The Journal of Nutrition, Health & Aging©
Volume 17, Number 7, 2013

VITAMIN D STATUS AMONG OLDER COMMUNITY DWELLING MEN LIVING IN A SUNNY COUNTRY AND ASSOCIATIONS WITH LIFESTYLE FACTORS: THE CONCORD HEALTH AND AGEING IN MEN PROJECT, SYDNEY, AUSTRALIA

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Abstract: *Objectives:* Inadequate vitamin D status (25-hydroxyvitamin D (25(OH)D) concentrations <50 nmol/L) is an increasingly important public health issue in Australia. The aim of this analysis is to describe 25(OH)D levels in community dwelling men aged ≥70 years in Sydney, Australia, and to determine associations between serum 25(OH)D levels and socioeconomic and lifestyle factors. *Design:* A population-based, cross-sectional analysis of the baseline phase of the Concord Health and Ageing in Men Project (CHAMP), a large epidemiological study conducted in Sydney between January 2005 and May 2007. *Participants:* 1659 non-institutionalised men aged ≥70 years. *Methods:* The cross-sectional analysis of the baseline phase of the Concord Health and Ageing in Men Project (CHAMP), a large epidemiological study conducted in Sydney between January 2005 and May 2007. Participants included 1659 community dwelling men who were interviewed and had clinical assessments. Main outcome measurements included serum 25(OH)D levels measured in blood samples using a radioimmunoassay kit (DiaSorin Inc., Stillwater, MN). Covariates included age, socioeconomic measures, season of blood sample, physical activity, sun exposure, vitamin D supplement use, cigarette smoking status, alcohol consumption, obesity and measures of health. *Results:* Prevalence of vitamin D insufficiency was 43.0%; highest in winter (55.5%) and spring (53.9%), and was associated with season (winter and spring), low physical activity, avoidance of sun exposure, current smoking and obesity, even after adjustment for confounding factors. *Conclusion:* Inadequate vitamin D status is highly prevalent among Australian older men and is associated with specific lifestyle factors. These findings emphasize the need to screen and monitor 25(OH)D levels in this population group, despite living in a sunny country such as Australia.

Key words: Inadequate vitamin D status, older men, Sydney, Australia, population study.

Introduction

Inadequate vitamin D status (25-hydroxyvitamin D (25(OH)D concentrations <50 nmol/L) is a widespread and re-emerging health problem globally (1, 2). A recent position statement on vitamin D and health highlights that low vitamin D status is a public health issue in Australia and New Zealand (3). The importance of vitamin D for bone health is well known. There is some evidence to suggest that poor vitamin D status increases the risk of a wide range of non-communicable diseases (4).

There is still no clear consensus on optimal 25(OH)D levels for human health (4-7). We used the definition of 'frank vitamin D deficiency' as levels <30 nmol/L and 'insufficiency' as levels <50 nmol/L according to the US Institute of Medicine (IOM) and the recent Australian position paper (3, 6).

Inadequate vitamin D status has been identified as a problem among older people living in residential care in Australia (8), but recent data on the prevalence of low vitamin D status among older men living in the community is lacking. A study among adults aged ≥25 years (mean age 48-49 years) who participated in the Australian Diabetes, Obesity and Lifestyle study (AusDiab) conducted in 1999/2000 (9), reported on vitamin D prevalence, but there were smaller numbers of older men aged 70 and over and the study did not investigate associations between vitamin D status and a broad range of lifestyle factors. Therefore, the aims of this current study were to: (a) evaluate the prevalence of 25(OH)D status in a large group of men aged ≥70 years living in the community, in Sydney, Australia; and (b) assess associations between vitamin D insufficiency and socioeconomic and lifestyle factors to help identify men at high risk of inadequate vitamin D status who would benefit most from vitamin D testing and supplementation.

Methods

Study Subjects

The Concord Health and Ageing in Men Project (CHAMP) is an epidemiological study of a wide range of health issues in Australian men aged 70 years and over (10).

Subject selection has been described in detail elsewhere (10). Briefly, CHAMP involves men living in a defined urban geographical region (the Local Government Areas of Burwood,

Received October 5, 2012
Accepted for publication November 20, 2012

Canada Bay and Strathfield) near Concord Hospital in Sydney, Australia. The sampling frame was the New South Wales Electoral Roll, on which registration is compulsory in Australia. The only exclusion criterion was living in a residential aged care facility. Eligible men were sent a letter describing the study and, if they had a listed telephone number, were telephoned about one week later. Of the 2815 men contacted, 1511 participated in the study (54%). An additional 194 men aged 70 years or older living in the study area volunteered to be in the study before receiving the invitation letter; these men had been told about the study by friends or read reports in newspapers.

