Seasonality of vitamin D status in older people in Southern Germany: implications for assessment

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Abstract

Background: from a clinical and public health perspective, it is important to understand the influence of seasonality on the serum vitamin D level to adequately assess and interpret an individual measurement. Therefore, the aim of this study was to analyse the effects of seasonal conditions on 25-hydroxyvitamin D (25(OH)D) serum levels in a population-based cohort of older people.

Methods: between March 2009 and April 2010 the 25(OH)D serum level was assessed in 1,418 community-dwelling individuals living in Germany aged ≥65 years (56.7% men) with no subscribed vitamin D supplementation. Least-square means of monthly 25(OH)D serum levels with 95% confidence intervals (CI) were estimated, adjusted for gender, age and body mass index. Additionally, the proportion of vitamin deficiency (<20 ng/ml), insufficiency (20–<30 ng/ml) and sufficiency (30 ng/ml or higher) were estimated for each month. Finally, mean values of daily total global solar radiation and daylight were calculated for each month.

Results: the minimum 25(OH)D serum level was observed in March with 15.4 ng/ml (SD = 6.56 ng/ml) and the maximum in August with 25.6 ng/ml (SD = 6.59 ng/ml). Compared with daylight and global solar radiation the progression over the year was similar but delayed by 2 months. The proportion of vitamin D deficiency, insufficiency and sufficiency were 78.8, 19.2 and 1.9% in March and 16.1, 63.4 and 20.5% in August, respectively.

Conclusion: vitamin D insufficiency was very common in this cohort and showed a strong seasonal effect with lowest values in March.

Keywords: season, daylight, global solar radiation, vitamin D, older people
Introduction

The vitamin D serum level is inversely associated with musculoskeletal health and other health outcomes such as cardiovascular disease and cancer [1, 2]. In Europe the main source of vitamin D is the sunlight exposure of unprotected skin [3]. The effective ultraviolet solar radiation varies throughout the year due to changes in daylight and zenith angle, depending on the latitude of residence [4]. During the winter months the zenith angle of sunlight increases on the Northern hemisphere. This also increases the filtering of the ozone layer and decreases the UVB radiation. Consequently, the photosynthesis of provitamin D3 due to outdoor activities is of little clinical significance in Central Europe between October and March [4]. From a clinical perspective, it is important to understand the effect of seasonality on the serum vitamin D level to adequately assess and interpret an individual measurement and its implications, but also to assure comparability among studies.

The aim of this study was to analyse the association of seasonal conditions on 25-hydroxyvitamin D (25(OH)D) serum levels, the most appropriate measure of defining vitamin D status, in a population-based cohort of older people in Southern Germany.

Methods

The Activity and Function in the Elderly in Ulm (ActiFE Ulm) study is a population-based cohort study in subjects aged ≥65 years located in Germany (48.4°N) [5, 6]. It was approved by the ethical committee of Ulm University. In brief, between March 2009 and April 2010, 1,506 community-dwelling individuals underwent a baseline assessment. People living in nursing homes or residential care were excluded. Among others blood was drawn under standardized conditions and measured in a blinded fashion. Each subject contributed one blood sample during the observation period. The 25(OH)D serum level (ng/ml) was measured by an ElectroChemilumineszenz ImmunoAssay (ECLIA) on a Roche E 2010 (inter-assay CV 4.96–5.43%). This method was standardized against Liquid chromatography-tandem mass spectrometry (LC-MS/MS), and LC-MS/MS again was standardized against Liquid chromatography-tandem mass spectrometry (LC-MS/MS). A mean of seasonality on the serum vitamin D level to adequately assess and interpret an individual measurement and its implications, but also to assure comparability among studies.

