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Vitamin D deficiency and nutritional status in elderly hospitalized subjects in Iceland

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Abstract

Objective: Poor nutrition and limited sunlight exposure (season) can be related to reduced serum 25-hydroxyvitamin D (25(OH)D) concentrations. Thus, elderly people in the Nordic countries might be at high risk for vitamin D deficiency. The aims of the study were to describe the prevalence of vitamin D deficiency in elderly hospitalized patients in Reykjavik, Iceland, and to investigate the effects of nutritional status and season on serum 25(OH)D.
Design: Cross-sectional study. Nutritional status was assessed and fasting blood was drawn and analysed for serum 25(OH)D and other clinical routine measurements.
Setting: Departments of Geriatrics, Landspitali-University Hospital, Reykjavik, Iceland.
Subjects: Sixty hospitalized patients (mean age 83·0 (SD 7·9) years) were randomly assigned.
Results: Of the patients, 12·3 % suffered from vitamin D deficiency (serum 25(OH)D < 25 nmol/l) and 71·9 % suffered from hypovitaminosis D (serum 25(OH)D = 25–75 nmol/l). There were no significant effects of gender or nutritional status on serum 25(OH)D. Anthropometric variables correlated significantly with serum 25(OH)D, but on stepwise linear regression modelling for the prediction of serum 25(OH)D, BMI remained the only predictor variable ($B = -1{\cdot}454$, 95 % CI −2·535, −0·373, $P = 0{\cdot}009$).
Conclusions: BMI was significantly negatively associated with serum 25(OH)D in hospitalized elderly patients. Neither nutritional status nor season significantly affected serum 25(OH)D in our patient group. Higher levels of serum 25(OH)D in elderly subjects with lower BMI are most likely explained by volume of distribution rather than by mobilization of vitamin D from its storage in adipose tissue due to age and disease-related catabolism.

Keywords
Serum 25-hydroxyvitamin D
Elderly patients
Nutritional status

Because of changes that occur with ageing, older people are likely to have inadequate stores of vitamin D. Issues such as reduced intestinal absorption[1], inadequate diet, reduced sunlight exposure due to frailty, physiological changes associated with ageing, polypharmacy and diseases that interfere with vitamin D metabolism contribute to this risk[2]. Nutritional status measured by a comprehensive nutritional assessment has been found to be significantly associated with vitamin D deficiency (serum 25-hydroxyvitamin D (25(OH)D) concentrations)[3,4]. Multiple studies have estimated the prevalence of vitamin D deficiency in various elderly populations to be between 25 % and >80 %[5–9].

The importance of vitamin D deficiency is related primarily to bone integrity and muscle strength, especially in the lower extremities. Because vitamin D is required for Ca homeostasis, secondary hyperparathyroidism may develop in patients with vitamin D deficiency. With increasing severity of vitamin D deficiency and secondary hyperparathyroidism, patients progress from states of increased bone turnover and decreased bone mass to states of impaired, and ultimately absent, mineralization with generalized osteomalacia[10]. Considering that receptors for vitamin D exist in a large number of different cells, among them cardiomyocytes, vascular endothelial cells and immune cells, and the inverse associations of vitamin D with heart disease, hypertension and type 2 diabetes, makes vitamin D insufficiency (hypovitaminosis D) an even more important health issue[11].

McKenna[6] has summarized a large number of studies from North America and Europe on vitamin D status in elderly subjects. Healthy elderly subjects had mean 25(OH)D concentrations in the insufficiency range throughout the year. In institutionalized subjects, most 25(OH)D concentrations were in the deficiency range.

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In Iceland, 25·1 % of those older than 80 years are institutionalized in nursing homes or geriatric departments (year 2007)[12]. Because solar UVB is the major source of vitamin D in man, it can be hypothesized that institutionalized elderly people in the Nordic countries are at especially high risk for vitamin D deficiency. The winter months in these countries are characterized by few or no hours of sunlight per day. In order to gain more knowledge on vitamin D status in the elderly, the present study aimed to investigate hospitalized elderly persons from a Nordic population (Reykjavik, Iceland; latitude 64°4′N) and determine: (i) the prevalence of vitamin D deficiency in these subjects; (ii) the possible associations between serum 25(OH)D and nutritional status; and (iii) predictors of serum 25(OH)D using multiple regression analysis.

