



Daily Intake, Adequacy of Intake and Food Sources of Calcium, Phosphorus, Magnesium and Vitamin D in the Spanish Population: findings from the ANIBES Study

With the participation of:



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Introduction

The decline of essential nutrients deficiencies over the past century along with the improvement in the treatment of infectious diseases has contributed to the increase in population life expectancy. However, in recent years, prevalence of nutrition-related chronic diseases, such as obesity, cardiovascular diseases and type 2 diabetes have increased remarkably, dwindling the quality of life of the population.

Studying the nutritional situation of the population as well as lifestyle habits is fundamental to design national guidelines and public health policies. Micronutrients such as calcium, phosphorus, magnesium and vitamin D have a key role in bone development and maintenance, as well as other relevant biological roles.

Moreover, national nutritional surveys are the most used tool to assess the nutrients intake and nutritional status of the population. The data collected in these surveys are mostly based on subjects self-reporting.

As this method is indirect, the surveys frequently report data that do not represent the habitual intake of the studied population and estimate energy intakes that are not plausible physiologically.

Currently there is not a gold standard method to collect nutritional intake data. Although some improvements have been made in the development of more objective measurement tools as digital photography, more research is needed to develop more accurate and objective methodologies.

This work within the ANIBES Study has reported energy intake for plausible and non-plausible reporters and is based on the “Guidance on the European Union Menu Methodology”, which is a document published by the European Food Safety Authority (EFSA) to facilitate the collection of more harmonized food consumption data from all EU countries.

An additional aspect to consider is the estimation of usual micronutrients intake using complex sample derived data from few days dietary food records, which introduces excessive intra-individual variation. To overcome this problem, different statistical procedures have been assessed and other approaches have been considered to managing and analysing intake population data.

This research is aimed to evaluate the disparity between the reported consumption and the level needed for an adequate contribution of the main micronutrients involved in bone metabolism (calcium, phosphorus, magnesium and vitamin D). To do so, the coefficients of within-person variations for different age groups, as well as the food and beverages, were considered. This way, intake was assessed for both general population and plausible reporters physiologically.



Materials and Methods

The design, protocol and methodology of the ANIBES Study have been already described in detail in Ruiz E. et al, 2015 and Varela-Moreiras G. et al, 2015.

For the collection of data, participants were provided with a tablet device. They were also trained in the use of a software to record information by taking photos of all food and drinks consumed during the three days of the field study, both before beginning to consume them, and after finishing, to record both the intake and the leftovers data.

Those participants who were unable to use this device used a digital camera, paper record or telephone interviews.

In the end, 79 % of the sample used table devices, 12 % a digital camera and 9 % opted for a telephone interview.

With these devices, 189,600 inputs (ingredients) in the study software were managed, which is equivalent to about 73 items per each of the 2,009 participants and 24.3 food/beverages items per person and day as mean.

The quality control of the collected information was supervised by trained dieticians-nutritionists, according to the following protocol:

1. The same dietician-nutritionist was responsible for checking the food records included by the participant during the three-day study.
2. The initial quality control was based on the photographs and descriptions sent by the participants, but also in the brief description that was asked before and after each meal or intake. Particular care was given to validate some variables such as ingredients, brands of ready-to-eat foods, portion size or culinary technique to obtain information as accurate as possible for further codification.
3. The final approval of the received information was given by a dietician-nutritionist and supervisor.

Evaluation of records

Overall, when the data of a nutrition survey are self-collected, people tend to underreport the consumption of food and beverages.

As a consequence, the EFSA recommendations have been included in this study, which have a harmonized approach to identify whether the information on energy intake is plausible or not physiologically. This body suggests that the data should be analyzed for the whole population as well as divided into plausible and non-plausible reporters of energy intake data.

This method evaluates the reported energy intake against the energy requirements. The reported energy intake is expressed as a multiple of the mean basal metabolic rate (BMR) estimated from formulas and it is compared with the energy expenditure of the studied population. The ratio between the reported energy intake / BMR estimated is referred to as the physical activity levels (PAL) of the studied population.

The protocol indicates that analyses should be done at two levels: group and individual. The first one determines the overall bias to the reported energy intake, and the second one shows the rate of under and over reporters.