Data collection

Baseline data were collected between January 2005 and June 2007. Men completed a questionnaire at home before coming to the study clinic at Concord Hospital. The clinic visit consisted of physical performance measures, biological measures, medication inventory and neuropsychological testing. Data were collected by fully trained staff, the same equipment was used for all measurements and assessments, which were carried out in a single clinic. Moreover, data entry was standardized and performed by a single qualified data-entry clerk. The quality of the data was checked using standard procedures of data management (i.e., data examination, data cleaning, and data analysis).

Measurements

Socioeconomic measures

Socioeconomic measures included occupation, source of income and education. Main lifetime occupation was dichotomised into professional and non-professional occupations. Source of income was categorized as reliant on a government pension only vs. other sources of income. Education status was classified as having a post school qualification vs. no post school qualification.

Lifestyle factors

Smoking status (never smoker, ex-smoker, current smoker) was assessed. Alcohol consumption was categorised as < 1 drink per week, 1-14 drinks /week, 15-28 drinks/week and 29+ drinks/week according to Australian alcohol guidelines (11).

Physical activity was measured using the Physical Activity Scale for the Elderly (PASE), a method that scores the level of physical activity in individuals aged 65 years or older (12). The total PASE score was computed by multiplying the amount of time spent in each activity (hours/week) or participation (yes/no) in an activity by empirically derived item weights and summing over all activities (12). In order to assess sun exposure, participants were asked the following questions: "How often do you go outside into the street or garden: Never or A few times a month or Weekly or Most days?" ''Do you avoid direct sunshine: Always or Usually or Never?" and "Have you had a suntan in the last 6 months: No or Slight tan or Obvious tan?" (13)

Height and weight were measured and body mass index (BMI) was calculated as kg/m^2 and categorised as underweight (less than 20), normal weight (20-24.9), overweight (25.0–29.9), and obese (30.0 or over). Total body fat, total body lean, and total body mass were measured by dual energy x-ray absorptiometry (DEXA) using a Discovery W scanner (Hologic Inc., Bedford, MA). All measurements were taken on the same machine using standardized procedures for participant positioning.

Vitamin D supplement use was coded as 'yes' if participants reported currently taking them. Supplements included ergocalciferol-D2, cholecalciferol-D3, alfacalcidol and Ostevit-D (providing 25 μg/1000 IU of vitamin D).

Health status

Data on self-rated health were obtained and dichotomized into excellent/good versus fair/poor/very poor. Data on medical conditions were obtained from the self-reported questionnaires in which participants reported whether a doctor or a health care provider had told them that they had any of the following diseases: diabetes, thyroid dysfunction, osteoporosis, Paget's disease, stroke, Parkinson's disease, epilepsy, hypertension, heart attack, angina, congestive heart failure, intermittent claudication, chronic obstructive lung disease, liver disease, cancer (excluding non melanoma skin cancers), osteoarthritis, and gout. For this study, medical conditions were dichotomised into having ≥ four health conditions versus < four health conditions.

A valid serum 25(OH)D sample was obtained from 97.3% (1659) of the total sample of men (1705 men) who participated in the study. Season of blood sampling was divided into summer (Dec-Feb), autumn (Mar-May), winter (Jun-Aug) and spring (Sept-Nov). Serum 25(OH)D was measured using a radioimmunoassay kit (DiaSorin Inc., Stillwater, MN). Sensitivity was measured at 4 nM, intra-assay precision was 7.6%, and interassay precision was 9.0%.

Statistical Analysis

Analysis was carried out using SPSS v19 and STATA v12. Descriptive characteristics were expressed as means (SD) and percentages. The proportions of men with serum 25(OH)D levels <30 nmol/L, 30.0-49.9 nmol/L, 50-74.9 nmol/L and 75 nmol/L and over were determined. The normality of the data was examined using graphical methods, as well as using the Shapiro-Wilk test. Logistic regression models were developed to examine associations between vitamin D insufficiency and possible risk factors. Unadjusted and adjusted odds ratios were calculated using the definition of vitamin D insufficiency of <50 nmol/L as the dependant variable (≥ 50 nmol/L as reference category). Independent variables were: age group, occupation, income, vitamin D supplement use, cigarette smoking status, alcohol intake, sun exposure, physical activity, BMI, body fat mass, and season. Univariate analysis was used to arrive at a final model that included significant (p<0.05) independent variables in the adjusted logistic regression analysis. Age was kept in the model regardless of statistical significance. Due to co linearity when including both body fat mass and BMI in the same multivariate model, adjustment was made by BMI only. Model 1 (Table 2) included adjustment by age group, season, physical activity level, sun exposure, BMI and cigarette smoking status (except when the variable was the independent variable). Associations between vitamin D insufficiency and lifestyle factors were in addition to the other variables in Model 1 also adjusted by self- rated general health and self reported medical conditions (Model 2, Table 2). The goodness of fit of all the final adjusted models was assessed using the Hosmer– Lemeshow statistic.

