Vitamin D status of Scottish adults: Results from the 2010 & 2011 Scottish Health Surveys

Report by Gillian Purdon[1], Fiona Comrie[1], Lisa Rutherford[2] and Anna Marcinkiewicz[2].

September 2013

[1]Food Standards Agency in Scotland
[2]ScotCen Social Research

Contents

Executive summary

Vitamin D is a fat-soluble vitamin, made in the skin in response to UV radiation from the sun and a small amount is obtained from the diet. Vitamin D has a number of important functions largely related to maintaining bone health, however low vitamin D status has also been implicated in a range of diseases. The dietary reference values (DRVs) for vitamin D were set by the Scientific Advisory Committee on Nutrition (SACN) and have been endorsed by the Chief Medical Officers (CMO) for all UK countries. These DRVs are currently under review by SACN and the updated draft recommendations are expected to be published in 2015.

A number of factors can influence vitamin D status including genetic factors, adiposity and factors affecting of vitamin D synthesis in the skin such as concentration of melanin (a skin pigment), age, season, latitude, time of day, amount of clothing worn and use of sunscreen.

There is limited data available on the vitamin D status of population groups in Scotland therefore the Scottish Health Survey rolling programme was used to obtain blood samples for vitamin D analyses. Over 1400 blood plasma samples were analysed for 25hydroxy(OH) vitamin D (the circulating metabolite of vitamin D) to provide a marker of vitamin D status from adults that participated in the 2010 and 2011 Scottish Health Surveys.

Analysis of vitamin D status indicated an average of 37.5nmol/l for the Scottish population. This is above the current indicator of optimal vitamin D status of >=25nmol/L however, more than a third of participants had sub-optimal vitamin D levels (<25nmol/L). This was shown in both males and females and across age groups.

Vitamin D status also varied by deprivation; almost half (47%) of participants in the lowest quintile of Scottish Index of Multiple Deprivation (SIMD) had suboptimal vitamin D status. Similarly those with the lowest incomes had the lowest mean vitamin D levels.

Scotland's latitude position at 55^{o} North means that useful sunlight for production of Vitamin D only occurs between April and September. As expected, these data show a clear link between season of interview and vitamin D status. However, 17% of individuals had suboptimal vitamin D status (<25nmol/L) during the summer months.

Vitamin D is a fat soluble vitamin that can be stored in body fat. Lower vitamin D status has previously been identified in overweight subjects. The results from this study showed a significant association between mean vitamin D levels and Body Mass Index (BMI); obese adults (those with a BMI over 30) were most likely to have suboptimal status and this association did not vary across the deprivation quintiles.

In summary, the average vitamin D status of the Scottish population was 37.5 nmol/L during 2010/11 and around a third of the population had sub-optimal vitamin D status (<25nmol/L). There was also an association of vitamin D and socio-economic status; those in the most deprived quintile of SIMD and with the lowest household incomes had poorer vitamin D status.

Background and Introduction

Vitamin D

Vitamin D is a fat-soluble vitamin, made in the skin in response to UV radiation from the sun (sunlight). Skin exposure to sunlight of the appropriate wavelength (290-310 nm) is essential for ensuring adequate vitamin D status. Small amounts (around 2-3ug) of vitamin D are also obtained from the diet.[1] Vitamin D has a number of important functions, including regulating the amount of calcium and phosphate in the body.

Vitamin D status

Several factors can potentially affect Vitamin D status. These include genetic factors, adiposity and factors affecting of vitamin D synthesis in the skin such as concentration of melanin (a skin pigment), age, season, latitude, time of day, amount of clothing worn and use of sunscreen.[2]

Sunlight varies with latitude, and in winter months (October to March) at latitudes of about 52^{o} and above, there is no synthesis of vitamin D in the skin (Scotland lies at approximately 55^{o}-61^{o} North). For the remaining months over half of the effective UV radiation occurs between 11am and 3pm. To maintain vitamin D status during winter, the population above this latitude relies on body stores and dietary vitamin D.

Blood plasma levels of 25 hydroxy vitamin D 25(OH)D serve as an indicator of vitamin D status. A plasma 25(OH)D concentration of 25nmol/l has been used as a cut-off for defining the lower limit of adequacy of vitamin D status.[2] Plasma 25(OH)D levels of less than or equal to 15nmol/l can be used to describe very low serum levels.

Vitamin D recommendations

Most people should be able to get sufficient vitamin D by getting a little sunlight and a small amount from their diet. The time required to make sufficient vitamin D is usually short and less than the amount of time needed for skin to burn. Vitamin D is found in small amounts in a few animal foods, such as red meat and egg yolks, and fortified foods such as some margarines and breakfast cereals.

