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Successful nutrition policy: improvement of vitamin D intake and status in Finnish adults over the last decade

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Background: Due to vitamin D intake below recommendation (10 μg/day) and low (<50 nmol/l) serum 25-hydroxycholecalciferol (25(OH)D) concentration in Finnish population, the fortification of liquid dairy products with 0.5 μg vitamin D/100 g and fat spreads with 10 μg/100 g started in Finland in December 2002. In 2010, the fortification recommendation was doubled. The aim of this study was to investigate whether the vitamin D intake and status have improved among Finnish adults as a consequence of these nutrition policy actions. A further aim was to study the impact of vitamin supplement use to the total vitamin D intake. **Methods:** A cross-sectional survey was conducted every 5 years. The National FINDIET Survey was conducted in Finland as part of the National FINRISK health monitoring study. Dietary data were collected by using a computer-assisted 48-h dietary recall. In 2002, dietary data comprised 2007, in 2007, 1575 and 2012, 1295 working aged (25–64 years) Finns. **Results:** The mean D-vitamin intake increased from 5 μg/day to 17 μg/day in men and from 3 μg/day to 18 μg/day in women from 2002 to 2012. The most important food sources of vitamin D were milk products, fat spreads and fish dishes. The share of milk products was 39% among younger men and 38% among younger women, and 29% among older men and 28% among older women. Fat spreads covered on average 28% of vitamin D intake, except for younger men for which it covered 23%. Fish dishes provided 28% of vitamin D intake for older men and women, and approximately 18% for younger ones. In January–April 2012, the average serum 25-hydroxycholecalciferol (25(OH)D) concentration for men was 63 nmol/l for men and for women 67 nmol/l for women. **Conclusions:** The fortification of commonly used foods with vitamin D and vitamin D supplementation seems to be an efficient way to increase the vitamin D intake and the vitamin D status in the adult population.

Introduction

Vitamin D consists of fat-soluble secosteroids. The most important compounds in this group are cholecalciferol (vitamin D_3) and ergocalciferol (vitamin D_2) which can be ingested from the food. Cholecalciferol can also be synthesized in the skin when sun exposure is adequate.[1] Vitamin D has an important role in regulating the calcium concentration in the body especially in bone, intestine and kidney. Vitamin D receptors are also found in many other organs and tissues such as skin, muscles, bone marrow, nervous system and genitals.[2]

The most important reasons for vitamin D deficiency are low vitamin D intake from food, lack of sun exposure and impaired absorption from intestine. Serum 25-hydroxycholecalciferol (25(OH)D) is used to measure the vitamin D status.[3] In the comprehensive review of vitamin D, there was found evidence that a concentration of ≥50 nmol/l could be optimal,[4,5] although there are different views in scientific community what the recommended level is depending on the endpoint.[6] Vitamin D has been associated with the risk of several chronic diseases e.g. diabetes, several cancers, allergies, depression and cardiovascular disease.[7,8] However, most findings about the health effects of vitamin D are still quite inconsistent.[9,10] The only exception is vitamin D's effects on bone health for which the dietary recommendations are based.

In Northern countries as in Finland, the amount of UVB radiation from October to March is too low to cause noteworthy vitamin D synthesis in the skin.[11] Low vitamin D status has been found in all age groups in Finland.[5,12,13] In FINRISK 2002 Study the mean (SD) serum 25(OH)D status for women was 47.6 (25.4) nmol/l and for men 45.0 (18.9) nmol/l.[13] Low vitamin D status has also been found in other Nordic countries especially among Muslims[14] and among pregnant women.[15] When comparing different studies, it has to be taken into the account that measurements for serum 25(OH)D analyses are not harmonized.[5] In a recent Swedish study,[16] the same samples were analysed in three different laboratories and the results varied largely. Vitamin D intake from food is low in all Nordic countries.[17] In Finland, the intake in 2002 for adults was on an average of 7.4 μg/day.[13] In Sweden, the mean vitamin D intake was 6 μg/day for women and 8 μg/day for men in 2010/2011.[17] In Iceland, vitamin D intake for adults who used cod liver was 13.5 μg/day, whereas vitamin D intake for non-users was 4 μg/day.[18] In Denmark, the estimated dietary intake of vitamin D of adults varied between 0.2 and 23 μg/day in 1999–2001.[19]