Ethics approval and informed consent

All participants gave written informed consent. The study was approved by the Sydney South West Area Health Service Human Research Ethics Committee, Concord Repatriation General Hospital, Sydney, Australia.

Table 1

Socioeconomic and lifestyle characteristics, mean 25(OH)D concentrations and prevalence of 25(OH)D by categories among men aged 70 years and over in the community

Variables	**N (%)**	**Mean 25 (OH)D**	**Serum 25(OH)D concentrations**			
		nmol/L (SD)	**<30nmol/L (%)**	**30-49.9nmol/L (%)**	**50-74.9nmol/L (%)**	**≥75 nmol/L (%)**
Age group	1659					
70-74	659(39.7)	56.0(22.5)	8.7	34.9	40.5	15.9
75-79	522(31.5)	56.3(21.7)	8.6	33.0	39.1	19.3
80-84	304(18.3)	55.8(21.1)	9.9	30.9	40.8	18.4
85+	174(10.5)	54.7(24.3)	15.5	33.4	27.6	23.6
Occupation	1648					
Professional	491(29.8)	56.2(21.6)	8.6	33.2	38.7	18.5
Non-professional	1157(70.2)	55.8(22.4)	10.3	33.2	38.9	18.1
Income	1638					
Other income	888(54.2)	56.0(21.6)	8.2	34.6	40.5	17.7
Pension	750(45.8)	56.1(22.8)	10.1	32.9	37.3	19.2
Education (%)	1636					
Post-school qualification	894(54.6)	56.5(22.5)	8.9	32.6	39.4	19.1
No post-school qualification	742(45.4)	55.4(21.8)	10.0	34.2	38.3	17.5
Taking vitamin D supplements	1659					
Yes	109(6.6)	58.7(23.9)	3.7	36.7	40.4	19.3
No	1550(93.4)	55.7(22.1)	10.0	33.2	38.6	18.2
Alcohol consumption	1636					
< 1 drink /week	401(24.8)	55.0(22.5)	11.0	34.9	37.2	17.0
1 to 14 drinks/week	974(60.2)	55.7(21.6)	8.8	33.4	40.7	17.1
15 to 28 drinks/week	182(11.3)	57.3(22.7)	10.4	31.3	36.8	21.4
29+ drinks/week	60(3.7)	59.3(25.0)	6.7	31.7	35.0	26.7
Cigarette smoking status	1641					
Never smoked	618(37.7)	57.4(23.9)	8.3	31.4	41.1	19.3
Ex-smoker	926(56.4)	55.6(21.9)	9.8	33.5	38.7	18.0
Current smoker	97(5.9)	52.4(23.5)	11.3	43.3	27.8	17.5
Sun exposure (avoids direct sunshine)	1635					
Never	589(35.5)	56.8(23.4)	9.5	32.8	37.5	20.2
Usually	886(53.4)	56.4(21.6)	9.1	31.7	41.2	17.9
Always	160(9.6)	50.8(19.7)	10.6	45.0	30.6	13.8
Physical activity (PASE score)	1641					
High (PASE≥85)	1202(73.2)	57.9(21.8)	7.2	31.2	42.3	19.3
Low (PASE<85)	439(26.8)	51.1(22.3)	15.5	39.0	29.6	15.9
BMI status	1632					
<20 kg/m²	27(1.7)	59.7(22.5)	7.4	29.6	37.0	25.9
20- 24.9 kg/m²	365(22.4)	58.8(24.3)	8.2	31.8	37.3	22.7
25-29.9 kg/m²	799(49.0)	56.4(22.0)	8.6	32.5	40.4	18.4
30 and over kg/m²	441(27.0)	52.4(20.0)	11.8	36.5	38.5	13.2
Body fat mass	1633					
Lowest quartile (<16.3kg)	408(25.0)	59.4(24.3)	8.6	30.2	39.0	22.1
Second quartile (16.3-20.7kg)	408(25.0)	56.8(20.0)	8.5	31.2	40.9	19.4
Third quartile (20.8-25.6kg)	409(25.1)	53.3(19.9)	10.0	37.2	37.7	15.2
Highest quartile (25.7-55.2kg)	408(25.0)	54.5(20.9)	11.0	34.3	38.2	16.7
Season	1659					
Summer: December to February	343(20.7)	58.1(20.0)	4.7	32.1	43.4	19.8
Autumn: March to May	473(28.5)	65.2(23.8)	4.0	23.0	42.7	30.2
Winter: June to August	409(24.7)	49.7(21.4)	15.9	39.1	33.5	11.5
Spring: September to November	434(26.2)	49.9(18.7)	13.6	40.3	35.7	10.4