Current recommendations for vitamin D intakes set by Scientific Advisory Committee on Nutrition (SACN) and endorsed by the CMOs for all UK countries[3] are that:

- women who are pregnant or breastfeeding should take 10 micrograms (0.01 mg) of vitamin D each day
- all infants* and young children aged 6 months to 5 years should take a daily supplement containing vitamin D in the form of vitamin drops, to help them meet the requirement set for this age group of 7-8.5 micrograms of vitamin D per day, and
- older people (>65 years) should take 10 micrograms of vitamin D each day

* Infants who are fed infant formula will not need vitamin drops until they are receiving less than 500ml of infant formula a day, as these products are fortified with vitamin D. Breastfed infants may need to receive drops containing vitamin D from one month of age if their mother has not taken vitamin D supplements throughout pregnancy

Other groups who may benefit from taking 10 micrograms of vitamin D each day include individuals who:

- who have darker skin, for example people of African, African-Caribbean and South Asian origin
- always cover up all of their skin outside
- rarely get outdoors

Vitamin D deficiency

Vitamin D has a number of important physiological functions, mainly relating to maintaining bone health. 25-hydroxyvitamin D (25(OH)D) is the major circulating metabolite of vitamin D is used as a measure of vitamin D status. A plasma 25(OH)D concentration less than 25nmol/l (10ng/ml) is currently regarded an index of suboptimal vitamin D status[1], this value is currently under review by SACN.

Deficiency of vitamin D results in rickets (in children) and osteomalacia (in adults). Rickets and osteomalacia are characterized by defects in bone growth and bone mineralization; both increase the risk of bone fracture. Rickets and osteomalacia are rarely reported among the white Scottish population although there is evidence of incidence in UK South Asian and Afro-Caribbean groups. There is also a higher prevalence of low vitamin D status among older people, particularly those living in institutions.[2]

Low vitamin D status has also been implicated in a range of diseases including osteoporosis, tuberculosis, cardiovascular disease, several cancers, multiple sclerosis and type I diabetes. Research in these areas is developing, but evidence is inconclusive at present. In 2010, the Institute of Medicine (IOM) reviewed the evidence on the health benefits of vitamin D. For health outcomes other than bone health, the IOM concluded that the evidence is limited or inconclusive.[4] This concurs with earlier advice issued by SACN in 2007.[1] SACN is presently reviewing the Dietary Reference Values for vitamin D intake, looking across a range of conditions, and is expected to publish its draft recommendations in 2015.[5]

Relevance of this work

There is limited data available on the vitamin D status of population groups in Scotland. The Scottish boost of the National Diet and Nutrition Survey rolling programme (2008/11) will provide some information on vitamin D status in Scotland, but will provide no more than 200 blood samples per fieldwork year (2008-11) and will not be available until spring 2014.

The Scottish Health Survey (SHeS) is funded by the Scottish Government (SG). It provides a detailed picture of the health of the Scottish population in private households.[6] The continuous annual rolling programme for the SHeS began in January 2008 and will run until 2015, and venous blood sampling was included as part of the nurse visit up to 2011. To address the lack of data on vitamin D status in Scotland, the Food Standards Agency in Scotland and Scottish Government funded the analysis of blood plasma for vitamin D status in samples collected in the 2010 and 2011 SHeS as part of the nurse visit. The data from this study will be used to

add to the evidence base around vitamin D status and will be used to inform SACN as part of their review of vitamin D.

Methods

In line with recommendations that results obtained by FSA-funded projects should be comparable with the values obtained from the NDNS[7], the DiaSorin Liaison Total assay was used for the measurement of 25OHD in blood plasma samples collected in the 2010 and 2011 Scottish Health Surveys. This assay is used for blood samples from the NDNS rolling programme (2008-2011)[8] as well as the Health Survey for England (HSE).

Between 2008 and 2011 the Scottish Health Survey used a two-stage design with interviews followed by nurse visits for a random sub-sample of participants aged 16 and over. Venous blood samples were collected as part of the nurse visit and were tested for 25 hydroxy-vitamin D (25(OH)D) at the Royal Victoria Infirmary, Newcastle Upon Tyne.

Further details of all the 2010 and 2011 response figures and survey methodology (including the quality control procedures for the blood analysis) are presented in 2010 and 2011 SHeS Technical Reports.[9,10]

Results

The tables in this section show the vitamin D status of participants in the 2010 and 2011 Scottish Health Surveys.