To manage insufficient vitamin D intake and status in the Finnish population, the National Nutrition Council has suggested fortification of specific food items, and a new decree based on that proposal was launched in December 2002. All liquid dairy products were recommended to be fortified with 0.5 μg vitamin D_3/100 ml and all fat spreads with 10 μg/100 g, except butter.[20] In consequence,

vitamin D status improved in all age groups but low 25(OH)D concentration (<50 nmol/l) was still found among 14–17-year old girls, 27–60-year-old women and 27–35-year-old men in 2004.[20] National FINDIET 2007 Survey[21] revealed that the average dietary intake of vitamin D was below recommendation both among women men. Therefore, in 2010, National Nutrition Council doubled the recommendation of vitamin D amount to be added to liquid dairy products (1 μg vitamin D_3/100 ml) and fat spreads (20 μg vitamin D_3/100 g). Most of the dairy products and fat spreads are fortified and sold in all grocery stores as well as used in mass catering services in Finland, although the fortification is not mandatory. Only organic products are not allowed to be fortified. In addition to the fortification, vitamin D supplementation has been used as a way to improve the 25(OH)D status in the population.[13] Fortification has been used to improve populations' nutrition in Finland since 1940s.[22] Vitamins A and D were added to margarine, iodine to table salt, iron and thiamine to white flour.

The aim of the current study was to investigate vitamin D intake and serum 25(OH)D status among Finnish adults in 2012. Further aim was to study whether the vitamin D intake has improved among Finnish adults as a consequence of nutrition policy actions implemented during the years 2003–2011 and to study the impact of vitamin supplement use to the total vitamin D intake.

Methods

The National Findiet 2012 Survey[23] was conducted between January and April 2012 as part of the National FINRISK 2012 Study.[24,25] Independent, random and representative population samples from five different parts of Finland were collected. Adults aged 25–74 years in each study region was selected as a random sample ($n = 2000$) stratified according to sex and 10-year age groups from the Population Register. The final sample size was 9905 from which 33% ($n = 3268$) was invited to the National Findiet 2012 Survey. Finally, 53% ($n = 1721$) of the invited participated the dietary survey and an accepted 48 h dietary recall was obtained from 52% ($n = 1708$) of those invited.

Respondent aged 25–64 years were included in the study (585 men and 710 women). The Findiet Survey was conducted in 2002 and 2007 in the same manner than in 2012. In 2002, acceptable 48-h recall was obtained for 63% ($n = 2007$) of the invited subjects,[26] and in 2007, acceptable data were obtained for 62% ($n = 2039$).[21] Final data for 2007 in the current paper were 1575 participants, since the oldest age group was excluded.

Dietary data were collected using a computer-assisted 48-h dietary recall that was carried out by trained nutritionists.[26] More detailed description on dietary data collection is described by Reinivuo et al.[27] and information of the validation process by Männistö et al.[26]

The vitamin supplement use was collected in 2002 by questionnaire from previous 6-month period, whereas in 2007 and 2012 by 48-h dietary recall. The Finnish food composition database, Fineli®,[28] was used to calculate daily vitamin D intakes and food use of the participants.[27] Fineli® database is completed with accurate vitamin D contents of the fortified foods after the fortification took place in Finland. Vitamin D content of fish was updated in 2003.

The study included a self-administered questionnaire and a health examination, where anthropometric measurements and blood sampling were carried out. The socio-demographic variables were gender, age and education. Age was divided into two categories (25–44- and 45–64-years-old). Education (in years) was categorised into tertiles by sex and birth year in order to take into account the changes in the education system over time.

All blood samples were handled with standardized international protocols.[29] Sera were frozen immediately after separating and sent in dry ice to the central laboratory of National Institute for Health and Welfare for analyses. The Architect 25-(OH)-D method was used for the determination of serum vitamin D. The method is a high through-put automated chemiluminescent microparticle immunoassay (ARCHITECT 25-OH Vitamin D assay, Abbott Laboratories, Abbott Park, IL, USA), which measures both 25-(OH)-D2 and 25-(OH)-D3. The coefficient of variation (CV%) of the controls was 3.8 ± 2.2% (mean ± SD). The laboratory has participated in DEQAS, an international 25-hydroxyvitamin D external quality assessment scheme, from January 2012 (4 times/year, 18 times so far). The performance target set by the DEQAS advisory panel was met for all rounds.

