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Vitamin D status in the Norwegian population

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Abstract

In Norway, rickets was eradicated during the 20th century, but have later re-emerged in certain subgroups of the population. Our objective is to give an overview of vitamin D status in Norway, as a basis for evaluating whether measures for increasing vitamin D status should be taken. We performed a systematic literature review in order to collect all data published during the previous 30 years on vitamin D status in healthy groups of the Norwegian population.

Existing data suggest that vitamin D status is sufficient in the general population, and it seems to be better than in populations further south in Europe. However, a relatively large proportion of the population has insufficient levels, and there is a drop in vitamin D status in late winter, also in southern Norway. Elderly, in particular nursing home residents, may have poor vitamin D status, depending on practice of supplementation. Some non-western immigrant groups, Pakistanis in particular, are at high risk of vitamin D deficiency. Levels that could imply risk of vitamin D toxicity were not found in any group.

We conclude that there is a need for measures to ensure vitamin D status in the population in Norway.

Introduction

Vitamin D is important for normal bone health (2). Vitamin D deficiency is a well-known cause of rickets in children and osteomalacia in adults, and it is also of importance for development of osteoporosis. Beyond this, vitamin D deficiency is suggested as a contributing factor in the development of several other diseases and conditions such as diabetes, some cancer types and immunologic diseases (2-4).

Early in the 20th century, vitamin D deficiency was a public health problem in Norway as well as in other northern countries. Addition of vitamin D to foods such as milk and margarine in the 1930s was probably the most important measure to eradicate rickets as a severe health problem in North-America and Europe. In Norway, vitamin D was added to margarine in 1950 and to butter in 1990. Mother and child health centers have also been working purposefully in order to increase the vitamin D supply to Norwegian infants. There are few natural sources of vitamin D. When the production in skin by ultraviolet radiation is insufficient, such as during wintertime at northern latitudes, diet and supplements become the most important sources. The only sources of importance in a typical Norwegian diet as of today are fatty fish, vitamin D-enriched butter and margarine, a few types of vitamin D enriched milk, as well as cod liver oil and multivitamin supplements.

The aim of this paper is to summarize published literature on vitamin D status in Norway, as a basis for evaluating whether there is a need for measures in order to increase vitamin D status in the population.

Materials and methods

Our intention has been to go through all published data from the previous 30 years where vitamin D status in the form of serum or plasma concentration of 25-hydroxyvitamin D has been determined in groups of the healthy population in Norway. We performed a systematic Medline search including the following criteria: Norway AND (”Vitamin D” OR ”vitamin D status” OR “vitamin D deficiency” OR “25-hydroxyvitamin D”). Of the 82 hits we retrieved, we excluded papers that were reviews, those that were not based on data from Norway, studies where 25-hydroxyvitamin D had not been measured, and/or where the sample was representative of certain disease conditions rather than groups of the general population. In addition, we have searched through the archives of the Journal of the Norwegian Medical Association (5), and we have gone through references in the publications we have retrieved. Furthermore, we have gone through previously published reports from the Directorate for Health and Social Affairs, and we have searched through the electronic archive of student assignments, master theses and doctoral theses at the universities in Norway. In our evaluation we defined levels of 25-hydroxyvitamin D <25 nmol/l as vitamin D deficiency, and levels <50 nmol/l as insufficient levels (2). It should, however, be kept in mind that interlaboratory variation could be a limitation when comparing data from different laboratories.

Results

We have retrieved results from 16 scientific papers as well as three doctoral theses, two cand. scient. theses and one report where 25-hydroxyvitamin D (25(OH)D) status had been measured in groups of the healthy population in Norway. The studies have been summarized in Table 1.

Infants and toddlers

A study performed during the early 1980s showed that 6 weeks old breastfed infants who did not receive vitamin D supplementation had very low vitamin D status measured in March. However, those who received infant formula had good vitamin D status. The sample size was small (6).
One year old children in Oslo studied in April-June 2000 had on average good vitamin D status (7). Among breastfed one-year-olds, 34% had levels <50 nmol/l, and among those not receiving breast milk, 20% had levels <50 nmol/l.
Two year old children in the same study had similar levels when measured in March-June 2001 (8). Among those receiving vitamin D supplements (n=109), mean 25(OH)D was 70 nmol/l and 14% had levels <50 nmol/l. Among those not receiving vitamin D supplements (n=61) mean 25(OH)D was 60 nmol/l and 38% had levels <50 nmol/l.