Response rates

Table 1 sets out the numbers of participating households, adult main interviews, nurse visits and blood samples obtained in 2010 and 2011. In both years a number of the blood samples collected were not valid, either due to an insufficient volume being collected, sample damage in transit, or problems with their processing in the lab. The final row of the table shows the total number of samples for which a valid vitamin D test was performed each year. Further details of all the 2010 and 2011 response figures are presented the 2010 and 2011 SHeS Technical reports.[9,10]

Table 1 Scottish Health Survey, core sample[a] response rates, 2010 and 2011

	2010		2011	
	n	%	n	%
Total eligible households	7093		7173	
Participating households	4470	63	4677	65
Total eligible adults (main interview)[b]	12274		12712	
Adult interviews	6770	55	7040	55
Total eligible adults (nurse visit)[b]	3438		2224	
Adults who saw a nurse	1063	31	972	28
Adults who gave a blood sample	843	25	725	24
Adults who gave a valid blood sample for vitamin D testing	764	22	689	20

[a] There were three main sample types on the 2010 and 2011 surveys. At core sample addresses all adults and up to two children per household were eligible to take part in the main interview. Only a sub-sample of adults were eligible to take part in the nurse interview, including blood sample collection.

[b] The total number of eligible adults in the interview and nurse visits are estimates derived from the number of adults in participating households, and the number of adults in non-participating households (where that information was obtained). They are likely to be overestimates. Full details of the estimation method are available in the 2010 and 2011 SHeS Technical reports.[9, 10]

Weighting

The SHeS data were weighted to adjust for non-response and differential selection probabilities. To account for the increasing levels of non-response as the survey stages progress separate weights were created for the main interview, nurse and blood data. Each survey year fieldwork was conducted continuously throughout the calendar year with roughly equal numbers of addresses issued each month. However, as a small amount of fieldwork was carried over until the start of the next calendar year there is a slight over-representation of winter months in the sample. As season is related to vitamin D exposure (via sunlight), an additional stage of calibration weighting was applied to the vitamin D blood sample data to adjust for the seasonal variation in sample collection. Full details of the main SHeS weighting are available in 2010 and 2011 SHeS Technical Reports,[9,10] further details of the additional vitamin D weighting are available on request.

Vitamin D levels

Vitamin D samples were collected in the 2010 and 2011 Scottish Health Surveys. The two years of data have been combined for this analysis to provide more robust estimates of vitamin D levels in Scotland.

In 2010/2011, the mean vitamin D level for all adults was 37.5nmol/ litre (SD 22.3). This exceeds the plasma concentration of 25nmol/l which has been used as a cut-off for defining the lower limit of adequacy of vitamin D status.[2]

A third (33%) of adults in Scotland had suboptimal vitamin D levels (a plasma 25(OH)D concentration of less than 25nmol/l) in 2010/2011. Two-thirds (67%) of adults had optimal levels of vitamin D. One in eight adults (12%) in Scotland had a plasma concentration below 15nmol.

Table 2 Vitamin D status, 2010-2011 combined

Aged 16 and over with valid blood sample		*2010-2011 combined*
Vitamin D status		
Plasma 25-hydroxyvitamin D		
Mean	nmol/L	37.5
SE of mean	nmol/L	0.9
Standard deviation	nmol/L	22.3
Optimal (>=25nmol) Vitamin D status	%	67
95% C.I.	%	(63-70)
Suboptimal (<25nmol/litre) status	%	33
95% C.I.	%	(30-37)
Suboptimal (<15nmol/litre) status	%	12
95% C.I.	%	(10-14)
Bases (weighted):		*1453*
Bases (unweighted):		*1453*

Sex and Age

The proportions of adults with suboptimal and optimal vitamin D status, and corresponding means, are presented in Table 3 by sex and age group. Mean vitamin D levels did not vary significantly by sex in 2010/2011 (36.9nmol for men and 38.2nmol for women) (p=0.275). Similarly, there was no statistically significant association between vitamin D status and gender. Around a third of both men and women had sub-optimal vitamin D levels during this period (34% of men and 33% of women) (p=0.722). The proportions of men and women with a plasma concentration below 15nmol/litre were also similar (13% and 11% respectively)(p=0.325).

While younger people appeared to have lower mean vitamin D levels than older people, age was not significantly associated with mean vitamin D (p=0.211). Mean levels for the two youngest age groups (16-34 year olds and 35-54 year olds) were 35.4nmol/litre and 37.2nmol/litre, respectively, while the average vitamin D level for older age groups was 39.6nmol/litre.

As with mean levels, the differences in vitamin D status observed by age were not statistically significant (p=0.095). Between 35% and 38% of 16-54 year olds had suboptimal vitamin D levels. For those aged 55 and over, sub-optimal status ranged between 28% and 29%. Fourteen percent of those aged 35-54 and those aged 75 or over had a plasma concentration below 15nmol/litre. Prevalence of <15nmol/litre levels did not vary significantly by age (p=0.226).