Experimental methods

Subjects

Sixty hospitalized long-stay patients with multiple morbid conditions from the Departments of Geriatrics were randomly assigned to participate in the study in the period from June 2002 to March 2003. The patients were cognitively intact but had multiple diseases and medications at the same time. Typically the main diagnoses were fractures such as hip fractures, chronic obstructive lung disease, heart failure and strokes. Frequently, patients suffered from infections such as urinary tract infection or pneumonia. The subjects represent typical patients within a geriatric hospital department for the non-demented. This cohort was originally used to compare various nutritional assessment tools[13]. Power calculations done for the present analysis showed that the standard deviation of serum 25(OH)D of 22 nmol/l allowed detection of differences between groups of 16 nmol/l or more (power = 0·8, $P < 0{\cdot}05$). The inclusion criterion was age >65 years; exclusion criteria were severe cognitive impairment and failure to provide written consent for study participation. The study protocol was approved by the Local Ethical Committee of Landspitali-University Hospital in Reykjavik, Iceland, where the study was conducted.

Assessment of nutritional status

Full nutritional assessment, as used previously in various patient groups[13,14], included seven variables: BMI (kg/m^2), information on unplanned weight loss, triceps skinfold thickness, mid-arm muscle circumference, serum albumin, serum prealbumin and total lymphocyte count, all of which are variables associated with malnutrition and clinical outcomes such as duration of hospital stay and mortality, and are therefore accepted as indicators of nutritional status[13,14]. Patients were defined as malnourished when at least three of the seven parameters were below reference values. The lower reference value for BMI was 20 kg/m^2. Reference values for skinfold thickness and mid-arm muscle circumference were derived from the 5th percentile of the National Health and Nutrition Examination Survey (1971–4) population, standardized for age and sex. Unplanned weight loss was defined as weight loss of >5 % without intention in the three previous months. Reference values for this age group used by the hospital laboratory were 31–51 g/l for serum albumin, 180–450 mg/l for serum prealbumin and $1{\cdot}82 \times 10^9$/l for total lymphocyte count. Subjects were grouped accordingly as well-nourished or malnourished.

Measurements and analytical methods

The patients were asked their height and weight was measured in the hospital using standardized scales, from which BMI was calculated. The patients were also asked about nutritional issues (e.g. loss of appetite). Mid-arm circumference (MAC) was measured using a tape measure and triceps skinfold thickness was measured with skinfold callipers. These measurements were used to calculate mid-arm muscle circumference (MAMC) as follows: MAMC = MAC $- \pi \times$ skinfold thickness. Blood samples were drawn after an overnight fast and analysed for lymphocytes, albumin, prealbumin, serum 25(OH)D concentration, blood lipids and serum creatinine at the laboratory of Landspitali-University Hospital in Reykjavik. Lymphocytes were measured by a Coulter STKS (Coulter Electronics Ltd, Hialeah, FL, USA) and by volume–conductivity scatter. Serum albumin was measured by the Kodak Ektachem colorimetric test (Eastman Kodak Co., Rochester, NY, USA). Serum prealbumin was measured by the Beckmann (Munich, Germany) prealbumin reagent test using rate nephelometry. Creatinine was measured by standard dry chemistry methodology on a Vitros 750 XRC 700 analyser (Johnson & Johnson Co., Rochester, NY, USA). 25(OH)D levels were measured using RIA (DiaSorin, Stillwater, MN, USA). Inter-assay variations were 6·9 % and 8·5 % for serum 25(OH)D levels of 37 and 127 nmol/l, respectively. Subjects were grouped into vitamin D deficiency (25(OH)D < 25 nmol/l), hypovitaminosis D (25(OH)D = 25–75 nmol/l) or normal vitamin D (25(OH)D ≥ 75 nmol/l)[15].