Children and adolescents

A study from Bergen (60°N) published in 1982 showed on average good vitamin D status in 191 healthy children and adolescents aged 8-18 years (mean 80 nmol/l) (9). Vitamin D status in children and adolescents was dependent both on use of vitamin D supplements and of season (10). The poorest vitamin D status was observed in samples from 17 year old boys in Bergen analyzed in January (n=20). In contrast, 11 year old girls in Bergen analyzed in September had a very good vitamin D status on average, and none had vitamin D deficiency (n=19). Ten-year-olds in Hammerfest (70°N) did not have poorer vitamin D status compared with children in Bergen (10).

Adult ethnic Norwegians

Among 869 ethnic Norwegian men and women aged 45-75 years who participated in the population based Oslo Health Study 2000-2001, the majority had sufficient vitamin D status, and there was no gender difference in vitamin D status (11).

Three hundred women aged 44-59 years living in Northern Norway (65-71°N) who had their vitamin D status measured in a population based study had on average sufficient 25(OH)D levels (12). However, a relatively large proportion had levels <50 nmol/l (Figure 1). There was a strong association between dietary vitamin D intake and 25(OH)D levels when those reporting use of tanning beds or sun holidays were excluded.

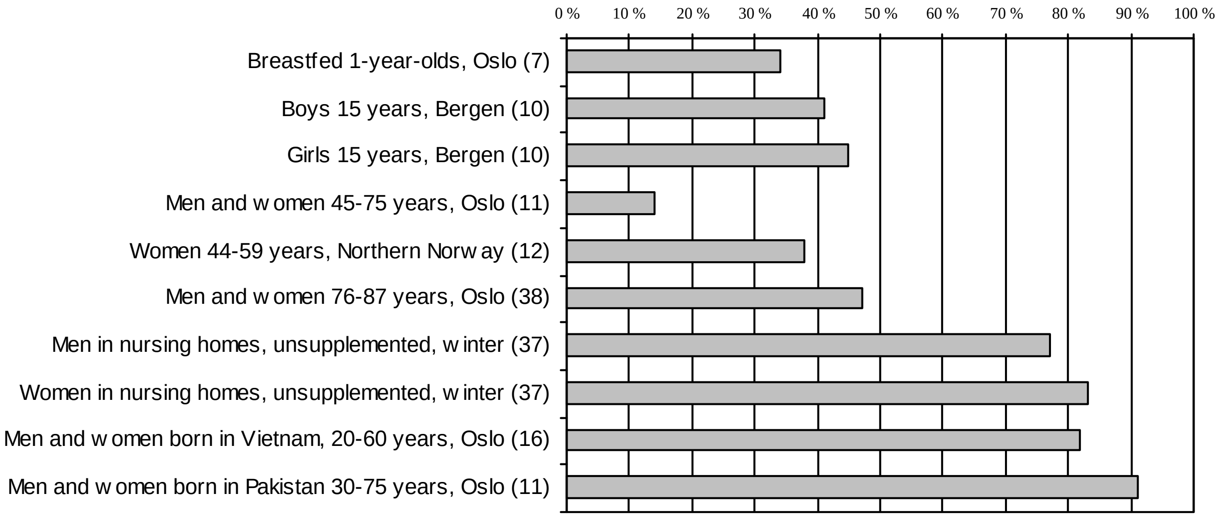

Figure 1. *Prevalence of vitamin D insufficiency (defined as serum 25-hydroxyvitamin D <50 nmol/l) in groups of the Norwegian population*

Non-western immigrants

In a study among Pakistani and Norwegian women delivering at Ullevål University Hospital during spring 1990 and 1991, all except one of the Pakistani women had vitamin D deficiency defined as serum 25(OH)D <30 nmol/l (97%), whereas among the Norwegian women, 8 out of 23 (35%) had vitamin D deficiency (13).

In another study from Oslo, pregnant Pakistani women also had much lower vitamin D status compared with Norwegian women (14). Margarine was the largest source of vitamin D, and it contributed to almost ¾ of estimated intake of vitamin D in the Pakistani women.

Also among premenopausal women, vitamin D status was lower in Pakistanis than among Norwegians (15).

Vitamin D status was very low both among women and men with Pakistani background who met to the Oslo Health Study, and the prevalence of serious vitamin D deficiency (defined as secondary hyperparathyroidism) was 4-5 times higher in Pakistanis compared to Norwegians (11). A high prevalence of vitamin D deficiency was also found in both women and men born in Turkey, Sri Lanka, Iran, Pakistan, and Vietnam (n=1000) who met to the Oslo Immigrant Health

Study in 2002 (16). Frequent use of cod liver oil supplements and fatty fish was associated with high serum 25(OH)D in these five immigrant groups.