Table 3 Vitamin D status by age group and sex

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**Age**				**Sex**		**Total**
		16-34	35-54	55-74	75+	Men	Women	
Mean	nmol/L	35.4	37.2	39.6	39.6	36.9	38.2	37.5
SE of mean	nmol/L	1.8	1.3	1.3	2.3	1.1	1.0	0.9
Standard deviation	nmol/L	21.22	22.58	22.74	23.26	21.7	22.9	22.3
Optimal (>=25nmol/litre) status	%	62	65	71	72	66	67	67
95% C.I.	%	(54-70)	(60-70)	(67-76)	(64-80)	(61-71)	(63-71)	(63-70)
Suboptimal (<25nmol/litre) status	%	38	35	29	28	34	33	33
95% C.I.	%	(31-46)	(30-40)	(24-33)	(20-36)	(29-39)	(29-37)	(30-37)
Suboptimal (<15nmol/litre) status	%	11	14	9	14	13	11	12
95% C.I.	%	(7-18)	(11-18)	(7-13)	(9-22)	(10-17)	(8-14)	(10-14)
Bases (weighted):		*428*	*507*	*389*	*128*	*696*	*757*	*1453*
Bases (unweighted):		*258*	*552*	*494*	*149*	*656*	*797*	*1453*

National Statistics Socio-economic classification (3 categories)

Table 4 presents mean vitamin D levels and suboptimal and optimal vitamin D status by the National Statistics Socio-economic classification (NS-SEC) of the household reference person. NS-SEC is an occupational based classification but has rules to provide coverage of the whole adult population.[11] In this analysis the 3 category version of NS-SEC was used.

There was a significant association between mean vitamin D levels and NS-SEC (p=0.002). Vitamin D levels were highest for adults living in managerial and professional households (40.9nmol/litre compared with 36.2nmol/litre and 35.5nmol/litre among those living in other types of household).

While it also appears that adults living in managerial and professional households were less likely than others to have suboptimal levels of vitamin D (29%) the differences in status were not statistically significant (p=0.259).

Table 4 Vitamin D status by National Statistics socio-economic classification

Aged 16 and over — *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**NS-SEC**		
		Managerial & professional	Intermediate & self-employed	Lower supervisory, technical, semi & routine manual
Mean Vitamin D	nmol/L	40.9	36.2	35.5
SE of mean	nmol/L	1.3	1.4	1.0
Standard deviation	nmol/L	24.1	20.7	20.5
Optimal (>=25nmol/litre) status	%	71	67	65
95% C.I.	%	(65-75)	(60-73)	(61-70)
Suboptimal (<25nmol/litre) status	%	29	33	35
95% C.I.	%	(25-35)	(27-40)	(30-40)
Bases (weighted):		*479*	*280*	*606*
Bases (unweighted):		*504*	*280*	*606*

Equivalised household income

Vitamin D levels by equivalised household income quintile are presented in Table 5. Equivalised household income is household income adjusted to take into account the size and composition of the household.[12]

Mean vitamin D levels varied significantly by equivalised household income (p=0.002). Average levels declined in line with income, from 41.8nmol/litre for those in highest quintile, to 33.2nmol/litre for those in the lowest income households.

The association between vitamin D status and household income was also statistically significant, with optimal vitamin D status declining as household income declined (p=0.004). In 2010/2011, a quarter (25%) of adults in the highest income households had suboptimal status, this increased to 42% of those in the lowest income households.

Table 5 Vitamin D status by Equivalised household income

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**Equivalised household income quintile**				
		1st (highest)	2nd	3rd	4th	5th (lowest)
Mean Vitamin D	nmol/L	41.8	39.5	38.0	33.8	33.2
SE of mean	nmol/L	1.6	1.8	2.1	1.8	0.0
Standard deviation	nmol/L	23.0	23.5	21.9	20.9	36.9
Optimal (>=25nmol/litre) status	%	75	69	69	59	58
95% C.I.	%	(39-45)	(36-43)	(34-42)	(30-37)	(29-37)
Suboptimal (<25nmol/litre) status	%	25	31	31	41	42
95% C.I.	%	(19-31)	(24-39)	(23-39)	(33-49)	(33-52)
Bases (weighted):		*301*	*280*	*284*	*207*	*199*
Bases (unweighted):		*321*	*271*	*288*	*217*	*181*

Scottish Index of Multiple Deprivation

Table 6 illustrates the variation in vitamin D levels by area deprivation. The Scottish Index of Multiple Deprivation (SIMD) identifies small area concentrations of multiple deprivation across all of Scotland.[13]

In 2010/2011, there was a significant association between mean vitamin D levels and area deprivation. Average levels declined in line with increasing deprivation, from 45.7nmol/litre for those living in the 20% least deprived areas in Scotland (SIMD quintile 5) to 31.3nmol/litre for those in Scotland's most deprived areas (SIMD quintile 1). Mean vitamin D levels of those living in the 15% most deprived areas in Scotland were also compared with those living elsewhere. Average levels for those in Scotland's most deprived 15% of areas were significantly lower than those living in the 85% least deprived areas (29.1nmol/litre compared with 39.1nmol/litre) ($p=<0.001$).