The present results of this cross-sectional study demonstrate a strong relationship between season and 25(OH)D serum levels. The progression of 25(OH)D serum levels seems to go in line with global solar radiation and daylight duration with a lag-time of 6 to 8 weeks. The lowest values were seen in March—therefore probably a good time to assess the serum levels of individuals and the degree of a

Table 1. Characteristics of study population (n = 1,418)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Men, n (%)</td>
<td>821 (57.9)</td>
</tr>
<tr>
<td>Age (years), mean (SD)</td>
<td>75.5 (6.57)</td>
</tr>
<tr>
<td>Duration of school education (years), median (Q1–Q3)</td>
<td>8 (6–11)</td>
</tr>
<tr>
<td>Mini Mental State Examination &lt;25, n (%)</td>
<td>72 (5.5)</td>
</tr>
<tr>
<td>Body mass index (kg/m²), mean (SD)</td>
<td>27.6 (5.16)</td>
</tr>
<tr>
<td>≥30 kg/m², n (%)</td>
<td>342 (24.1)</td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>136 (9.2)</td>
</tr>
<tr>
<td>Self-reported history of co-morbidity, n (%)</td>
<td>760 (53.6)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>124 (8.7)</td>
</tr>
<tr>
<td>Myocardial infarct</td>
<td>207 (14.6)</td>
</tr>
<tr>
<td>Heart failure</td>
<td>41 (2.9)</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>194 (13.7)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>83 (5.9)</td>
</tr>
<tr>
<td>Neurological disease</td>
<td>20.1 (7.59)</td>
</tr>
</tbody>
</table>

Results

The study population consisted of 1,418 subject [57.9% men, mean age = 75.5 (SD = 6.57) years, range = 65 to 91 years] with complete measurements on the 25(OH)D serum level and no prescribed vitamin D supplements (Table 1). An average 25(OH)D serum level was 20.1 ng/ml (SD = 7.59 ng/ml). In total, 24.1% of participants were obese, 9.2% were current smokers.

Figure 1 shows the mean 25(OH)D serum levels for each month after adjustment for gender, age and BMI. The minimum value was observed in March with 15.4 ng/ml (SD = 6.56 ng/ml) and the maximum in August with 25.6 ng/ml (SD = 6.59 ng/ml). The proportion of vitamin D deficiency, insufficiency and sufficiency were 78.8, 19.2 and 1.9% in March and 61.6, 36.3 and 20.5% in August, respectively. The progression of daylight and global solar radiation over the year was nearly identical but shifted compared with vitamin D by 2 months with a natural maximum in June (mid-summer) and a minimum in December (mid-winter). In contrast, the maximum of average daily temperature was shifted towards August [the peak months of 25(OH)D serum levels] and the minimum towards January [2 months before the nadir of 25(OH)D serum levels].

Discussion

The present results of this cross-sectional study demonstrate a strong relationship between season and 25(OH)D serum levels. The progression of 25(OH)D serum levels seems to go in line with global solar radiation and daylight duration with a lag-time of 6 to 8 weeks. The lowest values were seen in March—therefore probably a good time to assess the serum levels of individuals and the degree of a
potential undersupply. Nevertheless, showing strong seasonal differences with respect to 25(OH)D serum levels, the majority of the elderly subjects had levels far below the recommended threshold and would need supplementation throughout the whole year.

According to a review by Holick et al. and recommendations by the Endocrine Society summarizing the results of several studies from the USA and Europe, between 20 and 100% of elderly community-dwelling subjects are vitamin D deficient [1, 8, 9]. As skin exposure to sunlight is the main source of vitamin D in humans, the time frame of vitamin D assessment and the latitude of residence have to be considered when interpreting results from epidemiological studies. International recommendations do not consider these seasonal patterns, yet [10]. It is very likely that a person with just sufficient vitamin D serum levels in August may well be deficient in March. For the assessment of the overall burden of affected subjects in a specific population, as well as for the investigation of potential subsequent health consequences, seasonality has to be taken into account. In our study, we saw a decline of 25(OH)D serum levels of almost 40% from August to March in the overall population. The patterns are similar to the study results of Romero-Ortuno et al. [11] conducted in Irish older people (living at 53°North) who visited an outpatient clinic. The implications of these different serum levels for the supplementation strategy are not clear yet and may need more investigation.

