



Revisión

Evolution of the intake and nutritional recommendations of calcium and vitamin D for the last 14 years in Spain

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Abstract

Introduction: calcium and vitamin D are essential for the human being. Scientific evidence supports the correlation between both nutrients and their essential processes in the correct functioning of the human's organism, which is what justifies the increase of the recommended ingestion in Spain, since 2001 until nowadays.

Objectives: to analyse the evolution on calcium and vitamin D ingestion related to the evolution of the Dietary Reference Intake, as well as its repercussion, since 2001 until nowadays.

Design/Setting: a bibliographical search in major scientific data bases, PubMed, SciELO and EMBASE was conducted.

Subjects: a review focused on the scientific literature on vitamin D and calcium, the evolution of its intake, changes in nutritional recommendations and the importance and consequences of these aspects.

Results: actual ingestion of calcium and vitamin D, during this period of time, has decreased in Spain, reaching average consumption values below recommended.

Conclusion: it may be necessary to increase the consumption of supplements and fortified foods, in some specific cases, in order to achieve the Dietary Reference Intake.

(Nutr Hosp. 2015;32:1987-1993)

DOI:10.3305/nh.2015.32.5.9683

Key words: *Calcium. Vitamin D. Daily reference intake. Spain.*

EVOLUCIÓN DE LA INGESTA DE CALCIO Y VITAMINA D Y SUS RECOMENDACIONES NUTRICIONALES EN LOS ÚLTIMOS 14 AÑOS EN ESPAÑA

Resumen

Introducción: el calcio y la vitamina D son esenciales para el ser humano. La evidencia científica apoya la correlación entre ambos nutrientes y sus procesos esenciales en el correcto funcionamiento del organismo del ser humano, que es lo que justifica el aumento de la ingesta recomendada en España, desde 2001 hasta hoy en día.

Objetivos: analizar la evolución en la ingesta del calcio y la vitamina D en relación con la evolución de las *Ingestas Diarias Recomendadas*, así como su repercusión, desde 2001 hasta hoy en día.

Diseño: revisión bibliográfica en las principales bases de datos científicas, PubMed, SciELO y EMBASE. Se realizó una revisión centrada en la literatura científica sobre la vitamina D y el calcio, la evolución de su ingesta, cambios en las recomendaciones nutricionales y la importancia y las consecuencias de estos aspectos.

Resultados: la ingestión real de calcio y vitamina D, durante este período de tiempo, ha disminuido en España, alcanzando valores medios de consumo por debajo recomendado.

Conclusión: es posible que sea necesario aumentar el consumo de suplementos y alimentos fortificados, en algunos casos específicos, a fin de lograr la *Ingesta Diaria Recomendada*.

(Nutr Hosp. 2015;32:1987-1993)

DOI:10.3305/nh.2015.32.5.9683

Palabras clave: *Calcio. Vitamina D. Ingesta diaria recomendada. España.*

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Recibido: 27-VII-2015.
Aceptado: 17-VIII-2015.

Abbreviations

AECOSAN: *Agencia Española de Consumo, Seguridad Alimentaria y Nutrición*.

Ca: Calcium.

DRI: Dietary Reference Intake.

EAR: Estimated Average Requirement.

EFSA: European Food Safety Authority.

Fe: Iron.

FOS: Fructooligosaccharides.

IOM: Institute of Medicine.

MD: Mediterranean Diet.

RDA: Recommended dietary allowance.

UL: Upper intake Level.

Zn: Zinc.

Introduction

An adequate intake of calcium and vitamin D, in a well-balanced Mediterranean Diet (MD), is necessary in all stages of life. Scientific evidence links them to bones development¹ and maintenance², but they are also essential in other processes. Calcium contributes to blood coagulation, energetic metabolism, neuromuscular and digestive enzymes function and to cellular's division and differentiation. Vitamin D contributes to calcium and phosphorus absorption and calcium homeostasis in blood; it is involved in the correct immune system and muscles functioning, and in cellular division process³. Prospective cohort studies have shown a relationship between 25-hydroxy-vitamin D3 low serum concentration and increased risk of colorectal cancer, cardiovascular, infectious and autoimmune diseases and diabetes mellitus type II. It has been proved, that 10 μg of vitamin D daily supplementation prevents rickets^{3,4}.