Table 2
Estimated odds ratio for vitamin D deficiency (25(OH)D below 50 nmol/l), by socioeconomic and lifestyle factors among men aged 70 years and over living in the community

Variables	**Unadjusted odds ratio, 95% CI**	**P value**	**Model 1* Adjusted: odds ratio, 95% CI**	**P value**	**Model 2† Adjusted as Model 1 and for self-rated health and health conditions: odds ratio, 95% CI**	**P value**
Age group						
70-74	Ref		Ref		Ref	
75-79	0.92 (0.73,1.16)	0.50	0.81 (0.63,1.05)	0.11	0.81 (0.63,1.05)	0.11
80-84	0.89 (0.68,1.18)	0.42	0.80 (0.59,1.08)	0.15	0.82 (0.60,1.11)	0.19
85+	1.24 (0.89,1.73)	0.21	1.20 (0.82,1.75)	0.35	1.2416 (0.85,1.82)	0.27
Occupation §						
Professional	Ref					
Non-professional	1.01(0.82,1.25)	0.92	-	-	-	-
Income§						
Other income	Ref					
Pension	1.07(0.88,1.30)	0.49	-	-	-	-
Education (%)§						
Post-school qualification	Ref					
No post-school qualification	1.13(0.93,1.38)	0.23	-	-	-	-
Taking vitamin D supplements§						
Yes	Ref					
No	1.12(0.76,1.67)	0.57	-	-	-	-
Alcohol consumption§						
< 1 drink /week	Ref					
1 to 14 drinks/week	0.86 (0.68,1.09)	0.21	-	-	-	-
15 to 28 drinks/week	0.85 (0.59,1.20)	0.59				
29+ drinks/week	0.73 (0.42,1.28)	0.42				
Cigarette smoking status						
Never smoked	Ref		Ref		Ref	
Ex-smoker	1.16(0.95,1.43)	0.15	1.11(0.89,1.39)	0.36	1.08(0.87,1.36)	0.48
Current smoker	1.83(1.19,2.82)	0.006	1.97(1.24,3.13)	0.004	1.96(1.23,3.12)	0.005
Sun exposure (avoids direct sunshine)						
Never	Ref		Ref		Ref	
Usually	0.94 (0.76,1.16)	0.59	1.03 (0.82,1.29)	0.83	1.01 (0.81,1.27)	0.92
Always	1.71(1.20,2.43)	0.003	2.04(1.40, 2.98)	<0.0001	2.03 (1.38,2.97)	<0.0001
Physical activity (PASE score)						
High (PASE≥85)	Ref		Ref		Ref	
Low (PASE<85)	1.92(1.54,2.40)	<0.0001	2.01(1.58,2.55)	<0.0001	1.81(1.42,2.32)	<0.0001
BMI status						
20- 24.9 kg/m^2		Ref		Ref		Ref
25-29.9 kg/m^2	1.07(0.83,1.38)	0.61	1.16(0.88,1.52)	0.30	1.15(0.88,1.52)	0.31
30 and over kg/m^2	1.42(1.07,1.89)	0.02	1.40(1.03,1.89)	0.03	1.34(0.98,1.82)	0.06
<20 kg/m^2	0.90(0.40,2.02)	0.80	0.95(0.40,2.25)	0.90	0.94(0.39,2.24)	0.89
Body fat mass						
Lowest quartile (<16.3kg)	Ref		Ref		Ref	
Second quartile (16.3-20.7kg)	1.03(0.78,1.37)	0.83	1.03(0.76,1.39)	0.85	1.01(0.74,1.36)	0.97
Third quartile (20.8-25.6kg)	1.40(1.06,1.85)	0.02	1.35(1.00,1.81)	0.05	1.33(0.99,1.80)	0.06
Highest quartile (25.7-55.2kg)	1.29(0.97,1.70)	0.08	1.21(0.89,1.63)	0.22	1.15(0.85,1.56)	0.38
Season						
Summer: December to February	Ref		Ref		Ref	
Autumn: March to May	0.64(0.47,0.86)	0.003	0.63(0.45,0.86)	0.003	0.63(0.46,0.86)	0.004
Winter: June to August	2.11(1.57,2.82)	<0.001	2.21(1.63, 3.00)	<0.0001	2.28(1.67,3.11)	<0.0001
Spring: September to November	2.02(1.51,2.69)	<0.001	2.08(1.53,2.82)	<0.0001	2.18(1.60,2.96)	<0.0001