Statistical analyses

The differences in vitamin D intake and status between age groups and education levels as well as between supplement user groups were tested using analysis of variance. Values of vitamin D intake and vitamin D status were log-transformed before analysis in case of non-normality. If values were still not normal after transformation, the Mann–Whitney U test (age groups) or the Kruskal–Wallis test (education levels) was used for vitamin D intake and status. The proportions of vitamin D supplement users in years 2007 and 2012 were compared using logistic regression. Changes over time (2002–2012) in vitamin D intake from food and in the total vitamin D intake were examined using analysis of variance after log-transformation. The differences in vitamin D intake from supplements among supplement users in different study years were tested using the Kruskal–Wallis test. The analyses were done using the SAS statistical package (SAS Institute Inc., Cary, NC, USA, version 9.3).

Results

In 2012, the mean vitamin D intake for men was 17.3 (17.0) μg/day (table 1). The mean daily vitamin D intake for men who did not use supplements was 11.2 (7.5.) μg compared with that of 29.5 (23.1) μg among supplement users. The mean vitamin D intake for women was 17.5 (15.4) μg/day (table 1). For women who did not use supplements, the average daily intake from food was 8.6 (6.2) μg. Among supplement users, the daily intake was on an average three times higher [24.7 (16.8) μg] compared with non-supplement users.

Serum 25-OH-vitamin D concentration in 2012 was on average 63.3 (23.6) nmol/l for men and 66.5 (24.0) nmol/l for women. For supplement non-users the average vitamin D (25(OH)D) level in serum was almost 60 nmol/l and for supplement users over 70 nmol/l (table 1).

In the 25th percentile, the serum 25-OH-vitamin D concentration was 48.0 nmol/l and 49.0 nmol/l for men aged 25–44 years and 45–64 years, respectively. For women, the figures were 51.0 nmol/l and 52.0 nmol/l (table 2). Median of the status was around 60 nmol/l and 75th percentile over 70 nmol/l for men and women in both age groups. There were altogether 26% of men and 21% of women who had serum 25-OH-vitamin D concentration below recommended 50 nmol/l (table 2). Of those, 83% (men) and 71% (women) were supplement non-users.

There were no differences in vitamin D intake or status between age or educational groups (table 1). The proportion of vitamin D supplements users did not change from 2002 to 2007, but increased from 2007 to 2012 ($P < 0.0001$) (figure 1). In 2007, 22% of younger men (25–44 years old) and 16% of older men (44–65 years old) reported to use supplements which contained vitamin D, and in 2012 the proportion of supplement users was 33% for both age groups. Among women the proportion of supplement users was 28% and 34% in 2007, and 53% and 57% in 2012, in respective age groups.

The most important food sources of vitamin D were dairy products and fat spreads and fish dishes. For younger Finns (25–44 years), the dairy products (ca. 38%) were the most important source of vitamin D whereas for older (45–64 years) respondents dairy products, fat spreads and fish dishes were equally important, ca. 28%. There were few respondents who did not use fish or dairy at

Table 1 Mean daily vitamin D intake and serum 25-hydroxycholecalciferol (25(OH)D) concentration in men and women by vitamin D supplement use in 2012

