nmol/L) and 16 to 130 nmol/L in summer (mean 76 nmol/L). Gender differences (p=0.05) were observed between females (n=42) having a winter status range of 17 to 142 nmol/L (mean 60 nmol/L) while males, for the same season had values ranging from 19 to 147 (mean 72nmol/L). Similarly in summer, females had a lower 25(OH)D status then males (p=0.001) with a mean of 71.6 nmol/L (range 12 to 109 nmol/L) compared to the males mean of 85 nmol/L (range 52-130 nmol/L). Body mass index and serum intact parathyroid hormone serum was negatively correlated with 25(OH)D status (-0.323 p=0.05 and -0.312 p=0.015 respectively). Figure 1 (below) shows the summer and winter comparisons of the study cohort.

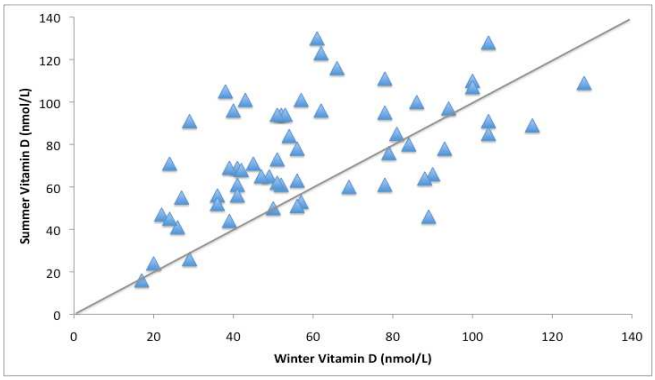

Figure 1. Relationship between vitamin D status in summer versus winter.

No significant relationships were found between self reported time outdoors in the sun and 25(OH)D status both for the summer and winter seasons. This included the total time in the sun and also time spent outdoors in hourly time intervals. Summer 25(OH)D status was positively correlated (p=0.003) with sunscreen use whilst in winter no similar relationships were found.

Melanin density was calculated using measurements of skin spectral reflectance. The change from winter to summer in values located at a high UV exposure site, in this case the forehead was used to estimate the tanning response of an individual. A positive correlation between seasonal changes in forehead melanin density (winter to summer) was found for 25(OH)D status (0.417 p=0.001). The amount (expressed as a percent) of skin exposed caused an increase in 25(OH)D status by 0.703 nmol/L for every 1% increase in amount of skin exposed.

The model could explain 31% of the variation in the change of serum 25(OH)D concentrations over this summer-winter period (adjusted R2 0.306).

Discussion

The data presented suggest that the relative ranking of Vitamin D from summer to winter changes for a population based in SE Queensland. Interestingly, for some individuals who have high winter Vitamin D status, they can, move to a low summer Vitamin D status. The results indicate that little is understood of the determinants on seasonal Vitamin D status on an individual and population based level. Further investigations into the role sun exposure, skin type and genetic factors involved in seasonal Vitamin D status is warranted.

References

Holick MF (2004a) Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers and cardiovascular disease. *Am J Clin Nutr*, 80(6S):1678S-88S.

WHO, World Health Organisation, International Agency for Research on Cancer (2008) *Vitamin D and Cancer*. IARC Working Group Reports volume 5.

Webb AR, de Costa BR, Holick MF (1989). Sunlight regulates the cutaneous production of Vitamin D3 by causing its photodegradation. *J Clin Endocrinol Metab*, 68:882-887.

Holick MF. (2004b) Vitamin D: Important for bone health and prevention of chronic diseases. *Osteoporos Int*; 5:S1-S1 Suppl.

Nakamura K, Nashimoto M and Yamamoto M (2000) Summer/winter differences in the serum 25-hydroxyvitamin D3 and parathyroid hormone levels of Japanese women. *Int J Biometeorol* 44(4), 186-189.