*Model 1.Adjusted by age group, season, physical activity level, sun exposure, BMI (or body fat mass for BMI status) and cigarette smoking status (except when the variable was the independent variable); †Model 2. As model 1 plus adjusted by self-rated health and self-reported health conditions; §occupation, income, education, alcohol consumption and vitamin D supplement use were not adjusted since they were not associated with 25(OH)D

Results

Characteristics of participants

The mean age of the study population was 77 years (70-97 years). Table 1 presents the participants' characteristics and also means and categorised levels of serum 25(OH)D by age group and other covariates. There were no significant differences in the baseline characteristics between volunteers and non-volunteers including mean age, marital status and self-rated health status (data not shown).

Distribution of serum 25(OH)D concentration

The mean (±SD) serum 25(OH)D concentration was 55.9±22.2 nmol/L. Mean serum 25(OH)D levels varied little by age group, ranging from 56.0 nmol/l in those aged 70-74 to 54.7 nmol/l among those aged ≥85.

Prevalence of vitamin D deficiency and insufficiency

Prevalence of frank vitamin D deficiency (25(OH)D <30nmol/l) was 9.6% and 33.4% of men had levels of 25(OH)D between 30-49.9 nmol/L, meaning that, overall, 43% of men had levels below 50nmol/l. Only 18.3% of men had serum 25(OH)D levels ≥75nmol/L (Table 1). There were no consistent trends by age group categories (Table 1).

The proportion of men in each of the four categories (<30.0 nmol/L, 30-49.9nmol/L, 50-74.9 nmol/L and 75 nmol/L and above) of 25(OH)D levels varied by season of blood sample collection. The highest prevalence of frank vitamin D deficiency (<30 nmol/L) was among men seen during the winter (15.9%). Levels <50 nmol/L were also highest in winter (55.0%); 27.1% of men had levels <50 nmol/L in autumn, 36.7% in the summer and 53.9% in spring (Table 1). Mean vitamin D levels were lower, and prevalence of frank vitamin D deficiency was higher (10.6%), in men who reported that they 'always' avoided sun exposure. Only 6.6% of men were taking vitamin D supplements (Table 1).

Logistic regression analysis of risk factors for vitamin D insufficiency

The associations between vitamin D insufficiency and socioeconomic and lifestyle factors are presented in Table 2. Factors significantly associated with low 25(OH)D levels (<50 nmol/L) in univariate analysis were season (winter and spring), low physical activity, BMI 30 kg/m^2 and above, current smoking, and avoidance of sun exposure. All these associations, except BMI ≥30 kg/m^2 remained statistically significant after adjustment for covariates in the final models (model 2, Table 2). Body fat mass in the third quartile (20.8-25.6kg) was significantly associated with low 25(OH)D levels in unadjusted analysis but, with adjustment, the association was no longer significant. Further analysis identified that adjustment by sun exposure and physical activity level contributed to the non-significance. There were no statistically significant associations between low 25(OH)D levels and age group, socioeconomic status (educational status, income, occupation), alcohol consumption and vitamin D supplement use.

Discussion

In this study, we have shown that community-dwelling older men aged 70-97 years living in Australia, a country well known for its abundance of sunshine, have a high prevalence of vitamin D insufficiency (defined as 25(OH)D<50 nmol/L). Almost half of the participants (43%) were vitamin D deficient and only a small proportion (18.3%) had levels 75nmol/L or above, considered the optimal level by some authorities (7, 20). We found a much higher prevalence of vitamin D insufficiency than found in the AusDiab study, where the prevalence was 27.6% among men aged 75-95 years which was different to that in our study where the age range was 70 -97 years (9). Variability in methods used for 25(OH)D analysis between different laboratories makes comparisons in prevalence difficult (14). However, this is unlikely to explain the large observed differences in vitamin D insufficiency between CHAMP and AusDiab, since the serum 25(OH)D samples in AusDiab were analysed using the same method as ours (the DiaSorin Kit). The lower prevalence of vitamin D insufficiency in the AusDiab study could have been related to the inclusion of data from different areas of Australia with a wide variance in latitudes from <30 ºS to >35 ºS (i.e. Tasmania with a latitude of 41-43 ºS in comparison to the Northern Territory with a latitude of 12 ºS), whereas the participants in our study lived in the suburbs near Concord, Sydney with a latitude of 33.9° S. The novelty of our study is that it includes measures of sun exposure practices, and a broad range of lifestyle factors.