It is important to highlight that the ANIBES Study is the first national diet and nutrition survey reporting intake both for plausible and non-plausible reporters of energy intake, based on well-harmonized procedures.



Calcium, Phosphorus, Magnesium and Vitamin D Intake and Distribution in the Whole Population

The mean reported dietary consumption of calcium, phosphorus, magnesium and vitamin D for the whole population participating in the ANIBES Study was:

- Calcium: 698 ± 7 mg/day (71-2,551 mg/day)
- Phosphorus: $1,176 \pm 8$ mg/day (331-4,429 mg/day)
- Magnesium: 222 ± 2 mg/day (73-782 mg/day)
- Vitamin D: 4.4 ± 0.1 µg/day (0.0-74.2 µg/day)

Men reported significantly higher consumption of calcium, phosphorus and magnesium than women when the total sample was considered.

By age groups, the male population reported a higher intake of calcium in the group of children, adolescents and adults, as well as of magnesium in the group of adolescents, adults and elderly.

Higher intake of calcium was observed in children and adolescents compared with adults and elderly. Furthermore, the consumption of phosphorus decreased, and that of vitamin D increased, with advancing age.

Daily calcium, phosphorus, magnesium and vitamin D intake by sex and age group (Mean ± SEM)

	Total		Children (9-12 years)		Adolescents (13-17 years)		Adultos (18-64 años)		Elderly (65-75 years)	
n	Total:	2,009	Total:	213	Total:	211	Total:	1,655	Total:	206
	Men:	1,013	Men:	126	Men:	137	Men:	798	Men:	99
	Women:	996	Women:	87	Women:	74	Women:	857	Women:	107
Calcium (mg/day)										
Total		698 ± 7		826 ± 17^a		817 ± 23^a		689 ± 7^b		645 ± 19^b
Men		726 ± 10 [*]		872 ± 22 [*]		875 ± 31 [*]		711 ± 11 [*]		662 ± 31
Women		670 ± 8		759 ± 26		708 ± 29		668 ± 9		629 ± 21
Phosphorus (mg/day)										
Total		1,176 ± 8		1,285 ± 22^a		1,261 ± 24^a		1,175 ± 9^b		1,097 ± 23^c
Men		1,246 ± 12 [*]		1,340 ± 27 [*]		1,323 ± 31 [*]		1,247 ± 14 [*]		1,177 ± 38 [*]
Women		1,104 ± 9		1,206 ± 35		1,145 ± 35		1,108 ± 10		1,023 ± 25
Magnesium (mg/day)										
Total		222 ± 2		220 ± 4		216 ± 4		223 ± 2		226 ± 6
Men		233 ± 2 [*]		224 ± 5		224 ± 5 [*]		236 ± 3 [*]		246 ± 11 [*]
Women		210 ± 2		214 ± 7		200 ± 7		211 ± 2		207 ± 6
Vitamin D (µg/day)										
Total		4.4 ± 0.1		2.8 ± 0.2^a		3.7 ± 0.4^{a,b}		4.5 ± 0.1^b		4.4 ± 0.4^b
Men		4.4 ± 0.2		2.6 ± 0.2		4.0 ± 0.6		4.7 ± 0.2		4.5 ± 0.5
Women		4.3 ± 0.2		3.0 ± 0.3		3.1 ± 0.5		4.4 ± 0.2		4.3 ± 0.5

* T-tests or Mann-Whitney U test were used to evaluate differences by sex within the whole population and within each age group. ANOVA or Kruskal-Wallis analysis were used to calculate differences among age groups (mean values within the same row with unlike superscript letters were significantly different).
p < 0.05 was considered statistically significant.



Data of Intake in Plausible Reporters

In the entire ANIBES population, 27 % (543 individuals) were plausible reporters of energy intake. On the contrary, 73 % (1,466 individuals) were non-plausible reporters.

The consumption of the four micronutrients both overall and by age groups was significantly higher in the group of plausible reporters than in the non-plausible reporters.

Divided by age groups, 56 % of the group of children were plausible reporters, as well as 36 % of the group of adolescents, 26 % of the group of adults and 22 % of the group of elderly.