Men (*n*=584)													
	Mean intake μg/d (SD)							**Mean 25(OH)D status nmol/l (SD)**					
	Non-supplement users (*n*=391)		**Supplement users (*n*=193)**		***P* values**	**All**		**Non-supplement users (*n*=391)**		**Supplement users (*n*=193)**		***P* values**	**All**	
Age group														
25–44	11.1	(6.5)	32.2	(29.1)	<0.001	18.1	(20.1)	57.3	(18.4)	75.9	(32.1)	<0.001	63.5	(25.3)
45–64	11.3	(8.1)	27.5	(17.4)	<0.001	16.7	(14.2)	58.9	(20.9)	72.2	(22.3)	<0.001	63.3	(22.3)
P values	*ns.*		*ns.*					*ns.*		*ns.*				
Education[a]														
Low	11.9	(7.2)	29.0	(21.7)	<0.001	17.2	(15.6)	57.4	(15.5)	72.3	(25.8)	<0.001	62.0	(20.4)
Medium	11.6	(8.2)	29.7	(23.0)	<0.001	16.9	(16.4)	59.9	(20.8)	75.7	(32.1)	<0.001	64.5	(25.6)
High	10.1	(7.0)	29.6	(24.5)	<0.001	17.8	(18.9)	57.3	(22.9)	73.5	(23.8)	<0.001	63.7	(24.6)
P values	*ns.*		*ns.*					*ns.*		*ns.*				
All	**11.2**	**(7.5)**	**29.5**	**(23.1)**	<0.001	**17.3**	**(17.0)**	**58.2**	**(19.9)**	**73.7**	**(26.9)**	<0.001	**63.3**	**(23.6)**
Women (*n*=710)														
	Mean intake μg/d (SD)							**Mean 25(OH)D status nmol/l (SD)**					
	Non-supplement users (*n*=317)		**Supplement users (*n*=393)**		***P* values**	**All**		**Non-supplement users (*n*=317)**		**Supplement users (*n*=393)**		***P* values**	**All**	
Age group														
25–44	8.3	(5.3)	25.5	(18.7)	<0.001	17.4	(16.5)	56.6	(18.4)	74.7	(26.1)	<0.001	66.2	(24.5)
45–64	8.8	(6.9)	24.0	(15.0)	<0.001	17.5	(14.3)	59.2	(19.3)	72.3	(24.9)	<0.001	66.7	(23.6)
P values	*ns.*		*ns.*					*ns.*		*ns.*				
Education[a]														
Low	8.8	(7.5)	25.7	(18.4)	<0.001	17.0	(16.2)	54.9	(16.7)	73.5	(25.5)	<0.001	64.0	(23.3)
Medium	8.2	(4.9)	24.4	(16.0)	<0.001	17.6	(14.9)	59.9	(16.5)	76.2	(29.5)	<0.001	69.4	(26.1)
High	8.7	(5.3)	24.2	(16.3)	<0.001	17.9	(15.1)	59.5	(22.4)	70.8	(21.2)	<0.001	66.2	(22.4)
P values	*ns.*		*ns.*					*ns.*		*ns.*				
All	**8.6**	**(6.2)**	**24.7**	**(16.8)**	<0.001	**17.5**	**(15.4)**	**57.9**	**(18.9)**	**73.4**	**(25.4)**	<0.001	**66.5**	**(24.0)**

a: Education was categorised into tertiles by year of birth.

Table 2 Percentiles of daily serum 25-OH-vitamin D concentration in men and women in 2012

Age group			**Men 25(OH)D status (mmol/l)**							**Women 25(OH)D status (mmol/l)**						
	n	**1st percentile**	**25th percentile**	**Mean**	**SD**	**50th percentile**	**75th percentile**	**99 percentile**	**n**	**1st percentile**	**25th percentile**	**Mean**	**SD**	**50th percentile**	**75th percentile**	**99th percentile**
25–44	248	30.0	48.0	63.4	25.3	59.0	73.0	168.0	341	24.0	51.0	66.2	24.5	62.0	77.0	162.0
45–64	336	20.0	49.0	63.3	22.3	62.0	74.0	128.0	369	28.0	52.0	66.7	23.6	64.0	76.0	130.0
All	584	22.0	48.0	63.3	23.6	60.0	73.0	155.0	710	27.0	51.0	66.5	24.0	62.5	77.0	139.0
25(OH)D concentration <50 nmol/l (%)									25(OH)D concentration <50 nmol/l (%)							
26									21							

all, they vitamin D intake and serum 25(OH)D status was lower compared with fish and dairy users (data not shown).