Vitamin D insufficiency in older age may be due to physiological factors such as a decline in efficiency of vitamin D synthesis due to decreasing concentrations of 7-dehydrocholesterol (vitamin D precursor) that is photochemically transformed into cholecalciferol in the skin (15). This process is dependent upon ultra-violet B (UVB) radiation with wavelengths between 290 and 315 nm (16). We have shown that lifestyle factors such as lack of sun exposure among older people is a contributing factor for low vitamin D levels. More than 50% of CHAMP participants 'usually' avoided sun exposure and around 10% of men reported that they 'always' avoided sun exposure. A simple public health strategy to improve vitamin D status could be an intervention that involves increased sunlight exposure at appropriate times of day. However, it is worth noting that this strategy has not proven to be effective in residential aged care facilities due to poor adherence (17). Guidelines on exposure to sunshine are difficult to devise as many factors need considering, including latitude, season, time of day, skin pigmentation, and clothing. Current recommendations in Australia (3) likely to achieve adequate vitamin D levels among people with fair skin are 6–7 minutes of sun exposure mid-morning or mid-afternoon, on most days in summer and 7–40 minutes of sun exposure, with as much bare skin exposed as feasible, on most days, in the winter. Older people have a lowered capacity to synthesize vitamin D when exposed to sunlight so may need to spend more time outdoors to meet their requirements (4).

Poor health may potentially limit outdoor activity leading to inadequate sun exposure, as shown among older people living in residential care (8, 18). Our study, however, showed that even after adjustment for self-reported health and comorbidities the association between vitamin D insufficiency and sun

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Volume 17, Number 7, 2013

exposure and physical activity remained statistically significant.

Inadequate dietary vitamin D intakes may have also contributed to the observed high prevalence of vitamin D insufficiency in our study. However, diet alone is insufficient to meet vitamin D requirements. Vitamin D is obtained from a limited number of foods such as oily fish (e.g. herring and mackerel) and fortified margarines. Dietary intake of vitamin D was not measured in our study and currently there is no data available on dietary intakes specifically among older people living in Australia. Estimates of adult vitamin D intakes show figures of 2.0–3.0 μg/day (19). This is much lower than the recommended dietary intake from both diet and supplements of 20 μg/day (800 IU/day) for older people (3, 6), effective in reducing falls and fracture, to preserve muscle strength and functional ability (20).

Our study shows that only a small proportion of men (6.6%) were taking vitamin D supplements, despite the high prevalence of vitamin D insufficiency. It was surprising to find no differences in the percentage with vitamin D levels above 30 nmol/L between users and non-users of vitamin D supplements. These findings are clinically important because they suggest that there may be problems with compliance and/or prescription of appropriate doses of vitamin D supplements for older men.

Participants with blood samples collected in the winter and spring had lower serum 25(OH)D levels than those collected in the summer or autumn. The participants resided in suburbs near Concord which is situated at a latitude 33.9° S. The mean daily sun exposure during the blood sampling period between Jan 2005-May 2007 was lowest for the months from May to July, i.e. autumn and winter (21), leading to lower vitamin D levels in winter and spring. It has been suggested that the lower 25(OH)D concentrations among older age groups may predominantly result from being housebound or institutionalised (22-24). Our data suggest that older people need to spend more time outdoors in all seasons, which is achievable in Australia.

We found associations between low vitamin D levels and some lifestyle factors, consistent with other research showing a greater risk of vitamin D insufficiency in cigarette smokers (25), and that vitamin D insufficiency is associated with decreased outdoor physical activity (26) most likely due to decreased synthesis of vitamin D by sun exposure.

Obese (BMI ≥ 30 kg/m^2) participants had more than a 40% increased odds of having vitamin D insufficiency compared with those with a normal BMI (20-25 kg/m^2). This was also shown for men with a body fat mass in the third quartile (20.8-25.6kg) compared with those in the first quartile body fat mass<16.3kg. Low physical activity and avoidance of sun exposure explained the association with body fat mass. The AusDiab study found an association with obesity and vitamin D insufficiency but did not ask about sun exposure. Obesity has been shown to be associated with a decreased bioavailability of vitamin D due to its deposition in fat (27). Our study suggests that lifestyle factors associated with obesity such as physical activity and sun exposure may be more important explanations for the observed associations between obesity and vitamin D levels.

