Better knowledge on vitamin D and calcium in older people is associated with a higher serum vitamin D level and a higher daily dietary calcium intake

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Abstract

Objective: The objective of the present study was to examine knowledge on vitamin D and calcium in a cohort of older adults and to test the association between health knowledge, vitamin D status and dietary calcium intake.

Methods: The participants of this cross-sectional survey consisted of 426 individuals (≥ 65 years), living in residential homes. Participants were tested for their knowledge on vitamin D and calcium using a standardized questionnaire. Serum 25-hydroxyvitamin D_3 (25(OH)D_3) levels and dietary calcium intake were measured.

Results: The mean serum 25(OH)D_3 level was 39.1(± 21.4) nmol/l and the mean daily dietary calcium intake was 826 (± 242) mg/day. Of the participants, only 38% indicated that they knew or had heard of vitamin D. Participants overestimated their daily calcium intake. Better knowledge on vitamin D and calcium was associated with both higher vitamin D levels (P<.0001) and a higher daily dietary calcium intake (P<.0001).

Conclusion: Given the poor knowledge on vitamin D and calcium and the observed associations, improving health knowledge could be a possible intervention to improve vitamin D status and calcium intake in older people. Further studies are needed to assess whether education will indeed lead to improvement of vitamin D levels and calcium intake in this age group.

Key words: Geriatrics • Health Knowledge • Prevention • Calcium intake • Vitamin D_3

Introduction

Osteoporosis is a skeletal disease characterized by low bone mass and micro-architectural deterioration, which results in an increased bone fragility and fracture risk[1]. The incidence of osteoporosis increases with age[2]. Important risk factors for osteoporosis are vitamin D deficiency and a low dietary calcium intake[3]. Especially among older people, vitamin D deficiency and low dietary calcium intake are very common[4]. A possible contributing cause may be a lack of knowledge on vitamin D and calcium in this age group. Health knowledge, or literacy, is an essential requirement to allow people to make health-conscious decisions. Older people are a high risk group for low health literacy[5]. Data on knowledge among the general public, and older people in particular, about vitamin D and calcium is scarce. Studies that have been conducted are generally telephone- or online-surveys among relatively young individuals[6-8]. To our knowledge, no study has specifically evaluated knowledge on vitamin D and calcium among older people or, examined the association between knowledge, vitamin D status and calcium intake.

In order to gain more insight in the effect of health literacy in this age group, we tested the possible association between health knowledge, vitamin D status, and dietary calcium intake in a cohort of older persons.

Methods

Study participants

We performed a cross-sectional study among older people living in residential homes. Inclusion criteria were: no diagnosis of dementia (medical history) and aged 65 years and older. The study was approved by the Medical Ethics Committee of the Erasmus MC University Medical Center (MEC-2007-160). Written informed consent was obtained from all participants.

Baseline characteristics

Participants underwent a clinical assessment including medical history, biography, current physical complaints, and medication-use including supplements. Information on co-morbidities was obtained from the record of the residential home (physician) and this was cross-checked with information of the general practitioner. Cognitive functioning was assessed using the Dutch *v*ersion of the Mini-Mental State Examination, with a score ranging from 0 points (poor cognitive functioning) to 30 points (good cognitive functioning)[9]. Dietary food intake was assessed using a 24-h dietary recall questionnaire. Calcium intake in milligrams per day was calculated using the Dutch National Food Composition Table[10]. In a randomly selected subgroup (~25%) the 24-h recall dietary assessment was repeated within several weeks after the initial visit. The correlation between the two measurements was 0.56, suggesting a moderate day-to-day variation, comparable with other reports[11]. Serum 25(OH)D_3 levels (in nmol/l) of all participants were measured using a radio-immuno-assay (DiaSorin, Stillwater, MN, USA).

Testing of knowledge on vitamin D and calcium

Participants were asked about their knowledge on vitamin D and calcium during a structured face-to-face interview by the principal investigator (CO). The questions asked are shown in **Addendum 1**. Participants who reported knowing vitamin D (positive response on either question 1 (unprompted) or 2 (prompted)), were considered most knowledgeable on vitamin D (D+). Participants who responded negatively on both questions 1 and 2 were considered least knowledgeable on vitamin D (D-). Participants were considered most knowledgeable on calcium (Ca+) when they answered questions 2, 3 and 5 correctly (**Addendum 1**). Participants who did not answer these three questions correctly were considered least knowledgeable on calcium (Ca-).