There was also a significant association between vitamin D status and area deprivation ($p=<0.001$). The proportion of adults in the two most deprived quintiles (SIMD quintiles 1 and 2) with suboptimal vitamin D levels (47% and 38% respectively) were significantly higher than among those living elsewhere (29%, 26% and 25% in SIMD quintiles 3, 4 and 5 respectively). Half of those living in Scotland's 15% most deprived areas had sub-optimal vitamin D status, compared with 30% of those living elsewhere ($p=<0.001$).

In addition, Table 6 also presents the proportion in each of the deprivation groups with a plasma concentration below 15nmol/litre. While there was no significant association between this and SIMD measured in quintiles ($p=0.258$), the proportions with levels below 15nmol/litre did vary significantly between those living in the 15% most deprived areas in Scotland and those living elsewhere. ($p=0.014$). Nineteen percent of those in the 15% most deprived areas had a plasma concentration below 15nmol/litre compared with 11% of those living elsewhere in Scotland.

Table 6 Vitamin D status by Scottish Index of Multiple Deprivation

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**SIMD quintile**					**SIMD 15/85**	
		5th (least dep)	4th	3rd	2nd	1st (most dep)	85% least deprived	15% most deprived
Mean Vitamin D	nmol/L	45.7	40.9	38.7	31.5	31.3	39.1	29.1
SE of mean	nmol/L	2.4	1.7	1.7	1.2	1.6	1.0	1.5
Standard deviation	nmol/L	25.8	24.0	21.4	16.2	19.7	27.7	17.9
Optimal (>=25nmol/l) status	%	75	74	71	62	53	70	50
95% C.I.	%	(67-81)	(68-79)	(62-78)	(54-69)	(45-61)	(66.1-73.2)	(40.9-59.2)
Suboptimal (<25nmol/l) status	%	25	26	29	38	47	30	50
95% C.I.	%	(19-33)	(21-32)	(22-38)	(31-46)	(39-55)	(26.8-33.9)	(40.8-59.1)
Suboptimal (<15nmol/l) status	%	10	9	9	14	16	11	19
95% C.I.	%	(6.0-15.8)	(5.7-15.2)	(5.7-15.1)	(9.8-20.7)	(10.7-23.5)	(8.4-13.0)	(12.6-28.7)
Bases (weighted):		*285*	*290*	*291*	*285*	*302*	*1228*	*225*
Bases (unweighted):		*299*	*330*	*305*	*253*	*266*	*1258*	*195*

Season of interview

Table 7 presents vitamin D results by the season in which the blood sample was taken. Mean levels of vitamin D were significantly lower in the January to March period (27.9nmol/litre) than in all other seasons, when it ranged between 34.9nmol (October to December) and 51.3nmol/litre (July-September) (p=<0.001).

There was a significantly higher prevalence of suboptimal vitamin D levels in the January to March periods (54%) compared to the other seasons (p=<0.001). The proportion of adults with optimal levels of vitamin D was highest in the summer months (July-September) with 83% having optimal levels in this period.

Table 7 Vitamin D status by season of interview

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**Season of interview**			
		Autumn (Oct-Dec)	Winter (Jan-Mar)	Spring (Apr-Jun)	Summer (Jul-Sep)
Mean Vitamin D	nmol/L	34.9	27.9	36.1	51.3
SE of mean	nmol/L	1.4	1.2	1.3	1.9
Standard deviation	nmol/L	19.7	16.9	18.8	26.2
Optimal (>=25nmol/l) status	%	68	46	70	83
95% C.I.	%	(61-74)	(38-54)	(64-75)	(77-88)
Suboptimal (<25nmol/l) status	%	32	54	30	17
95% C.I.	%	(26-39)	(47-62)	(25-36)	(12-23)
Bases (weighted):		*363*	*363*	*363*	*363*
Bases (unweighted):		*320*	*413*	*356*	*364*

In the previous section a strong association between SIMD quintile and vitamin D status was noted. Given that there was also a strong link between vitamin D status and season, Table 8 shows SIMD against season of interview to establish if seasonality is confounding the SIMD results. It is clear that that seasonal spread is fairly evenly balanced by SIMD; the chi-square test for association was not significant (p=-0.655). Season of interview is therefore unlikely to be confounding the link between vitamin D status and SIMD.