Vitamin D intake from food ($P < 0.0001$) as well as from supplements ($P < 0.001$) increased over the 10 years (table 3). Vitamin D intake from food was equal for those who used supplements compared with those who did not and has doubled during the study years (table 3). The mean vitamin D intake from food was 4.5 μg/day and 6.9 μg/day for men and 3.3 μg/day and 4.1 μg/day for women in age groups (25–44 year, 45–64 year) in 2002. In 2012, the mean vitamin D intake from food for younger men was 11.1 μg/day and 11.3 μg/day for older men. For younger women, the mean vitamin D intake was 8.3 μg/day and for older women 8.8 μg/day.

Using vitamin D supplements increased the vitamin D intake in all study years ($P < 0.0001$) (table 3). The vitamin D intake from supplements was tripled over the study years, and even quadrupled among younger men. The mean intake from supplements for male supplement users was 5.5 μg/day in 2002 in both age groups and 22.8 μg/day for men aged 25–44 year and 15.4 μg/day for older men (44–64 year) in 2012 (table 3). For female supplement users, the vitamin D intake from supplements in 2002 was 5.7 μg/day for the younger age group and 6.0 μg/day for older age group. In 2012, younger women obtained 16.6 μg/day vitamin D from supplements, whereas older women obtained 15.4 μg/day.

Discussion

The vitamin D intake from food doubled in a decade in the Finnish adult population. From the year 2002, the mean D-vitamin intake from fortified and non-fortified food sources increased from 5 μg/day to 17 μg/day in 2012 in men and from around 3 μg/day to 18 μg/day, respectively, in women. Vitamin D intake from food was equal among supplement users and supplement non-users. Also, the use of dietary supplements containing vitamin D increased as well as the amount of vitamin D from the supplements.

The mean vitamin D intake and serum 25(OH)D concentration for Finnish adults were satisfactory in 2012. On an average, both

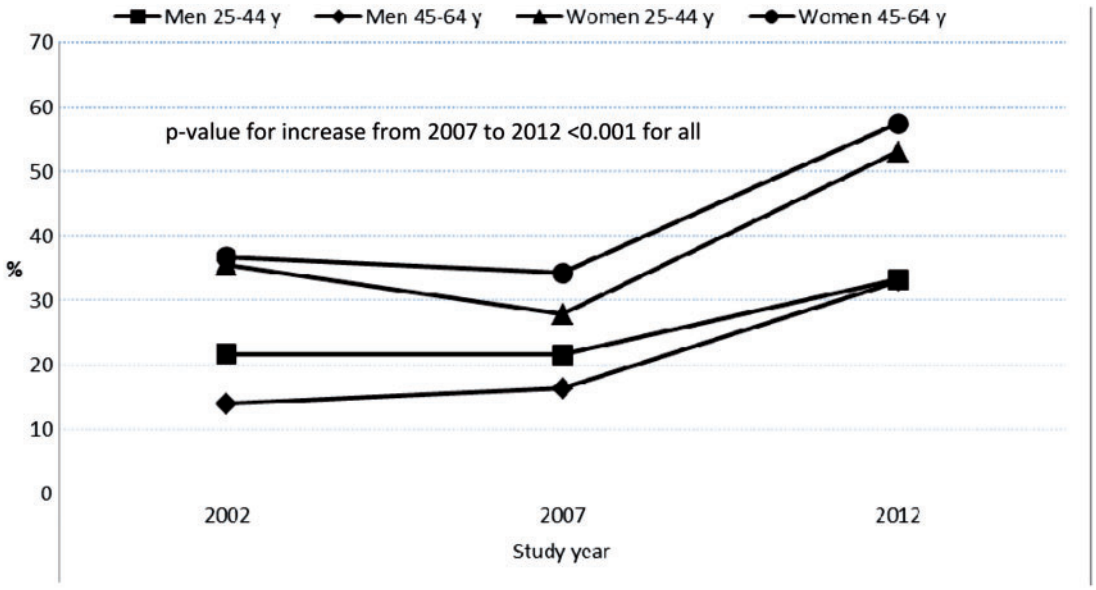

Figure 1 Proportion of vitamin D supplement users in 2002, 2007 and 2012

Table 3 Mean daily vitamin D intake from food and supplements in men and women in 2002, 2007 and 2012 by the age group