Statistical analysis

Population characteristics were reported as mean ± SD. Baseline differences between the two groups (most or least knowledge) were tested using an independent t-test for normally distributed variables (age, gender and MMSE score) and the Mann-Whitney test for skewed variables (calcium intake and serum 25(OH)D_3 level). Secondly, the association between knowledge and vitamin D status and calcium intake was tested using linear regression analysis. To account for potential confounding, we computed a multi-variate model containing covariates that were considered biologically plausible (age, gender, education and MMSE score) or changed the point estimate 10% or more (none). Serum 25(OH)D_3 level and dietary calcium intake were natural log-transformed given their skewed distributions.

All statistical analyses were performed using SPSS software (version 16.1.1; SPSS Inc., Chicago, Illinois). $P < .05$ was considered statistically significant.

Results

In total 460 individuals met the inclusion criteria and of those, 426 (93%) consented. The mean age of the participants was 81.0 years (± 7.2), and 73% were female. Further population characteristics are shown in **Table 1**. The mean (± SD) serum 25(OH)D_3 level was 39.1 (± 21.4) nmol/l. Of the participants, 285 (67%) had 25(OH)D_3 serum levels < 50 nmol/l and 115 (27%) had serum levels < 25 nmol/l. The mean calcium intake was 826 (± 242) mg/day. A total of 132 (31%) participants had a calcium intake of < 700 mg/day and 77 (18%) had a calcium intake of > 1,200 mg/day.

Knowledge on vitamin D and calcium is shown in **Table 2**. Of the 426 participants, 106 reported knowing vitamin D without prompting and 55 reported knowing vitamin D after a prompt (total: n = 161/426; 38%). Dietary products were considered as most important source (n = 96; 60%). All participants (n = 426; 100%) had heard of calcium. A total number of 351 (82%) participants knew that calcium is important for bone health and 329 (77%) knew that dairy products are the main dietary source for calcium. The interrelation between estimated calcium intake and measured dietary calcium intake is shown in **Table 3**.

In total 161 (38%) participants were regarded most knowledgeable on vitamin D (D+). Likewise, 104 (24%) participants were considered most knowledgeable on calcium. The association between health knowledge and vitamin D status or calcium intake is shown in **Figure 1**. Participants in the group D+ had a mean serum 25(OH)D_3 level of 58.5 (± 17.7) nmol/l, in the group D- this was 27.4 (± 13.5) nmol/l (P<.0001) respectively. Among the participants that were considered D+, those who knew the advice of the Dutch Health Council on vitamin D had the highest serum 25(OH)D_3 levels (mean: 67.4 ± 16.5 nmol/l). The dietary calcium intake in the Ca+

group (1003 (± 208) mg/day) was significantly higher ($p<.0001$) compared to the Ca- group (769 (± 225) mg/day). Both the association between knowledge on vitamin D and serum $25(OH)D_3$ levels and the association between knowledge on calcium and the daily dietary calcium intake remained significant after exclusion of people that used either vitamin D and/or calcium supplementation. For both knowledge on vitamin D and knowledge on calcium, no association was observed with MMSE score or total years of education.

Table 4 shows the regression model of the association between health knowledge and vitamin D status and calcium intake. After adjustment for possible confounders the associations between health knowledge and the health outcomes remained significant.

Discussion

The associations between health knowledge and serum 25(OH)D_3 levels and dietary calcium were examined in a cohort of older persons. We demonstrated that better knowledge on vitamin D and calcium was associated with both higher 25(OH)D_3 levels and a higher daily dietary calcium intake. Only a third of the participants were familiar with vitamin D and knowledge of sources and effects of vitamin D was poor. The importance of calcium for bone health was generally well known, but most participants were falsely under the impression that their dietary calcium intake was sufficient.

Participants with the most knowledge on vitamin D (D+) had a serum 25(OH)D_3 level of 58.5 nmol/l, roughly twice as high as participants that had the least knowledge on vitamin D. The observed mean serum 25(OH)D_3 level of 39.1 nmol/l is in accordance with previous reports on the vitamin D status of older people both from the Netherlands and other western countries[12-13]. In the Netherlands, serum 25(OH)D_3 levels of $\geq$ 50 nmol/l are currently recommended and in the United States levels of $\geq$ 75 nmol/l are advised[14-15].

The observed association was less outspoken for individuals with either the most or the least knowledge on calcium. Although higher, the mean dietary calcium intake of 1,003 mg/day in participants with the most knowledge on calcium (Ca+) was still below the recommended daily dietary calcium intake. The Dutch Health Council and the American Institute of Medicine currently recommend a daily calcium intake of 1,200 mg/day for individuals $\geq$ 70 years[15,16]. While low, the mean dietary calcium intake of 826 mg/day in this cohort is still higher than reported calcium intakes in older people in other countries such as England, France, the United States and Austria, illustrating the large regional and cultural variance in dietary calcium

intake[11,17-19]. A large study from the Netherlands in non-institutionalized older people reported a daily dietary calcium intake of up to 1,129 mg/day[20]. Possible explanations for the difference between the reported intakes in the study by Koek *et al*. and our study could be a difference in age and frailty between the studied participants.