Although short but frequent exposure to sunlight in the mid-day hours are able to increase the vitamin D status during the summer, as demonstrated in middle aged subject [12], it is certainly not possible to reach a sufficient vitamin D level only by sunlight exposure for the majority of the older population. A study from Australia conducted in adults aged <60 years (living between 27° and 43°South) found that less than a fifth of the variation of 25(OH)D serum levels were explained by season and latitude [13], and personal factors such as outdoor activity and clothing behaviour should also be considered. This may hold true especially for older people, who may spent even less time outside and also suffer additional mobility restrictions. Furthermore, ageing is associated with a decreased

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**Figure 1.** Effect of total global solar radiation and daylight on monthly serum levels of 25-hydroxyvitamin D after adjustment for gender, age, and BMI as well as vitamin D status in community-dwelling individuals aged ≥65 years living in Germany assessed between March 2009 and April 2010. Subjects with prescribed vitamin D supplements were excluded.
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concentration of the precursor of vitamin D3 in the skin, which puts older people at a particular high risk of vitamin D deficiency [14]. As our data imply for most of the subjects an increased sunlight exposure is probably only part of the solution. However, it may be of additional value especially in late spring, summer and early fall.

The following limitations should be considered: global radiation is only an indirect marker of UVB radiation, which has much greater seasonal variations. However, the association between global radiation and 25(OH)D serum levels was consistent. We had no information on the dietary habits. However, in Europe nearly no foods are fortified with vitamin D and diet seems to be constant during the whole year in developed countries with constant food supply over the year. In addition, we only had one spot measurement for each participant. Serial measurements over the year would be an added value and future studies may also consider individual minima and maxima of vitamin D over a season as risk factor for the various outcomes. Our study has also several strengths: we included a large sample of community-dwelling older people, a special population with high medical needs, and obtained measurements over 1 year. Furthermore, 25(OH)D values were adjusted for gender, age and BMI and subjects with prescribed vitamin D supplements were excluded [15].

In conclusion, vitamin D insufficiency was very common in our cohort and showed a strong seasonal effect with the lowest values in March. However, even in August a sufficient vitamin D level was achieved only by one-fifth of the older population in Southern Germany. These seasonal variations should be considered when measuring vitamin D serum levels and may also have implications for current medical and dietary recommendations. Considering these strong seasonal differences, supplementation seems to be necessary in older populations over the whole year, especially from February to May.

Key points

- Vitamin D shows a strong seasonality with lowest values in March.
- Even in August with maximum vitamin D serum levels a sufficient supply was achieved only by one-fifth of the older population.
- Seasonal variations should be considered when measuring and reporting vitamin D serum levels.

Acknowledgement

The ActiFE Ulm study group consists of further members: H. Geiger, Department of Dermatology and Allergology; A. Lukas, Agaplesion Bethesda Clinic, Ulm; J. Stingl, Institute of Pharmacology of Natural Products and Clinical Pharmacology; M. Riepe, Division of Gerontopsychiatry, Department of Psychiatry and Psychotherapy II; L. Rudolph, Max-Planck Group for Stem Cell Research; K. Scharffetter-Kochanek, Department of Dermatology and Allergology; C. Schumann, Department of Internal Medicine II—Pneumology; J. M. Steinacker, Department of Internal Medicine II—Sports- and Rehabilitation Medicine; A. Ludolph, C. von Arnim, Department of Neurology; F. Herboldsheimer, G. Weimayr, Institute of Epidemiology and Medical Biometry. All Institutes are located at Ulm University.

Conflicts of interest

None declared.

Funding

The study was funded by a grant from the Ministry of Science, Research and Arts, State of Baden-Württemberg, Germany, as part of the Geriatric Competence Center, Ulm University. M.D. was supported by a ‘Forschungskolleg Geriatrie’ grant from the Robert Bosch Foundation, Stuttgart, Germany. None of the sources had any influence on the content.

References


Received 21 November 2012; accepted in revised form 6 February 2013