Table 8 Season of interview by Scottish Index of Multiple Deprivation quintile

Aged 16 and over with valid blood sample *2010-2011 combined*

Season of interview	**SIMD quintile**				
	5th (least deprived)	4th	3rd	2nd	1st (most deprived)
	%	%	%	%	%
Autumn (Oct-Dec)	24	21	24	29	27
95% C.I.	(16-33)	(14-29)	(17-33)	(21-40)	(19-36)
Winter (Jan-Mar)	26	20	27	28	24
95% C.I.	(18-35)	(14-28)	(19-37)	(19-39)	(17-32)
Spring (Apr-Jun)	23	29	25	27	22
95% C.I.	(16-30)	(21-38)	(18-33)	(19-37)	(15-30)
Summer (Jul-Sep)	28	30	24	16	27
95% C.I.	(19-39)	(23-39)	(18-31)	(10-23)	(19-37)
Bases (weighted):	*285*	*290*	*291*	*285*	*302*
Bases (unweighted):	*299*	*330*	*305*	*253*	*266*

BMI

As vitamin D is a fat-soluble vitamin, it can be stored in body fat. Vitamin D levels by Body Mass Index (BMI) group are presented in Table 9. In 2010/2011, there was a significant association between mean vitamin D levels and BMI. Adults with BMI of 30 or above had the lowest mean vitamin D level (33.3nmol/litre), compared with 38.5nmol/litre for those in the lowest BMI group (less than 25) and 41nmol/litre for those in the 25 to less than 30 BMI group (p=<0.001).

The association between vitamin D status and BMI was also significant (p=0.037). Those with a BMI of 30 or over were most likely to have suboptimal status (38%), compared with those 28% of those with a BMI of 25 to less than 30 and 33% of those with a BMI under 25.

Vitamin D levels by Scottish Index of Multiple Deprivation and BMI are in Table 10. Vitamin D levels did not significantly vary by BMI group across the deprivation quintiles.

Table 9 Vitamin D status by BMI Group

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**BMI Group**		
		Less than 25	25 to less than 30	30 and over
Mean Vitamin D	nmol/L	41.0	38.5	33.3
SE of mean	nmol/L	1.8	1.1	1.1
Standard deviation	nmol/L	25.7	21.7	18.4
Optimal (>=25nmol/l) status	%	67	72	62
95% C.I.	%	(60-73)	(67-76)	(56-68)
Suboptimal (<25nmol/l) status	%	33	28	38
95% C.I.	%	(27-40)	(24-33)	(32-44)
Bases (weighted):		*470*	*498*	*364*
Bases (unweighted):		*412*	*515*	*400*

Table 10 Vitamin D status by SIMD and BMI Group (kg/m^2)

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**5th (Least deprived)**			**4th**			**3rd**			**2nd**			**1st (Most deprived)**		
		Less than 25 (kg/m^2)	25 to less than 30 (kg/m^2)	30 and over (kg/m^2)	Less than 25 (kg/m^2)	25 to less than 30 (kg/m^2)	30 and over (kg/m^2)	Less than 25 (kg/m^2)	25 to less than 30 (kg/m^2)	30 and over (kg/m^2)	Less than 25 (kg/m^2)	25 to less than 30 (kg/m^2)	30 and over (kg/m^2)	Less than 25 (kg/m^2)	25 to less than 30 (kg/m^2)	30 and over (kg/m^2)
Mean Vitamin D	nmol/L	52.3	43.7	36.8	45.2	42.2	35.3	41.0	40.4	35.7	33.3	31.8	30.0	32.0	31.7	30.9
SE of mean	nmol/L	4.56	2.50	3.11	4.08	2.15	2.16	3.72	2.40	2.43	2.07	2.06	1.99	3.10	2.33	2.24
Standard deviation	nmol/L	28.88	22.65	20.58	28.98	23.60	17.98	23.67	21.77	18.86	16.41	16.58	16.15	22.75	18.93	18.41
Optimal (>=25nmol/l) status	%	78	76	66	68	82	68	69	77	70	70	59	59	45	59	53
95% C.I.	%	(66.6-87.0)	(66.1-84.3)	(49.1-80.3)	(54.6-79.4)	(73.1-88.0)	(56.3-78.5)	(48.7-83.4)	(67.0-85.3)	(58.4-79.6)	(53.5-82.7)	(45.7-70.3)	(45.6-71.2)	(32.8-58.0)	(45.7-71.5)	(40.1-65.3)
Suboptimal (<25nmol/l) status	%	22	24	34	32	18	32	31	23	30	30	41	41	55	41	47
95% C.I.	%	(13.0-33.4)	(15.7-33.9)	(19.7-50.9)	(20.6-45.4)	(12.0-26.9)	(21.5-43.7)	(16.6-51.3)	(14.7-33.0)	(20.4-41.6)	(17.3-46.5)	(29.7-54.3)	(28.8-54.4)	(42.0-67.2)	(28.5-54.3)	(34.7-59.9)
Bases (weighted):		*104*	*112*	*46*	*87*	*113*	*75*	*97*	*98*	*71*	*96*	*89*	*64*	*87*	*86*	*108*
Bases (unweighted):		*94*	*121*	*59*	*93*	*130*	*88*	*88*	*106*	*84*	*67*	*78*	*71*	*70*	*80*	*98*