We found no associations between vitamin D insufficiency and socioeconomic status. This is in contrast to a UK study that reported that low income/material deprivation was associated with low vitamin D status (28), although the participants in the UK study were younger (age range 19-64 years) in comparison to the present study. Another study in England that showed low socioeconomic status among older people to be a risk factor for vitamin D insufficiency (23), but this study also had different population characteristics to the present study since it also included institutionalised participants.

The main strengths of our study are that it involves a large, representative sample of community-dwelling older Australian men aged 70 and over. The age distribution of the men in the CHAMP study is similar to that of the target population (10), and the prevalence of self-reported disease in CHAMP participants is very similar to that found in a recent Australian national telephone survey of men's health (29). The only other Australian population-based study of vitamin D levels, the AusDiab Study, included a smaller number of older men and did not collect information on factors that may be associated with low vitamin D levels, such as sun exposure and use of vitamin D supplements.

There are some study limitations. We did not measure dietary vitamin D intake, nor did we obtain data on time spent outdoors or sunscreen use, which is important since UVB exposure is the primary source of vitamin D. The CHAMP study does not include women, who are more likely to have vitamin D insufficiency than men (30).

The findings from our study might help clinicians identify older men who would benefit most from vitamin D testing and supplementation.

The algorithm for the screening and management of vitamin D insufficiency for older men living in Australia could include: measurement of serum 25(OH) D levels performed by a reputable laboratory, men with vitamin D insufficiency should receive appropriate vitamin D supplementation i.e. 3000–5000IU (75–125μg) per day for at least 6–12 weeks followed by monitoring of vitamin D levels after 3 months, followed by ongoing treatment with a lower dose of around 1000–2000IU per day (3). It is also important to implement and encourage outdoor physical activity programmes for older people using safe sun practices. This may be helpful in allowing maintenance of adequate vitamin D levels.

Conclusion

We found that older men living in the community in Sydney, Australia, where there is an abundance of sunshine are still at high risk of vitamin D insufficiency. Our findings suggest a need for effective age-appropriate strategies such as development of guidelines on safe sun exposure practices for older people, increasing awareness of the need to consume vitamin D rich foods, importance of outdoor physical activity and appropriate use of vitamin D supplementation to prevent declines in vitamin D status and its negative consequences.

Acknowledgements: The CHAMP study is funded by the National Health and Medical Research Council and the Ageing and Alzheimer's Research Foundation (AARF).We thank all the staff working on CHAMP and the participants in the project. The lead author is funded by ARC Centre of Excellence in Population Ageing Research (CEPAR).

Funding: The views expressed are those of the authors, not of the funders. Data analysis and interpretation were carried out by the authors independently of the funding sources based on the available data. The corresponding author had full access to the survey data.

Sponsor's Role: The funding body played no role in the formulation of the design, methods, subject recruitment, data collection, analysis, or preparation of this paper.

Competing interests: None declared.