Statistical analysis

The data were analysed using the SPSS statistical software package version 11·0 (SPSS Inc., Chicago, IL, USA). Data are described as means and standard deviations. Distributions of all continuous variables were normal according to the Kolmogorov–Smirnov test. Differences between groups (e.g. well-/malnourished, female/male) were calculated using the independent-samples *t* test. Correlations between variables were calculated using the Pearson correlation coefficient (*r*). In order to determine the variables predicting serum 25(OH)D, stepwise linear regression analysis was done. Gender, season and variables which were associated ($P < 0{\cdot}1$) with serum 25(OH)D in the bivariate analysis were used in the regression model.

If independent variables correlated with each other, the one which correlated most strongly with serum 25(OH)D was used in the regression analysis. Residuals were checked for normality using the Kolmogorov–Smirnov test. $P < 0{\cdot}05$ was regarded as statistically significant.

Results

Mean serum 25(OH)D was 50·6 (SD 22·5) nmol/l (minimum 11·9 nmol/l, maximum 97·3 nmol/l). Of the patients, 12·3 % suffered from vitamin D deficiency, 71·9 % suffered from hypovitaminosis D and 15·8 % were in the normal range. Vitamin D concentrations in patients grouped by nutritional status, season, unplanned weight loss and loss of appetite can be seen in Table 1.

The mean age of the patients was 83·0 (SD 7·9) years. Malnourishment was diagnosed for thirty-five patients (58·3 %) by full nutritional assessment. Malnourished patients had lower BMI, serum albumin, prealbumin, triceps skinfold thickness and mid-arm muscle circumference and were older than well-nourished patients. Only one patient had received enteral or parenteral nutrition, respectively.

The length of hospitalization was very variable (range 3–638 d) and not significantly different between subjects with vitamin D deficiency, hypovitaminosis D or normal vitamin D status (125 (SD 152), 80 (SD 64) and 120 (SD 141) d, respectively; $P > 0{\cdot}05$). Serum 25(OH)D correlated or tended to correlate with anthropometric variables and HDL cholesterol (Table 2).

Regression analysis was performed with serum 25(OH)D as the dependent variable and the following independent variables: gender, season, glomerular filtration rate, loss of appetite and BMI. HDL cholesterol was not entered because it correlated not only with serum 25(OH)D, but also with BMI (collinearity problem). Only BMI remained a significant predictor (Fig. 1) after adjustment for these factors. R^2 was 11·7 % and the residuals were normally distributed ($P = 0{\cdot}908$).

Table 1 Serum 25-hydroxyvitamin D (25(OH)D) concentrations in elderly hospitalized patients (*n* 60), Reykjavik, Iceland, 2002–3

	25(OH)D (nmol/l)		
	Mean	SD	*P* value*
Male (*n* 22; 36·7 %)	50·0	22·2	0·869
Female (*n* 38; 63·3 %)	51·0	23·0	
Well-nourished (*n* 25; 41·7 %)	46·4	21·5	0·217
Malnourished (*n* 35; 58·3 %)	53·9	23·0	
Summer season (*n* 26; 43·3 %)	55·0	24·1	0·093
Winter season (*n* 34; 56·7 %)	44·9	19·3	
Unplanned weight loss (*n* 17; 28·3 %)	51·5	25·3	0·858
No weight loss (*n* 43; 71·7 %)	50·3	21·6	
Loss of appetite (*n* 23; 38·3 %)	57·6	23·8	0·072
Good appetite (*n* 37; 61·7 %)	46·5	21·0	

*Independent-samples *t* test.

Discussion

The prevalence of vitamin D deficiency was 12·3 % and of hypovitaminosis D was 71·9 % in our group of elderly long-stay hospital patients in Iceland with a mean hospitalization length of 107 d. Because vitamin D status is related to bone health and is an important health factor, these findings underline the importance of targeted nutrition or vitamin D supplementation for disease prevention in elderly patients.