	Men 2002 (*n*=912) μg	2007 (*n*=729)	2012 (*n*=585)	*P* valuestest for trend[a]	Women 2002 (*n*=1095) μg	2007 (*n*=846)	2012 (*n*=710)	*P* valuestest for trend[a]
From food, non-supplement users								
25–44 year	4.5	6.6	11.1	<0.0001	3.3	4.6	8.3	<0.0001
45–64 year	6.9	7.3	11.3	<0.0001	4.1	5.6	8.8	<0.0001
All	5.9	7.0	11.2	<0.0001	3.7	5.1	8.6	<0.0001
From food, supplement users								
25–44 year	4.6	6.2	9.6	<0.0001	2.9	4.6	8.9	<0.0001
45–64 year	5.9	8.2	12.1	<0.0001	4.6	5.9	8.5	<0.0001
All	5.2	7.2	11.0	<0.0001	3.8	5.4	8.7	<0.0001
From supplements								
25–44 year	5.5	6.3	22.8	<0.0001*	5.7	6.5	16.6	<0.0001*
45–64 year	5.5	8.8	15.4	<0.0001*	6.1	7.5	15.4	<0.0001*
All	5.5	7.6	18.5	<0.0001	5.9	7.1	16.0	<0.0001
Total, supplement users								
25–44 year	10.1	12.5	32.3	<0.0001	8.7	11.1	25.5	<0.0001
45–64 year	11.4	17.0	27.5	<0.0001	10.7	13.4	24.0	<0.0001
All	10.7	14.8	29.5	<0.0001	9.7	12.5	24.7	<0.0001

a: Kruskal–Wallis test.

men (17 μg/day) and women (18 μg/day) met the current vitamin D intake recommendation (10 μg/day) and had sufficient serum 25(OH)D concentration (>50 nmol/l). However, for women who did not use vitamin D supplements, the mean vitamin D intake from food was slightly lower than currently recommended (8.6 μg/day). The use of vitamin D supplements increased the intake above the recommended level. Fortified foods (liquid milk products and fat spreads) in addition to fish dishes were most important vitamin D sources for adult Finns in 2012. The vitamin D intake from milk products was around 39% among younger men and women, and 29% among older men and women. Fat spreads covered on average 28% of vitamin D intake, except for younger men (23%). Fish dishes provided 28% of vitamin D intake for older men and women, and approximately 18% for younger ones.

Current vitamin D recommendation can be reached from food especially when using fortified foods. For example, by consuming two glasses of milk or sour milk (4 μg) and two slices of bread including six tea spoons of bread spread (6 μg), the recommendation is met. If fortified foods are not used it is recommended to use vitamin D supplementation.[29,30]

Serum 25(OH)D concentration was over 50 nmol/l also in the 25th percentile among women, and around 48 nmol/l among men. However, it is important to pay attention to the fact that 26% of men and 21% of women had serum 25-OH-vitamin D concentration below recommended 50 nmol/l.

It is of great public health interest that Finnish nutrition policy actions regarding vitamin D were successful in all studied adult population groups as there were no differences in vitamin D intake, supplement use or 25(OH)D status between educational or age groups. It should, however, kept in mind that we did not have BMI, sun exposure or calcium intake as background variables in our analysis, which all are associated with 25(OH)D concentration.

In 2002–2004 in Finland, the vitamin D insufficiency was common in men aged 27–35 years and for women aged 27–60 years.[20] Vitamin D intake and serum 25(OH)D status has been of a concern also in other Nordic countries.[30,31] When comparing serum 25(OH)D statuses, it is important to bear in mind that due to huge differences between analytical methods, the results are not completely comparable.[5]

In Sweden, the median daily vitamin D intake for adults was lower than 6 μg/day in 1998.[31,32] Unlike in Finland where the vitamin D intake has improved in Sweden, the mean vitamin D intake was still quite low in 2010/2011 (6 μg/day for women and 8 μg/day for men).[17] In Denmark, the estimated dietary intake of vitamin D of adults aged 30–60 years varied between 0.2 and 23 μg/day in 1999–2001.[19,32,33] The overall prevalence of vitamin D insufficiency was 52% in 1999–2001 in Denmark.