To meet calcium and vitamin D requirements, which ensures optimal functions, Dietary Reference Intake (DRI) are established (10-20 $\mu\text{g}/\text{day}$ of vitamin D and 1200-1500 mg/day of calcium, depending on age). EFSA (**European Food Safety Authority**), of European scope, or AECOSAN (*Agencia Española de Consumo, Seguridad Alimentaria y Nutrición*), in Spain, are responsible for estimating the DRI and its compliance. Recent research has modified recommended values for an optimal health condition, to others capable of avoiding diseases⁵.

Recommended dietary allowances (RDA) are estimated with a wide safety margin (they cover the needs of 97.5 % of the population)⁶. Normally a person may be at risk of deficiency when, at least, 80% of DRI is not reached. However, this percentage is a vague criterion so any possible deviation must be confirmed with individual biochemical, anthropometrical and clinical studies⁷.

As sources that provide higher levels of calcium and vitamin D, the following should be considered:

VITAMINA D sources. Exposure to sunlight contributes to 2/3 of vitamin D supply per year; diet to the other third. Even so, both may turn out to be insuffi-

cient. Certain groups may need vitamin D supplements (preferably D3), such as enriched margarine or milk⁴. The 8 fish/shellfish richest in vitamin D are: eel (20 $\mu\text{g}/100\text{g}$), herring (17 $\mu\text{g}/100\text{g}$), salmon (15 $\mu\text{g}/100\text{g}$), sardines (11 $\mu\text{g}/100\text{g}$), mackerel (10 $\mu\text{g}/100\text{g}$), trout, oysters (8 $\mu\text{g}/100\text{g}$) and anchovy (7 $\mu\text{g}/100\text{g}$)⁸, which surpass 100% of DRI for one meal and contribute to 70% of vitamin D DRI. In a minor extent, products like liver, eggs and dairy products, provide 66%, 21% and 3% of DRI, respectively. Cereals, vegetables, fruits, nuts and legumes are considered to be lack of vitamin D. Vitamin D-fortified foods become necessary in individuals not able to cover vitamin D needs through endogenous synthesis⁹. Beneficial effects of sun exposure, such as for vitamin D production, can be fully achieved while still avoiding too much sun exposure, which is the main cause of skin cancer¹⁰.

CALCIUM sources: dairy products (cheese: 636mg/100g; fat milk: 120mg/100g; yogurt: 142mg/100g)¹¹ which cover 20-30% of DRI needs per meal and contribute to 44% of daily calcium ingestion. Certain vegetables (spinach: 126mg/100g; endive: 67mg/100g; leek: 60mg/100g)¹² cover 10-20% of DRI needs per meal. All shellfish and legumes can cover 16% and 10% of DRI needs per meal, respectively¹².

Calcium intake, in Spanish adult population, is lower than AECOSAN recommendations. The inadequacy of its intake is particularly significant in postmenopausal women (600 mg Ca/day) and >65 years old men¹³. 20.5% ingested calcium supplements – depending on age, sex and region – but only the 23.2% with deficient ingestion used them.

One of the most effective mechanisms to increase calcium absorption is vitamin D intake, due to its calcium control and regulation contribution, magnifying its intestinal absorption by increasing synthesis of calcium transporting protein¹⁴. Therefore, dairy products are conceived as a good choice to maintain calcium homeostasis, if ingested regularly.

Another strategy to increase calcium absorption involves intake of fructooligosaccharides (FOS)¹⁵. FOS decrease intestinal pH as a result of short chain fatty acids production. This pH drop increases calcium solubility and its paracellular and transcellular transportation^{16,17}.

Similarly, vitamin D deficiency is common, especially among elderly, whose skin production and renal synthesis is limited¹⁸. Spanish women vitamin D ingestion is inferior to 84.3%, and lower than 67% of recommendations in 72.2%; menopausal women ingestion is inferior to 85.2%, and lower than 67% of recommendations in 75.9%¹⁹. Vitamin D needs duplicate in 50-59 year old population, therefore, its consumption is highly distant to the recommended⁶.

Vitamin D is scarce in the diet, making it difficult to reach its DRI and causing an imperative public health problem. For this reason, vitamin D-fortified food products have been suggested²⁰. Enriched milk provides 15% of DRI against 3% provided by non-enriched milk.

Objectives

Analyse the evolution on calcium and vitamin D ingestion related to the evolution of the DRI since 2001, as well as its repercussion. Specific objectives: 1) To know the evolution of calcium DRI and vitamin D DRI since 2001, in Spain; 2) To analyse real average calcium and vitamin D consumption since 2001, in Spain; 3) To study the consequences of the lack of temporary uniformity and real adjustment to the needs of Spanish population.