The observed association between health- knowledge and vitamin D status and calcium intake in our study indicate a promising intervention possibility. Improving health knowledge in old age groups using guidance by health professionals has been shown to be beneficial in raising awareness of health concepts[21]. In addition, a study by Engels *et al.* in a cohort of older persons demonstrated that informing participants about vitamin D increased the intention to start using vitamin D supplements[22]. The intention to start supplements was especially high when patients received this advice from their own physician. In contrast, a recent study in young women found no effect of increasing knowledge on vitamin D and calcium on dietary intake of vitamin D or calcium[23]. Additionally, the interrelation between knowledge and behaviour can also be conflicting. For example, a previous study on sunlight and vitamin D revealed a conflict between knowledge and behaviour. Individuals who were best aware of the benefits of sunlight and the importance of vitamin D for bone health, tended to avoid sunlight most by using sunscreen and parasols, and staying indoors[24]. This illustrates that ideally the effect of increasing health knowledge needs to be tested in a randomized controlled trial to ascertain a possible effect on vitamin D status and calcium intake. Multi-disciplinary teaching groups, taking into account patients specific background and experiences could perhaps be an effective method[25].

Our study has several strengths. This is, to the best of our knowledge, the first study on knowledge about vitamin D and calcium that examined the participants' knowledge during a face-to-face interview with the use of standardized methods. This

is also the first study that assessed the interrelation of health knowledge with vitamin D status and calcium intake. Another strength of the present study is that participants were unaware of the study and its goals before the initial visit. Consequently, participants were not able to prepare themselves for any of the questions. Furthermore, the participation rate of the individuals that were asked to participate in this study was high (93%).

A limitation of the study is that because of the cross-sectional design, no causality can be concluded regarding the association between health knowledge and vitamin D status and/or calcium intake. For example, better knowledge in patients using vitamin D or calcium supplements could be due to the use itself rather than that participants with more health knowledge started using supplements. However, our finding remained significant after exclusion of participants that used vitamin D or calcium supplementation.

In conclusion, knowledge on vitamin D and calcium among this cohort older of older persons was poor and this may have contributed to the high prevalence of vitamin D deficiency and low dietary calcium intake in this age group. In view of the severe consequences of vitamin D deficiency in old age, we feel that it is important to better inform older persons about the role and necessity of vitamin D and calcium, and to improve knowledge on current guidelines and possible preventative measures. Further studies are however needed to assess whether education will indeed lead to improvement of vitamin D levels and calcium intake in this age group.

Conflict of interest statement

None of the authors had a personal or financial conflict of interests.

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CO: Study design, data acquisition & analysis, drafted paper; KH: Drafted paper, data analysis, critical revision; JvL: Interpretation of the data, critical revision, supervision, EC: Interpretation & statistical analysis, critical revision; NvdV: Data analysis & interpretation, critical revision; TvdC: Study design, critical revision, supervision.

Table 1. Characteristics of the study population

Characteristic	Participants (n = 426)	Range (min – max)
Age, yr	81.0 ± 7.2	65 – 103
Female, n (%)	315 (74%)	-
Education, yr	8.7 ± 3.1	1 – 20
MMSE score (points)	26.5 ± 2.6	20 – 30
Serum 25(OH)D_3 (nmol/l)	39.1 ± 21.4	65 – 103
Dietary calcium intake (mg/day)	826 ± 294	226 - 1345
Use of vitamin D/calcium prescribed, n (%)	51 (12%)	-
Use of vitamin D/calcium non-prescribed, n (%)	30 (7%)	-

Mean ± standard deviation (SD).