In Iceland, vitamin D intake and serum 25(OH)D status varies considerably according to cod liver oil use.[18,33,34] Intake of vitamin D for adults who used cod liver was 13.5 μg/day, whereas intake for non-users was 4 μg/day.[18] Also in Norway, the cod liver oil is important source of vitamin D,[34,35] and vitamin D status is sufficient for the majority in the general population.

In Finland, nutrition policy actions have been performed in order to increase the vitamin D intake and to improve the 25(OH)D status in the population. The fortification of liquid dairy products with 1 μg vitamin D/100 g and dietary fats with 20 μg/100 g has been performed since 2010 and detailed instructions for vitamin D supplementation for different population groups were launched in 2011 and revised in 2014. In newest Finnish Nutrition Recommendations[29,30] as well as in Nordic dietary recommendations,[35,36] instructions for vitamin D supplement use were updated. During winter time (October–March), it is recommended also for adults to have vitamin D supplements (10 μg/day),[29,30,36,37] unless they consume fish at least twice a week, fortified liquid dairy products half a liter a day and/or fortified fat spreads. Vitamin D recommendation was increased from 7.5 μg to 10 μg (6 months–74 years), and for 75-y and older up to 20 μg/d.

In other Nordic countries parallel, but lighter policy actions have been enforced during 21st century. In Iceland, one brand of low fat milk is fortified with vitamin D, and in Norway, all milk is fortified with 0.4 μg/100 g, butter and margarine with 10 μg/100 g and all cooking and salad oils with 10 μg/100 g.[5] In Sweden, all low-fat milk and dairy products are fortified with vitamin D.

There are some limitations in our study. This study was performed in Finland between January and April, at the same time, when that serum 25(OH)D concentrations are at their lowest. More representative results would have been received if blood samples had been collected during different seasons. Nutritional data were collected by 48-h dietary recall and the recall days were consecutive. The fish intake is probably underestimated, due to the dietary recall method. Participants were interviewed between Mondays and Fridays, thus the number of Thursdays and Saturdays is about half compared with other days, Fridays are lacking. Information about supplement usage was collected somewhat differently in 2002, this could explain the drop in supplement use in 2007, but confirms the increase in supplement use in 2012. Underreporting is a common cause of recall bias in dietary recall[37,38,39] and this could have affected on vitamin D intake results. More precise results could have been received by collecting data for non-consecutive days, and for different seasons, during the year. However, in the National FINDIET Survey 2007, the seasonality in nutrient intake over all was quite mild, whereas day-to-day variation was more prominent (un-published data). In this paper, we did not use BMI or sun exposure habits as background variables; they might have had some effect on the results.

This study gives important feedback to Finnish policy makers about the feasibility of the policy actions used to improve nutritional status of Finnish population. Vitamin D intake and status have improved in Finnish population after policy actions performed in 2003, 2010 and 2011. The fortification of commonly used food products with vitamin D and vitamin D supplementation seems thus to be an efficient way to increase the average vitamin D intake and the serum 25(OH)D concentration in the population.

Regardless of the current quite satisfied situation, it is necessary to continuously monitor the intake of vitamin D and 25(OH)D concentration in the population to enable an immediate reaction to potential unfavourable changes. It is also important to analyse more carefully how to reduce the proportion of those who still have serum 25(OH)D concentration below the recommended level. In our data, there were few people who had serum 25(OH)D concentrations over 125 nmol/l. Attention should be paid to the communication when giving recommendations for vitamin D supplement use to minimize the risk for extreme high doses of vitamin D.

Funding

The work was carried out at the National Institute for Health and Welfare.

Ethical Standards

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. The Coordinating Ethics Committee of Helsinki and Uusimaa Hospital District (HUS) approved the FINRISK 2012 protocols. All participants received information of the study and provided their written informed consent.

Conflicts of interest: None declared.

Key points

- The fortification of commonly used food products with vitamin D and vitamin D supplementation seems to be an potential way to increase the average intake and the serum 25(OH)D concentration in the adult population.
- The vitamin D intake from food was equal among supplement users and non-users.
- Vitamin D intake and 25(OH)D concentration were lower among those who did not consume fish or dairy products.
- Total vitamin D intake was three times higher among supplement users compared to non-users
- The vitamin D intake from food has doubled during the study years 2002–2012

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