Elderly

Seventy-five-year-olds living at home who participated in the Oslo Health Study had as good vitamin D status as younger Norwegians (11). In a European multi-center study, 70-75 year old Norwegian men and women in Elverum (61°N) had higher vitamin D status than men and women at the same age living at more southern latitudes in Europe (17).

Among men and women above 70 years in Oslo in the 1990s, 98 living at home and 277 recently hospitalized, vitamin D status was low, and it was lowest in the hospitalized (18). Half of the hospitalized women had vitamin D deficiency. In those living at home, 25(OH)D levels measured in late summer were significantly higher than those measured in late winter, but this was not found among the hospitalized.

In an intervention trial with vitamin D supplementation performed in 51 nursing homes in Oslo and Bergen, nursing home residents of both genders with mean age 85 years had mean 25(OH)D levels of 49 nmol/l at baseline (19). Mean 25(OH)D after one year of vitamin D supplementation was 64 nmol/l (n=31).

Discussion

In general, Norwegians appear to have a better vitamin D status compared to populations of other Nordic countries as well as countries further south (20). It is known that vitamin D status depends on diet and supplementation, sun exposure, season and latitude, as well as biologic factors such as age, skin pigmentation, and body composition. The most sensitive measure of vitamin D status is the concentration of 25-hydroxyvitamin D in serum (4). There is of today no common consensus as to which levels should be regarded as optimal with regard to health. Based on studies on which levels are associated with increased parathyroid hormone response and bone turnover, different cut-off limits have been suggested. We have used a proposed cut-off that we regard as reasonable (2). However, it has been suggested that higher levels, such as in the magnitude of 90-100 nmol/l, may be optimal for bone mineral density, muscle function, dental health, and risk of falls, fractures, and colorectal cancer (3).

A serum concentration of 200 nmol/l is regarded as an upper limit where no adverse effects are observed (21).

Clinical signs of vitamin D deficiency are rarely seen in Norway today. However, an increasing number of infants and toddlers with rickets have been admitted to pediatric departments during the last decades, and these children are predominantly of immigrant background (22). Vitamin D stores decrease rapidly after birth in breastfed infants, and rickets usually makes its debut between the age of 6 months and 2 years (23). Children born of mothers with low stores of

25-hydroxyvitamin D will have poor vitamin D status from the start, and will have an increased risk of developing rickets. Breast milk contains little vitamin D, and breastfed infants need vitamin D supplements to reach the recommended intake (24).

There is a too limited data basis for drawing conclusions regarding vitamin D status in children and adolescents. As the intake of vitamin D is low in adolescents (25) there is reason to believe that vitamin D status may be low, particularly in Northern Norway where sun exposure is limited during the winter months.

Factors predisposing for vitamin D deficiency in persons with immigrant background from non-western countries include a high degree of skin pigmentation, avoidance of direct sun exposure combined with religious or cultural clothing habits, and a diet poor in vitamin D and limited use of cod liver oil and supplements (26). A high prevalence of vitamin D deficiency in immigrants from the Indian Subcontinent has been found in Denmark (27;28) and the UK (29;30), and Norwegian data correspond to this. However, we lack information about immigrant groups other than those who participated in the Oslo Immigrant Health Study.

In elderly, vitamin D status may be poor due to ineffective synthesis in the skin, as well as reduced dietary intake and outdoor activity. The production of the active vitamin D hormone will also decrease with impaired renal function (2). Existing data suggest that institutionalized elderly may benefit less of the sunlight during the summer months, thus supplementation is an all the more important source. Our knowledge about vitamin D status in elderly is not based on nationwide data but samples from Oslo and Bergen. Vitamin D status in elderly will depend upon local conditions such as dietary habits, sun availability and sun exposure, and routines for supplementation in the nursing homes.

Conclusion

Vitamin D status in the majority of the adult Norwegian population is sufficient. However, levels are insufficient in a relatively large proportion of the population, and there is a drop in vitamin D status in late winter, also in southern Norway. In particular, elderly nursing home residents and certain non-western immigrant groups are at high risk of vitamin D deficiency. There is a need for measures to increase vitamin D status, both in the form of increased addition of vitamin D to foods directed towards the general population, and vitamin D supplementation to high-risk groups. Monitoring vitamin D status is important in vulnerable groups, but also in representative samples of the general population.