Table 2 Correlations* between serum 25-hydroxyvitamin D (25(OH)D) concentrations, anthropometric variables and blood lipids in elderly hospitalized patients (*n* 60), Reykjavik, Iceland, 2002–3

		25(OH)D (nmol/l) (range 11·9–97·3 mmol/l)
Age (years) (range 66–105) years	*r*	0·197
	P value	0·141
BMI (kg/m^2) (range 16·5–40·9 kg/m^2)	*r*	−0·342
	P value	0·009
MAMC (cm) (range 14·3–35·4 cm)	*r*	−0·319
	P value	0·016
Total cholesterol (mmol/l) (range 3·0–7·6 mmol/l)	*r*	0·020
	P value	0·883
HDL cholesterol (mmol/l) (range 0·67–3·03 mmol/l)	*r*	0·335
	P value	0·011
Days of hospitalization (range 3–638 d)	*r*	0·014
	P value	0·924

MAMC, mid-arm muscle circumference.
*Pearson correlation coefficient, *r*.

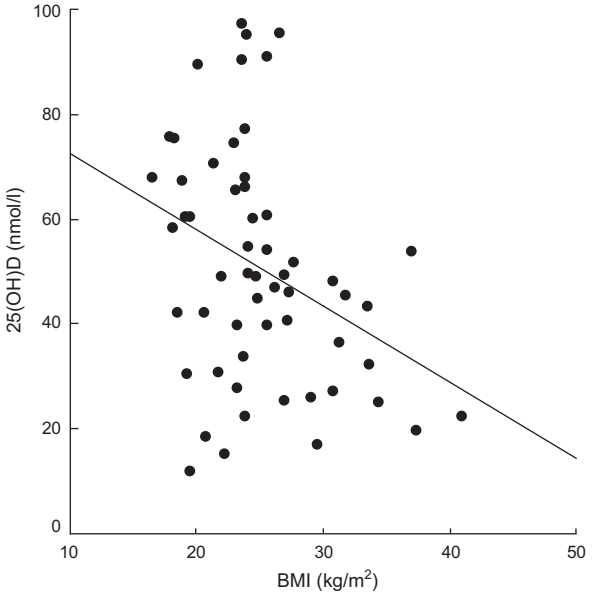

Fig. 1 Linear regression model for the prediction of serum 25-hydroxyvitamin D (25(OH)D) concentrations among elderly hospitalized patients (*n* 60), Reykjavik, Iceland, 2002–3 ($B = -1{\cdot}454$, 95 % CI −2·535, −0·373, $P = 0.009$; $R^2 = 11{\cdot}7$ %)

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It has been shown that serum 25(OH)D concentrations decrease progressively with advancing age[16,17]. Prevalence data from other studies on vitamin D deficiency in hospitalized patients range from 25% up to >80%, although direct comparison is difficult due to differences in the cut-off values used. In a US study, a high prevalence (57%) of vitamin D deficiency (cut-off value <37·5 nmol/l) was found in unselected general medical inpatients[4]. In an Italian study (cut-off value of 20·0 nmol/l), the highest prevalence of vitamin D deficiency was found in a group of patients engaged in long-term rehabilitation programmes, ranging from 57·8% in summer to 82·3% in winter[9]. This shows that the problem of vitamin D deficiency in patients in hospital in Iceland is more widespread than previously appreciated.

The mean 25(OH)D concentration was ~50 nmol/l in our patients, which is in good agreement with results from a recent Icelandic cross-sectional study (subjects aged 70–85 years) on vitamin D status based on the investigation of a random selection from the computerized population register of Reykjavik[18]. It is important to note that only two subjects of our group received enteral/parenteral nutrition. Such nutrition formula feeds include multivitamin solutions containing appropriate amounts of the vitamin. Considering the high latitude of Reykjavik (64°4′N) and the mean hospitalization length of 107 d, an even more adverse outcome could have been expected. In the SENECA study, a unexpectedly positive relationship between serum 25(OH)D and geographic latitude was observed in the elderly subjects. This paradox can be explained by different dietary and other lifestyle habits. Elderly people living in Scandinavia and South Europe seem to differ in their fatty fish consumption, use of vitamin supplements and frequency of sun exposure[19]. It is therefore possible that regular fish oil and fatty fish consumption in our subjects prevents a higher prevalence of vitamin D deficiency. According to the Icelandic National Dietary Survey of 2002[20], the mean daily fish consumption in elderly women and men is 47 and 65 g, respectively, and the mean daily fish oil intake is 2 g for both genders. Around two-thirds of the dietary vitamin D in Iceland is supplied by fish and fish oil. In the age group 70–80 years the mean vitamin D intake reaches 10·2 and 7·2 μg/d for men and women, respectively. The Nordic Nutrient Recommendations 2004 recommend 15 μg/d for both genders.