Table 2. Knowledge on vitamin D and calcium

Knowledge on vitamin D		Knowledge on calcium	
Having heard/learnt about vitamin D (n = 426)		**Having heard/learnt about calcium (n = 426)**	
Unprompted	106 (25%)	Positive response	426 (100%)
Prompted	55 (13%)	**Dietary sources of calcium (n = 426)**	
Sources of vitamin D (n = 161; 38%)		Dairy products	329 (77%)
Diet	96 (60%)	Meat	23 (5%)
Sun exposure	49 (30%)	Fruit	16 (4%)
Don't know sources of vitamin D / Other	16 (10%)	Don't know sources of calcium / Other	58 (14%)
Dietary sources of vitamin D (n = 96)		**Most important effect of calcium (n = 426)**	
Dairy products	42 (44%)	Bone health	351 (82%)
Fish	22 (23%)	Don't know the effects / Other	75 (18%)
Don't know any dietary sources / Other	32 (33%)	**Estimation of own calcium intake (n = 426)**	
Most important effect of vitamin D (n = 161)		Thinks calcium intake is sufficient	218 (51%)
Bone health	54 (34%)	Thinks calcium intake not sufficient	153 (36%)
Immunity	76 (47%)	Don't know	55 (13%)
Mobility/muscle strength/falls	22 (14%)	**Estimation of the recommended daily dietary calcium**	
Don't know the effects / Other	9 (5%)	**intake in mg/day for individuals aged ≥ 70 years (n = 426)**	
Advice of the Dutch health council on the			
prevention of vitamin D deficiency (n = 161)		< 700 mg	69 (16%)
Heard of the advice and named correct measure	23 (14%)	700 mg – 1200 mg	95 (22%)
Didn't hear of advice or named wrong measure	138 (86%)	> 1200 mg	107 (25%)
		Don't know	155 (36%)

Table 3. Interrelation between estimated calcium intake by participants and measured dietary calcium intake by 24-h recall

Estimated daily dietary calcium intake: n	**Measured daily dietary calcium intake n, (%)**	
< 700 mg/day: 52	< 700 mg/day	42
	700 – 1200 mg/day	8
	> 1200 mg/day	2
700-1200 mg/day: 89	< 700 mg/day	23
	700 – 1200 mg/day	44
	> 1200 mg/day	22
> 1200 mg/day: 138	< 700 mg/day	49
	700 – 1200 mg/day	71
	> 1200 mg/day	18

Table 4. Regression analysis of vitamin D status and calcium intake according to health knowledge

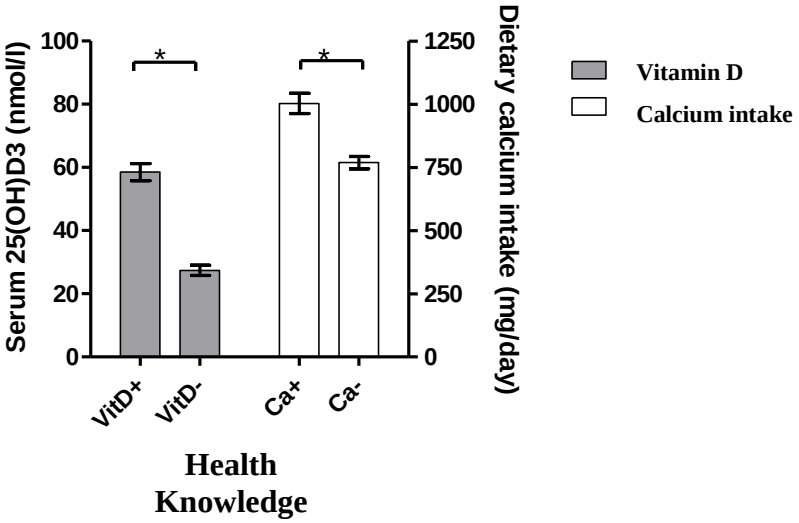
	Model 1			Model 2		
	B	SE	P-value	B	SE	P-value
Knowledge on vitamin D						
Serum 25(OH)D_3 level (nmol/l)*	0.837	0.049	<.0001	0.816	0.049	<.0001
Dietary calcium intake (mg/day)*	0.098	0.031	P = .002	0.075	0.031	P = 0.01
Knowledge on calcium						
Serum 25(OH)D_3 level (nmol/l)*	0.255	0.071	<.0001	0.254	0.07	<.0001
Dietary calcium intake (mg/day)*	0.288	0.032	<.0001	0.286	0.032	<.0001

Model 1: unadjusted.

Model 2: adjusted for: age, gender, years of education, MMSE score.

*Natural log-transformed.

Figure 1. Baseline association of knowledge on vitamin D and calcium with vitamin D status and dietary calcium intake



* p < .0001

Addendum 1. Questions asked

Knowledge on vitamin D

1. Name any vitamin you know
2. Do you know or have you heard of vitamin D (if not mentioned in question 1)?
3. Do you think your vitamin D status is sufficient?
4. What is the most important source of vitamin D?
5. Name dietary sources of vitamin D?
6. What is the most important effect of vitamin D?
7. Are you aware of the advice of the Dutch Health council regarding possible measures for the prevention of vitamin D deficiency?. If so, please name them.

Knowledge on calcium

1. Do you know or have you heard of calcium?
2. Name the most important dietary source of calcium?
3. What are the most important effects of calcium?
4. Do you think your dietary calcium intake is sufficient?
5. What is the daily recommended dietary calcium intake for individuals aged ≥ 70 years (in mg/day)?
6. Estimate your own daily dietary calcium intake (in mg/day).

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