Oily fish consumption

Vitamin D levels by oily fish consumption (as reported in the main SHeS interview) are presented in Table 11. While mean vitamin D levels appeared to be highest among those who consume oily fish most often (42.9nmol/L compared with 37.8nmol/L), the difference was not statistically significant (p=0.231). Over a third (35%) of adults who consumed oily fish less often than once a week had suboptimal vitamin D status, the equivalent for those who consumed oily fish once a week or more often was higher (23%). Again, however, these differences were not statistically significant (p=0.121).

Table 11 Vitamin D status by oily fish consumption

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**Oily fish consumption**	
		Once a week or more	Less often
Mean Vitamin D	nmol/L	42.9	37.8
SE of mean	nmol/L	3.7	1.9
Standard deviation	nmol/L	23.7	22.5
Optimal (>=25nmol/l) status	%	77	65
95% C.I.	*%*	(65-86)	(56-74)
Suboptimal (<25nmol/l) status	%	23	35
95% C.I.	*%*	(14-35)	(26-44)
Bases (weighted):		*55*	*225*
Bases (unweighted):		*64*	*220*

Vitamin supplements

Vitamin D levels by vitamin/mineral consumption are presented in Table 12. Adults who took vitamin/mineral supplements had significantly higher mean vitamin D levels than those who did not consume any (44.4nmol/litre compared with 35.5nmol/litre) (p=<0.001).

Adults who consumed vitamins/minerals were also significantly more likely to have optimal vitamin D levels than those that did not (77% compared with 63%) (p=<0.001).

Table 12 Vitamin D status by vitamin supplement consumption

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D		**Taking vitamins/mineral to improve health**	
		Yes	No
Mean Vitamin D	nmol/L	44.4	35.5
SE of mean	nmol/L	1.5	0.9
Standard deviation	nmol/L	24.5	21.2
Optimal (>=25nmol/l) status	%	77	63
95% C.I.	%	(72-82)	(59-67)
Suboptimal (<25nmol/l) status	%	23	37
95% C.I.	%	(18-28)	(33-41)
Bases (weighted):		*339*	*1114*
Bases (unweighted):		*377*	*1076*

Vitamin supplements consumption varied significantly by area deprivation (Table 13). Those living in the most deprived areas (SIMD quintile 1) were least likely to report taking vitamin supplements or minerals to improve their health (16%). Almost one in three (28%) of those living in the 20% least deprived areas (SIMD quintile 5) took vitamins or minerals to improve their health.

Table 13 Vitamin supplement consumption by Scottish Index of Multiple Deprivation quintile

Aged 16 and over *2010-2011 combined*

Plasma 25-hydroxyvitamin D	**SIMD**				
	5th (least deprived)	4th	3rd	2nd	1st (most deprived)
	%	%	%	%	%
Taking vitamins / minerals to improve health	28	27	22	24	16
95% C.I.	(22-34)	(22-34)	(17-28)	(18-32)	(12-21)
Bases (weighted):	*285*	*290*	*291*	*285*	*302*
Bases (unweighted):	*299*	*330*	*305*	*253*	*266*

Discussion

Response rate

These results reflect a subset of the total number of adults eligible to take part in the 2010 and 2011 Scottish Health Surveys. The sample represents over 1400 samples from 2 years sampling with a relatively even spread of samples across age, SIMD groups and between male and female respondents, therefore these results provide a useful overview of Vitamin D status of adults in Scotland in 2010/11.

Vitamin D status by age and sex

Mean Vitamin D status of 37.5nmol/l was above the current indicator of optimal Vitamin D status >=25nmol. However, more than one third of Scotland's adult population may not meet the criteria for optimal Vitamin D status. This was shown in both males and females and across age groups.