Table 1. *Overview over published studies that have assessed 25-hydroxyvitamin D status in groups of the healthy population in Norway*

	Publication	Place	Population	Age	n	Time of year	Mean (95% CI) serum 25(OH)D (nmol/l)	Proportion (%) with vitamin D deficiency	Cut-off limit for defining vitamin D deficiency (nmol/l)
Infants and toddlers	Markestad 1983 (6)	Bergen	Breastfed, not receiving supplementation	4 days	19	March	32 (25,39)		
			Breastfed, not receiving supplementation	6 weeks	16	March	16 (13, 19)	81%	20
			Formula fed infants	6 weeks	8	March	92 (77, 107)		
			Receiving sun exposure, no supplements	7-18 mo.	22	Sept	85 (73, 97)		
			Infants receiving vitamin D supplements	6-12 mo.	37	March	53 (44, 62)	19%	20
	Grønnerud 2000 (7)	Oslo	1-year-olds	1 y	249		61 (59, 63)		
	Kverndokk 2001 (8)	Oslo	2-year-olds	2 y	227	March-June	66 (63,69)	24%	50
Children and adolescents	Aksnes & Aarskog, 1982 (9)	Bergen	Boys and girls, supplemented	8-18 y	19	March	74 (64, 84)		
			Boys and girls, unsupplemented	8-18 y	34	March	55 (48, 62)		
	Pedersen et al., 1989 (10)	Bergen	Boys	12 y	26	April	68 (59, 76)	0 (27%)	30 (50)
			Girls	15 y	22	March	62 (51, 73)	9% (45%)	30 (50)
			Boys	15 y	32	March	61 (54, 68)	0 (41%)	30 (50)
			Boys	17 y	20	January	53 (43, 64)	25% (50%)	30 (50)
			Girls	11 y	19	Sept	112 (102,122)	0 (0)	30 (50)
			Boys	16 y	29	Sept	124.5	0 (0)	30 (50)
		Hammer-fest	Boys and girls, spring	10 y	20	March	64 (58, 70)	0 (5%)	30 (50)
			Boys and girls, autumn	10 y	20	Sept	73 (65, 81)	0 (5%)	30 (50)
Healthy adults (general population)	Vik et al., 1979 (31)	Tromsø	Men (control group)		46		63 (56, 71)		
	Vik et al., 1980 (32)	Tromsø	Adults, taking vitamin D supplement		6	March	82 (68, 96)		
			Adults, not taking vitamin D supplement		17	Sept	82 (70, 94)		
						Nov	55 (48, 62)		
						January	54 (48, 60)		
						March	52 (42, 61)		
						May	54 (47, 62)		
						July	84 (75, 94)		
						Sept	78 (68, 87)		

Table 1, cont.

	Publication	Place	Population	Age	n	Time of year	Mean (95% CI) serum 25(OH)D (nmol/l)	Proportion (%) with vitamin D deficiency	Cut-off limit for defining vitamin D deficiency (nmol/l)
	Markestad et al., 1986 (33)	Bergen	Young women	24-36 y	17	May-Oct	80 [(1)]		
	Bjørneboe et al., 1988 (34)	Oslo	Men	30-64 y	35	Jan-Feb	54 (44, 64)		
	Aksnes et al., 1989 (35)	Bergen	Young adults	22-59 y	25	April-June	63 [(1)]	0	30
	Falch & Steihaug, 2000 (15)	Oslo	Premenopausal women	35-50 y	24	March-May	65 (55, 74)		
	Tuohimaa et al., 2004 (36)	Several counties, including Oslo	Men (blood donors)		1077	Jan-Dec	55 (54, 56)		
	Brustad, 2004 (12)	Northern Norway	Women	44-59 y	300	Nov-June	57 (55, 59) [(2)]	38% 0.7%	50 25
	Meyer et al., 2004 (11)	Oslo	Men and women born in Norway	45-75 y	869	May-Jan	75 (73, 76)	0.2% (14%)	25 (50)
Pregnant and delivering women	Markestad, 1986 (33)	Bergen	1st trimester, unsupplemented, summer 1st trimester, unsupplemented, winter	23-40 y	22	May-Oct Nov-Apr	131 [(1)] 80 [(1)]		
	Brunvand & Haug, 1993 (13)	Oslo	Delivering Norwegian women	26±4.2 y	23	Feb-June	43	35%	30
	Henriksen et al., 1995 (14)	Oslo	Pregnant Norwegian women	26-32 y	36	Oct-Jan	55 (41, 72) [(1)]	6%	30