References

1. Dawson-Hughes B, Heaney RP, Holick MF et al. Estimates of optimal vitamin D status. Osteoporos Int 2005;16:713-16.
2. Mithal A, Wahl DA, Bonjour JP, Burckhardt P, Dawson-Hughes B, Eisman JA, El-Hajj Fuleihan G, Josse RG, Lips P, Morales-Torres J. Committee IOF., IOF Committee of Scientific Advisors (CSA) Nutrition Working Group Global vitamin D status and determinants of hypovitaminosis D. Osteoporos Int 2009; 20(11): 1807–1820.
3. Working group of the Australian and New Zealand Bone and Mineral Society, Endocrine Society of Australia and Osteoporosis Australia. Vitamin D and adult bone health in Australia and New Zealand: a position statement. Med J Aust 2012;196(11)18: 686-687.
4. Holick MF. Vitamin D deficiency. N Engl J Med.2007; 357: p 266–281.
5. Holick, M.F., Binkley, N.C., Bischoff-Ferrari, H.A., Gordon, C.M., Hanley, D.A., Heaney, R.P., Murad, M.H. & Weaver, C.M. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab 2011; 96: 1911-1930.
6. Ross, AC, Manson JE, Abrams SA et al. The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: what clinicians need to know. J Clin Endocrinol Metab. 2011;96: 53-58.
7. Pearce SH and Cheetham TD. Diagnosis and management of vitamin D deficiency. BMJ 2010; 340:b5664.
8. Sambrook PN, Cameron ID, Cumming RG et al. Vitamin D deficiency is common in frail institutionalised older people in northern Sydney. Med J Aust 2002; 176:560–560.
9. Daly RM, Gagnon C, Lu ZX et al. Prevalence of vitamin D deficiency and its determinants in Australian adults aged 25 years and older: A national, population-based study. Clin Endocrinol (Oxf). 2011. doi: 10.1111/j.1365-2265.2011.04320.x.
10. Cumming RG, Handelsman D, Seibel MJ, et al. Cohort profile: The Concord Health and Ageing in Men Project (CHAMP). Int J Epidemiol 2009 38:374-378.
11. NHMRC, Australian Alcohol Guidelines: Health Risks and Benefits. Canberra, NHMRC, N.H.a.M.R. Council, Editor. 2009, Commonwealth of Australia. http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/ds10-alcohol.pdf (accessed June 2012).
12. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol 1993; 46:153-162.
13. Bruce DG, St John A, Nicklason F, Goldswain PR.Secondary hyperparathyroidism in patients from Western Australia with hip fracture: relationship to type of hip fracture, renal function, and vitamin D deficiency. J Am Geriatr Soc. 1999 ;47(3):354-9.
14. Lai JK, Lucas RM, Banks E, Ponsonby AL; Ausimmune Investigator Group.Variability in vitamin D assays impairs clinical assessment of vitamin D status.Intern Med J. 2012 ;42(1):43-50.
15. Maclaughlin J, Holick MF. Aging decreases the capacity of human-skin to produce vitamin-D3. J Clin Invest.1985 ; 76(4) :1536–8.
16. Chen TC, Chimeh F, Lu Z et al. Factors that influence the cutaneous synthesis and dietary sources of vitamin D. Arch Biochem Biophys 2007;460:213 – 7.
17. Sambrook PN, Cameron ID, Chen JS et al. Does increased sunlight exposure work as a strategy to improve vitamin D status in the elderly: a cluster randomised controlled trial. Osteoporos Int. 2012 ;23(2):615-24.
18. Durvasula S, Kok C, Sambrook PN, Cumming RG, Lord SR, March LM, Mason RS, Seibel MJ, Simpson JM, Cameron ID. Sunlight and health: attitudes of older people living in intermediate care facilities in southern Australia. Arch Gerontol Geriatr. 2010;51(3):e94-9.
19. Baghurst KI, Record SJ. Re-analysis of the 1995 National Nutrition Survey. Adelaide: CSIRO, 2002.
20. Bischoff-Ferrari HA, Giovannucci E, Willett WC, Dietrich T, Dawson-Hughes B. Estimation of optimal serum concentrations of 25-hydroxyvitamin D for multiple health outcomes. Am J Clin Nut 2006; 84(1):18-28.
21. Australian Government Bureau of Meteorology, Internet Activity, Australia, Sep 2012. http://www.bom.gov.au/climate/ (accessed May 2012).
22. Webb AR, Pilbeam C, Hanafin N, Holick MF. An evaluation of the relative contributions of exposure to sunlight and of diet to the circulating concentrations of 25-hydroxyvitamin D in an elderly nursing home population in Boston. Am J Clin Nut 2009; 51; 1075- 81.
23. Hirani V, Primatesta P. Vitamin D concentrations among people aged 65 years and over living in private households and institutions in England: population survey. Age and Ageing 2005; 34: 485-91.
24. Flicker L, Mead K, MacInnis RJ et al. Serum Vitamin D and Falls in Older Women in Residential Care in Australia. J Am Geriatr Soc 2003; 51:1533-1538.
25. Brot C, Jorgensen NR, Sørensen OH. The influence of smoking on vitamin D status and calcium metabolism. Eur J Clin Nutr 1999; 53: 920–6.
26. Scragg, R, Camargo CA. Frequency of leisure-time physical activity and serum 25-hydroxyvitamin D levels in the US population: results from the Third National Health and Nutrition Examination Survey. Am J Epidemiol 2008;168: 577-586.
27. Snijder MB, van Dam RM, Visser M et al. Adiposity in relation to vitamin D status and parathyroid hormone levels: a population-based study in older men and women. J Clin Endocrinol Metab 2005; 90: 4119–4123.
28. Hirani V, Mosdøl A, Mishra G. Predictors of 25-hydroxyvitamin D status among adults in two British national surveys. Br J Nutr 2009; 101: 760–764.
29. Holden CA, McLachlan RI, Pitts M, et al. Men in Australia Telephone Survey (MATeS): a national survey of the reproductive health and concerns of middle-aged and older Australian men. Lancet 2005; 366: 218-224.
30. Maggio D, Cherubini A, Lauretani F et al. 25(OH)D serum levels decline with age earlier in women than in men and less efficiently prevent compensatory hyperparathyroidism in older adults. J Gerontol A Biol Sci Med Sci 2005; 60A:1414-1419.