Daily calcium, phosphorus, magnesium and vitamin D intake by plausible reporters, non-plausible reporters and age group

	Total		Children (9-12 years)		Adolescents (13-17 years)	
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM
Calcium (mg/day)						
Total	2,009	698 ± 7	213	826 ± 17	211	817 ± 23
Plausible reporters	543	862 ± 14	120	893 ± 22	76	978 ± 39
Men	232	934 ± 23	68	954 ± 29	48	1,049 ± 55
Women	311	807 ± 16	52	812 ± 32	28	855 ± 43
Non-Plausible reporters	1,466	637 ± 7	93	739 ± 25	135	726 ± 26
Men	781	664 ± 10	58	775 ± 30	89	782 ± 35
Women	685	607 ± 9	35	681 ± 41	46	619 ± 32
Phosphorus (mg/day)						
Total	2,009	1,176 ± 8	213	1,285 ± 22	211	1,261 ± 24
Plausible reporters	543	1,434 ± 14	120	1,408 ± 24	76	1,502 ± 33
Men	232	1,587 ± 23	68	1,456 ± 29	48	1,583 ± 41
Women	311	1,321 ± 16	52	1,344 ± 39	28	1,362 ± 48
Non-Plausible reporters	1,466	1,080 ± 8	93	1,128 ± 32	135	1,125 ± 26
Men	781	1,145 ± 12	58	1,203 ± 40	89	1,183 ± 34
Women	685	1,006 ± 10	35	1,002 ± 46	46	1,012 ± 36
Magnesium (mg/day)						
Total	2,009	222 ± 2	213	220 ± 4	211	216 ± 4
Plausible reporters	543	273 ± 3	120	242 ± 5	76	263 ± 6
Men	232	301 ± 5	68	248 ± 6	48	274 ± 8
Women	311	253 ± 4	52	233 ± 7	28	242 ± 9
Non-Plausible reporters	1,466	203 ± 2	93	192 ± 6	135	189 ± 4
Men	781	214 ± 2	58	196 ± 7	89	197 ± 5
Women	685	191 ± 2	35	185 ± 11	46	175 ± 6
Vitamin D (µg/day)						
Total	2,009	4.4 ± 0.1	213	2.8 ± 0.2	211	3.7 ± 0.4
Plausible reporters	543	5.5 ± 0.3	120	3.2 ± 0.3	76	3.8 ± 0.5
Men	232	5.5 ± 0.4	68	3.0 ± 0.3	48	4.0 ± 0.6
Women	311	5.5 ± 0.4	52	3.3 ± 0.4	28	3.3 ± 0.8
Non-Plausible reporters	1,466	4.0 ± 0.1	93	2.3 ± 0.2	135	3.7 ± 0.6
Men	781	4.1 ± 0.2	58	2.2 ± 0.3	89	4.0 ± 0.9
Women	685	3.8 ± 0.2	35	2.5 ± 0.5	46	2.9 ± 0.7

Results are expressed as the mean ± standard error of the mean. There were significant differences between plausible and non-plausible reporters of energy intake both for the whole population and within sexes into each age group (p < 0.05), except for vitamin D in the group of adolescents.



Daily calcium, phosphorus, magnesium and vitamin D intake by plausible reporters, non-plausible reporters and age group