Methodology

Review study, focused on the scientific literature on vitamin D and calcium. In particular on the evolution of its intake, on changes in nutritional recommendations and on the importance and consequences of these aspects. Therefore, a bibliographical search in major scientific data bases, PubMed, SciELO and EMBASE, was conducted.

To retrieve the most relevant studies, different strategies were designed by combining keywords according to the type of study required, with the highest scientific evidence. The search was limited to a period of time, mostly, did not exceed ten years of existence (2003-2013).

The search strategy used in PubMed was: (“vitamin D deficiency”[MeSH Terms] OR “vitamin D deficiency”[All Fields]) AND ((Meta-Analysis[p-ty] OR systematic[sb]) AND “2004/03/25”[PDat]: “2014/03/22”[PDat] AND “humans”[MeSH Terms]). Expressions of interest: (“vitamin d intake”, “calcium deficiency”, “calcium intake”, etc) AND (“calcium”[

MeSH Terms] OR “calcium”[All Fields]) AND (“osteoporosis, postmenopausal”[MeSH Terms] OR (“osteoporosis”[All Fields] AND “postmenopausal”[All Fields]) OR “postmenopausal osteoporosis”[All Fields] OR “osteoporosis”[All Fields] OR “osteoporosis”[MeSH Terms])) AND ((Meta-Analysis[p-ty] OR systematic[sb]) AND “2004/03/25”[PDat] : “2014/03/22”[PDat] AND “humans”[MeSH Terms]). Same procedure was followed for vitamin D and adapted to every search engine.

BEDCAs network was examined, also the opinions of the EFSA panel, responsible for regulating the reviewed aspects in this paper and the DRI of Institute of Medicine.

Results

In table I, vitamin D DRI is shown for years 2001, 2004, 2011 and 2013. Until 2004, vitamin D DRI was 5 µg for every age range, except for ages between 50-70 years, which showed a DRI of 10 µg, and population >70 years, who had a DRI of 15 µg. From 2011 on, DRI is increased to 10 µg for all ages, and between 20-25 µg in prematurity. The last DRI published maintains 10 µg/day for everyone, except in population >70 years, amounting to 20 µg/day.

Currently, the upper level (UL) of vitamin D for adults, pregnant and lactating women, is established in 100 µg/day. For children and adolescents twice as much as in 2001. The UL is set at 50 µg/day for ages 1-10 years and at 25 µg/day for infants up to 1 year, without changes in comparison to 2001 DRI. Data obtained from European population indicates vitamin D intake is below the UL in all subgroups²¹.

Tabla I
Vitamin D DRI and UL

Vitamin D	IR				UL					
	2001	2004	2011	2013	Increase 2001-2013	2001	2004	2011	2013	Increase 2001-2013
Age Range	DRI(µg/d)	DRI(µg/d)	DRI(µg/d)	DRI(µg/d)		UL(µg/d)	UL(µg/d)	UL(µg/d)	UL(µg/d)	
Newborns from 0 to 12 months	5	5	10	10	100%	25	25	25	25	0%
Newborns from 1 to 10 years	5	5	10	10	100%	50	50	50	50	0%
11-49 years	5	5	10	10	100%	50	50	100	100	100%
50-70 years	10	10	10	10	0%	50	50	100	100	100%
>70 years	15	15	10	20	33,34%	50	50	100	100	100%
Pregnancy	5	5	10	10	100%	50	50	100	100	100%
Lactation	5	5	10	10	100%	50	50	100	100	100%
Prematurity	-	-	20-25	20-25	-	-	-	100	100	-

Vitamin D DRI and UL in 2001, 2004, 2011 and 2013, in reference to all stages of life. Data shown in µg per day, and percentage increase from 2001 to 2013^{23,24}.

In table II, calcium DRI is shown for years 2001, 2004, 2011 and 2013. DRI increased in 2011 in several age ranges, especially from 4-8 years, which increased to 1200 mg/day, from 9-24 years, increasing to 1200-1500 mg/day, and for >65 years, increasing from 1200 mg/day, in 2001, to 1500 mg/day in 2011. A DRI of 100 mg/kg is set in prematurity. Actual DRI hold the same values.

Calcium UL is set on 2,500 mg/day in adults, pregnant and lactating women. European data indicates that calcium ingestion in great adult men consumers can be close to the UL. Available data is insufficient to establish an UL for newborns, children and adolescents, but it has not been identified any risk with the UL of calcium consumption in this groups¹⁴.