***Table 1**, cont.*

	Publication	Place	Population	Age	n	Time of year	Mean (95% CI) serum 25(OH)D (nmol/l)	Proportion (%) with vitamin D deficiency	Cut-off limit for defining vitamin D deficiency (nmol/l)
Elderly, healthy, living at home	Sem et al., 1987 (37)	Oslo	Women	70-92 y					
			unsupplemented, winter		10	Feb/Mar	54 (43, 65)	40%	50
			unsupplemented, summer		12	Aug/Sep	70 (55, 85)	17%	50
			supplemented, winter		14	Feb/Mar	89 (79, 99)	0	50
			supplemented, summer		12	Aug/Sep	94 (80, 109)	0	50
	Nes et al., 1988 (38)	Oslo	Men and women	76-87 y	15	Sep-June	58 (48, 69)	47%	50
	Aksnes et al., 1989 (35)	Bergen	Active elderly living at home	70-90 y	19	April-June	47 (1)	16%	30
	van der Wielen et al., 1995 (17)	Elverum	Men	70-75 y	32		45	28%	30
			Women	70-75 y	28		48	18%	30
	Mowé et al., 1998 (18)	Oslo	Men	>70 y	50	All year	60 (52, 68)	18%	30
			Women	>70 y	48	All year	49 (43, 54)	25%	30
	Meyer et al., 2004 (11)	Oslo	Men	75 y	70	May-Jan	76	0	25
			Women	75 y	219	May-Jan	73	0	25
Elderly, institutionalized, reduced functional level	Sem et al., 1987 (37)	Oslo (5 nursing homes)	Women	74-94 y					
			unsupplemented, winter		12	Feb/Mar	36 (25, 47)	83%	50
			unsupplemented, summer		12	Aug/Sep	49 (36, 61)	58%	50
			supplemented, winter		23	Feb/Mar	96 (83, 108)	9%	50
			supplemented, summer		23	Aug/Sep	97 (83, 111)	9%	50
			Men	69-96 y					
			unsupplemented, winter		13	Feb/Mar	42 (34, 49)	77%	50
			unsupplemented, summer		13	Aug/Sep	40 (33, 47)	77%	50

***Table 1**, cont.*

	Publication	Place	Population	Age	n	Time of year	Mean (95% CI) serum 25(OH)D (nmol/l)	Proportion (%) with vitamin D deficiency	Cut-off limit for defining vitamin D deficiency (nmol/l)
	Nes et al., 1988 (38)	Oslo	Women and men with dementia	76-87 y	15	Sep-June	50 (38, 63)	47%	50
	Aksnes et al., 1989 (35)	Bergen	Nursing home residents, vit D 10 µg/day	71-96 y	29	Apr-Jun	65 [(1)]	3%	30
			Nursing home residents, no supplement	73-96 y	14	Apr-Jun	34 [(1)]	36%	30
	Mowé et al., 1998 (18)	Oslo	Men admitted to hospital	>70 y	129	All year	40 (36, 44)	34%	30
			Women admitted to hospital	>70 y	148	All year	38 (34, 41)	49%	30
	Meyer et al., 2002 (19)	Oslo & Bergen	Elderly women in nursing homes		104		48 (43, 53)	21%	25
Non-western immigrants	Brunvand & Haug, 1993 (13)	Oslo	Delivering Pakistani women	28±5.8 y	30	Feb-June	15	97%	30
	Henriksen et al., 1995 (14)	Oslo	Pregnant Pakistani women	23-29 y	36	Oct-Jan	19 (15, 25) [(1)]	83%	30
	Falch & Steihaug, 2000 (15)	Oslo	Pakistani premenopausal women	35-50 y	26	Mar-May	22 (16, 27)	96%	50
	Meyer et al., 2004 (11)	Oslo	Pakistani men and women living in Oslo	30-75 y	177	May-Jan	25 (23, 27)	59%	25
	Holvik et al., 2005 (16)	Oslo	Men and women living in Oslo	20-60 y					
			Country of birth Turkey		188	Feb-Nov	29 (21, 38) [(1)]	35% (88%)	25 (50)
			Country of birth Sri Lanka		310	Feb-Nov	30 (22, 39) [(1)]	33% (92%)	25 (50)
			Country of birth Iran		199	Feb-Nov	29 (21, 39) [(1)]	36% (86%)	25 (50)
			Country of birth Pakistan		191	Feb-Nov	22 (18, 29) [(1)]	59% (97%)	25 (50)
			Country of birth Vietnam		112	Feb-Nov	38 (28, 47) [(1)]	18% (82%)	25 (50)

[(1)] Median (25, 75 percentile) serum 25(OH)D [(2)] Plasma 25(OH)D

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