Optimal vitamin D status was slightly higher in older participants; adults over 65 years are also recommended to take a Vitamin D supplement.

Vitamin D status, deprivation and income

The Scottish Index of Multiple Deprivation combines 38 indicators across 7 domains: income, employment, health, education, skills and training, housing, geographic access and crime. Suboptimal vitamin D status was significantly greater in the lowest SIMD quintile than the highest. Almost half (47%) of the participants from the lowest quintile of deprivation had suboptimal vitamin D status. Similarly, when vitamin D status declined in line with income and those with the lowest incomes had lowest mean vitamin D levels. Vitamin D status and socio economic classification (NS-SEC) were also significantly associated; those in managerial / professional households had highest mean vitamin D levels.

Vitamin D status and season of interview

Scotland's latitude position at 55^{o} North means that useful sunlight for production of Vitamin D only occurs between April and September. As expected, these data show a clear link between season of interview and vitamin D status. However, 17% of individuals had suboptimal vitamin D status (<25nmol/L) during the summer.

Vitamin D status and BMI

Vitamin D is a fat soluble vitamin that can be stored in body fat. Lower vitamin D status has previously been identified in overweight subjects.[2] There was a significant association between mean vitamin D levels and BMI; adults with a BMI over 30 were most likely to have suboptimal status. When compared with SIMD vitamin D levels did not significantly vary by BMI group across the deprivation quintiles.

Vitamin D status and dietary factors

Diet may play a small part in vitamin D status, although most people should be able to produce all the vitamin D they need by getting a little sunlight. The results that mean vitamin D levels were highest in those who consume oily fish, the difference was not however statistically significant. Those who reported taking vitamin/mineral supplements had significantly higher mean vitamin D levels and more likely to have optimal status that those who did not. It should be noted that the type of vitamin supplement consumed by the participants could not be ascertained as this question was not collected in the SHeS.

The combined 2010/11 data sets allowed comparison of vitamin supplement consumption by SIMD; those living in the most deprived quintiles were least likely to report taking a vitamin supplement.

Conclusion

Average vitamin D status of the Scottish population was 37.5 nmol/L during 2010/11 and around a third of the population had sub-optimal vitamin D status (<25nmol/L). There was also a trend by socio-economic status; those in the most deprived quintile of SIMD and with the lowest household incomes had poorer vitamin D status.

References

[1] National Diet and Nutrition Survey: Headline results from Years 1 and 2 (combined) of the rolling programme 2008-9 - 2009-10 https://www.gov.uk/government/publications/national-diet-and-nutrition-survey-headline-results-from-years-1-and-2-combined-of-the-rolling-programme-2008-9-2009-10

[2] Scientific Advisory Committee on Nutrition (2007) Update on Vitamin D. London: TSO http://www.sacn.gov.uk/pdfs/sacn_position_vitamin_d_2007_05_07.pdf

[3] http://www.scotland.gov.uk/Resource/0038/00386921.pdf

[4] IOM (Institute of Medicine) (2010) Dietary Reference Intakes for Calcium and Vitamin D. Washington, DC: The National Academies Press. http://www.iom.edu/Reports/2010/Dietary-Reference-Intakes-for-Calcium-and-Vitamin-D.aspx

[5] http://www.sacn.gov.uk/meetings/working_groups/vitamin/index.html

[6] Rutherford, L., Sharp, C. and Bromley, C. [eds] (2012) Scottish Health Survey 2011 - Volume 1: Adults. Edinburgh: Scottish Government. http://www.scotland.gov.uk/Publications/2012/09/7854

[7] UK Food Standards Agency Workshop Consensus Report: the choice of method for measuring 25-hydroxyvitamin D to estimate vitamin D status for the UK National Diet and Nutrition Survey

[8] http://www.natcen.ac.uk/media/978078/ndns-y3-report_all-text-docs-combined.pdf

[9] Bromley C., and Given.L. [eds] (2011) Scottish Health Survey 2010 - Volume 2: Technical Report report. Edinburgh: Scottish Government. http://www.scotland.gov.uk/Publications/2011/09/27124046/0

[10] Rutherford, L., Sharp, C. and Bromley, C. [eds] (2012) Scottish Health Survey 2011 - Volume 3: Technical Report. Edinburgh: Scottish Government http://www.scotland.gov.uk/Publications/2012/09/8038

[11] http://www.ons.gov.uk/ons/guide-method/classifications/archived-standard-classifications/ns-sec/index.html

[12] http://www.scotland.gov.uk/Topics/Statistics/Browse/Social-Welfare/IncomePoverty/Methodology

[13] http://www.scotland.gov.uk/Topics/Statistics/SIMD/BackgroundMethodology