Table III shows the actual real average intake of calcium and vitamin D. In both cases a decreasing tendency is observed, with actual mean values of calcium around 860 mg/day and 4 µg/day of vitamin D.

Discussion

Calcium and vitamin D DRI have been increasing since 2001, due to the importance of an adequate supply for an optimum functioning of the organism and prevention of diseases⁵.

In the particular case of vitamin D, the DRI have increased, in comparison with 2001, by 100% from birth to 50 years old stage, as well as for pregnant and lactating women. The values for 50-70 years old are stable and in senior population, values reach 20 µg/day (an increase of 33.34%) as production is reduced and renal synthesis is also altered¹⁸.

Vitamin D DRI increase is justified after multiple studies that relate higher intakes of it with the prevention of various diseases⁴.

Children up to 4 years old: 10 µg/day to prevent rickets.

Women 50-70 years old: 10 µg/day to reduce bone fractures.

Tabla II
Calcium DRI and UL

Calcium	2001		2004		Ages	2011		2013		DRI Increase 2001-2013	UL Increase 2001-2013
	DRI (mg/d)	UL (mg/d)	DRI (mg/d)	UL (mg/d)		DRI (mg/d)	UL (mg/d)	DRI (mg/d)	UL (mg/d)		
Newborns from 0 to 6 months	210	ND	210	ND	Newborns from 0 to 6 months	210	ND	210	ND	0%	-
7-12 months	270	ND	270	ND	7-12 months	270	ND	270	ND	0%	-
1-3 years	500	2500	500	2500	1-3 years	500	2500	500	2500	0%	0%
4-8 years	800	2500	800	2500	4-8 years	800- 1200	2500	800- 1200	2500	0 a 50%	0%
9-18 years	1300	2500	1300	2500	9-24 years	1200- 1500	2500	1200- 1500	2500	-7,69% a 15,38%	0%
19-50 years	1000	2500	1000	2500	25-65 years	1000	2500	1000	2500	35% (19-25 years) 0% (25-49 years)	0%
50-70 years	1200	2500	1200	2500	>65 years	1500	2500	1500	2500	-16.67% (50-65 years)	0%
>70 years	1200	2500	1200	2500	>65 years	1500	2500	1500	2500	25%	0%
Pregnancy <18	1300	2500	1300	2500	Pregnancy	+500	2500	+500	2500	38%-50%	0%
Pregnancy <18	1000	2500	1000	2500	Pregnancy	+500	2500	+500	2500	38%-50%	0%
Lactation <18	1300	2500	1300	2500	Lactation	+500	2500	+500	2500	38%-50%	0%
Lactation <18	1000	2500	1000	2500	Lactation	+500	2500	+500	2500	38%-50%	0%
Prematurity	-	2500	-	2500	Prematurity	100 mg/kg	2500	100 mg/kg	2500	-	0%

Calcium DRI and UL for 2001, 2004, 2011 and 2013, in reference to all stages of life, shown in mg per day or mg/kg/day, as well as the percentage increase from 2001 to 2013, choosing for its calculation the average value in those recommendations show in the margins^{23,24}.

Table III
Real average intake of calcium and vitamin D from 2000 to 2011

	2000	2003	2006	2008	2011
Calcium (mg)	889	997	871	874	860
Vitamin D (μg)	5.6	6.2	6.4	4.4	4.0

Real average mgestlon of Calcium and Vitamin D for years 2000, 2003, 2006, 2008, y 2011 shown in mg per day for Calcium and $\sim\text{g}$ per day for Vitamin Data obtained from Otten JJ et al⁵.

Seniors >70 years: 20 μg /day to reduce bone fractures.

Pregnant women: 10 μg /day to prevent low birth weight in newborns.

Calcium DRI have also increased, namely in age range groups of 4-8 years (800-1200 mg), which means a 50% increase if compared with 2001, in 9-24 years (1200-1500 mg), which means an increase of 15.4% until the age of 18, and a 50% increase between ages 19-24^{22,23}. In pregnant women the increase (+500 mg/day) is also significant, with a variation of > 50% if compared with 2001, as well as in senior citizens (1500 mg Ca), whose DRI were increased by 25%. For ages between 50-65 years, DRI values have decreased from 1200 to 1000 mg/day. What justifies the increase of calcium DRI is based on the conclusions reached by several studies about the importance of calcium in bone health^{1,2,3}.