The difference in serum 25(OH)D between summer and winter seasons was small (~10 nmol/l) and not statistically significant in the present study, which lacked the power to determine whether such small differences were significant ($P = 0·093$). Seasonal differences in serum 25(OH)D are commonly seen[4,9,18], with twofold higher 25(OH)D concentrations after the summer than after the winter, but varying with various patient groups or study subjects[9]. Several reasons could be responsible for the absence of such variation in long-stay patients: (i) the lack of sunshine exposure accounts for the lack of seasonal variation in vitamin D status as has been reported previously[9]; (ii) summers in Iceland are often cold and windy, so that people remain fully dressed and the exposed skin area does not differ in summer from that in winter; and (iii) cod-liver oil might overwhelm the effects of seasonal variation in such a northern country. Cod-liver oil is offered daily along with breakfast at the Departments of Geriatrics although the intake is voluntary.

In the regression model BMI was the only significant predictor for serum 25(OH)D. According to the model, serum 25(OH)D decreased by ~1·5 nmol/l for each increase in BMI by 1 kg/m^2. However, the statistical model predicted only about 12% of the variability in serum 25(OH)D.

Although BMI is an indicator of nutritional status in the elderly in general, we observed a negative association between serum 25(OH)D and BMI. Such negative associations have been observed in obese individuals[21,22] and we did not expect to see that negative association in our group because only 16·7% of the subjects were obese. The aetiology of reduced serum 25(OH)D in the obese is unknown although various explanations for this observation have been proposed, including decreased sun exposure of obese individuals, increased volume of distribution and physiological adaptation to the need for more bone mass to support the increased weight. The true clinical significance of these abnormalities is unknown[23–25]. It has been reported that poorer vitamin D status does not appear to be due to differences in dietary intake in the elderly, although reduced absorption of dietary vitamin D has been reported in this group[26]. The former suggestion is supported by our finding that patients with loss of appetite did not have lower serum 25(OH)D than patients with good appetite. In our group malnourished subjects tended to have higher serum 25(OH)D than their counterparts. Thus, the higher serum 25(OH)D in subjects with lower BMI in our group might indicate mobilization of vitamin D from its stores due to age and disease-related catabolism. This hypothesis is supported by an animal study (Wistar rats), in which the effects of feeding and fasting on circulating 25(OH)D were investigated. Fasting caused increased plasma NEFA, weight loss and raised plasma 25(OH)D in comparison to animals in energy balance[27]. However, our patients who had experienced unintended weight loss did not have higher serum 25(OH)D than patients without previous weight loss, thus indicating that not catabolism but rather volume of distribution plays a significant part in determining serum 25(OH)D concentrations.

Limitations

In the present study we did not measure dietary or supplemental vitamin D intake of the subjects and we cannot therefore investigate the effect of dietary vitamin D on serum 25(OH)D concentrations. However, because only

two subjects had received enteral/parenteral nutrition, the majority of the subjects received the same food from the hospital canteen. The sample size limits the power to detect possible effects of season on serum 25(OH)D levels.

Conclusion

The prevalence of vitamin D deficiency was 12·3 % and of hypovitaminosis D was 71·9 % in our group of hospitalized elderly patients from an Icelandic hospital with a mean hospitalization length of 107 d. BMI was significantly negatively associated with serum 25(OH)D in these elderly patients. Higher concentrations of serum 25(OH)D in elderly subjects with lower BMI are most likely explained by lower volumes of distribution rather than by increased mobilization of vitamin D from storage.

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