Proportionally to the DRI increase occurred in Spain since 2001, the real intake of calcium and vitamin D has decreased progressively, reaching mean values of 860 mg calcium and 4 μg vitamin D, both in 2011⁶. This is alarming because, apart from showing a downward intake every year, neither case reach established DRI. According to Estaire P et al (2012)²⁴, average calcium intake was below the recommended in 78.4% of participants (70% males, 86% women), with ingestions under 67% of DRI in 33.7% of participants (25.5% males, 40.9% women). The main source of calcium taken was daily products (58.7%) and, in fact, individuals who reached DRI of calcium had higher consumption of them (551.3 ± 240.4 g/day) compared to individuals who did not comply with the DRI (305.0 ± 150.3 g/day).

This mismatch between DRI and real ingestion could be due to the time set elapses since the new DRI establishment, based on scientific research, and its application, compromising populations' health. Reliability should be evaluated to conclude firmly in these needs/lacks for a specific population, with methodologies based in subjective records and auto-referred recounting. A recent study by San Mauro I (2014)²⁵ has stated a variability between 7 tools (food composition tables and menu calibration software), with a difference of 27% (342 mg) for calcium and 61% (6 μg) for vitamin D between the highest and lowest of the tools, concluding that actual methods for DRI evaluation, using national and international data bases, are not entirely reliable.

Another study²⁶ has tried to further, trying to establish DRI for bioactive food components, since there is an essential scientific evidence to validate the relation between its consumption and optimum health conditions.

In other countries, the average calcium and vitamin D ingestion has been studied. A Canadian study²⁷ found that vitamin D intake, related to the established DRI, was low and decreased since 2011 (11.1% in winter; 13.0% in summer), compared with the values obtained in 1997 (40% in winter; 47.8% in summer). Dairy products and fish were suggested as the main sources of vitamin D. Another study²⁸, focused on Inuit people and childbearing age women, determined inadequate intake of vitamin D, suggesting the need for supplementation protocols and/or food fortification to address this problem. A Spanish study²⁹ estimated the contribution of this and other minerals in food products. Results showed that the levels of trace elements were specially low and insufficient (mainly Fe, Zn and Ca) taking in consideration the DRI.

Due to the public health problem that vitamin D deficiency causes, Uriu-Adams JY (2013)³⁰ discussed the potential value of vitamin D supplementation in high risk pregnancies, during lactation time and early childhood, as this deficiency has been suggested as a risk factor for developing preeclampsia, partnering with a higher risk of skeletal disruptions and vascular or immunological disorders. Consumption of vitamin D low diets and inadequate exposure to sun are the main causes of deficiency. Black LJ et al (2014)³¹ defends vitamin D fortification of food products, specially breakfast cereals, spreadable greases and milk, as an option to reach the DRI in children (5-12 years old) and adolescents (13-17 years old). Similarly, and to prevent vitamin D deficiencies in children of 1-2 years old, Ghisolfi J et al (2012)³² established that consumption of growing-up milk (≥ 250 ml/day) reduces significantly risk of vitamin D deficiency, α acid - linolenic, Fe, and vitamin C, comparing it to cow's milk consumption (≥ 250 ml/day). Despite the benefits that could arise from fortification or supplementation, there is no consensus on how to choose the optimal dose, the vitamin D type and how to use evidences to monitor treatments in adults³³.

It is considered, in one hand that the actual consumption of calcium and vitamin D in the worldwide population is far from the DRI, causing concerns

that could entail consequences on health. But, on the other hand, it is suggested that the evaluation methods of those DRI are not completely reliable and perhaps may be overestimated. Baladia E (2014)³⁴ supports this theory and confirms that, according to the Institute of Medicine, intakes below the recommended should not be assumed to be inadequate, as RDA, by definition, exceed the real requirements of the entire population, and proposed another method to estimate the prevalence of inadequate intakes: the EAR (Estimated Average Requirement), based on the fact that prevalence of an inadequate intake of a population is the proportion of the individuals in the group with intakes below the EAR. On the contrary, another author³⁵, justifies the DRI increase at certain stages of life (childhood or senior age) and manifests an insufficient intake of dairy products necessary to meet the DRI.

Conclusions

It has been stated the increase, nationally and internationally, of calcium and vitamin D DRI. This increase is found to be slow and the used methods to calculate the DRI have been criticised, as well as the population's deficit of both nutrients ingestion, which represents a public health problem. More studies should be carried out to demonstrate the reliability of DRI, using a more exact methodology, closer to reality. A suggestion could be population sampling, not just registers, made in health centres and hospitals, measuring calcium and vitamin D levels in blood, in order to obtain results that can be applied in preventive medicine as a way of achieving an optimal health condition.

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