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	Adults (18-64 years)		Elderly (65-75 years)	
	n	Mean \pm SEM	n	Mean \pm SEM
Calcium (mg/day)				
Total	1,655	689 \pm 7	206	645 \pm 19
Plausible reporters	433	853 \pm 16	45	807 \pm 47
Men	158	938 \pm 29	24	857 \pm 71
Women	275	804 \pm 17	21	750 \pm 59
Non-Plausible reporters	1,222	631 \pm 7	161	600 \pm 18
Men	640	655 \pm 11	75	600 \pm 31
Women	582	604 \pm 9	86	600 \pm 21
Phosphorus (mg/day)				
Total	1,655	1,175 \pm 9	206	1,097 \pm 23
Plausible reporters	433	1,433 \pm 17	45	1,410 \pm 51
Men	158	1,638 \pm 30	24	1,537 \pm 72
Women	275	1,315 \pm 17	21	1,265 \pm 57
Non-Plausible reporters	1,222	1,084 \pm 9	161	1,009 \pm 21
Men	640	1,151 \pm 13	75	1,061 \pm 36
Women	582	1,010 \pm 11	86	963 \pm 24
Magnesium (mg/day)				
Total	1,655	223 \pm 2	206	226 \pm 6
Plausible reporters	433	278 \pm 4	45	300 \pm 16
Men	158	319 \pm 6	24	327 \pm 27
Women	275	254 \pm 4	21	269 \pm 15
Non-Plausible reporters	1,222	204 \pm 2	161	205 \pm 5
Men	640	215 \pm 3	75	220 \pm 9
Women	582	191 \pm 2	86	192 \pm 5
Vitamin D (μg/day)				
Total	1,655	4.5 \pm 0.1	206	4.4 \pm 0.4
Plausible reporters	433	5.8 \pm 0.3	45	6.7 \pm 0.9
Men	158	5.9 \pm 0.5	24	8.0 \pm 1.3
Women	275	5.7 \pm 0.4	21	5.2 \pm 1.2
Non-Plausible reporters	1,222	4.1 \pm 0.1	161	3.8 \pm 0.4
Men	640	4.3 \pm 0.2	75	3.4 \pm 0.4
Women	582	3.7 \pm 0.2	86	4.1 \pm 0.6

Results are expressed as the mean \pm standard error of the mean. There were significant differences between plausible and non-plausible reporters of energy intake both for the whole population and within sexes into each age group ($p < 0.05$), except for vitamin D in the group of adolescents.

Adequacy to recommendations and food sources

76 % and 79 % of the population had reported intakes for calcium and magnesium below the 80 % of the national recommended daily intakes. Concerning references at a European level, these figures accounted for 66 % and 72 %, respectively.

As for vitamin D, 94 % of the population reported intakes below 80 % of the daily intake recommendations at a national level, figure that represents 93 % when referring to the European reference values.

The results indicate that there is an important percentage of the ANIBES population not meeting the current recommended intakes for calcium, magnesium and vitamin D, even when considering only the sample comprising the plausible reporters.



Population with disparity between reported intake and the level needed for adequacy for calcium, magnesium and vitamin D. The whole population and plausible reporters by age groups (%)

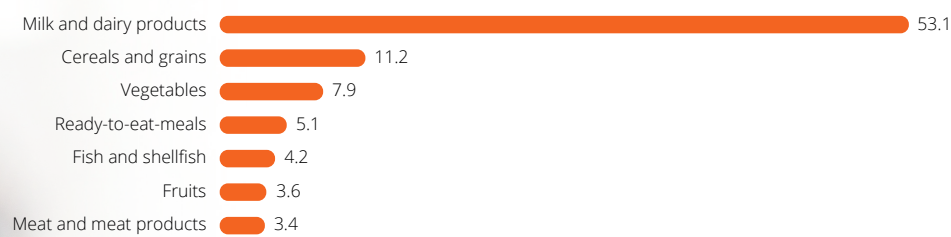
	Total		Children (9-12 years)		Adolescents (13-17 years)		Adults (18-64 years)		Elderly (65-75 years)	
	Spain	EFSA	Spain	EFSA	Spain	EFSA	Spain	EFSA	Spain	EFSA
Calcium										
Whole population	76	66	62	38	78	65	74	66	90	73
Men	72	63	57	29	71	58	70	64	88	71
Women	80	69	68	53	91	77	78	68	92	75
Plausible reporters	56	44	48	23	65	45	55	47	67	49
Men	49	37	44	12	54	35	45	40	63	46
Women	61	50	52	38	79	61	60	51	71	52
Magnesium										
Whole population	79	72	65	48	90	57	78	73	79	79
Men	78	74	69	53	91	60	76	76	81	81
Women	80	70	59	40	89	51	80	71	77	77
Plausible reporters	53	40	49	29	72	26	51	41	44	44
Men	45	38	57	34	73	29	35	35	54	54
Women	58	42	38	23	71	21	60	45	33	33
Vitamin D										
Whole population	94	93	99	99	95	95	93	93	97	94
Men	93	93	99	99	94	94	92	92	99	93
Women	94	94	98	98	97	97	94	94	95	94
Plausible reporters	90	89	98	98	93	93	89	88	94	84
Men	91	89	99	99	92	92	88	88	96	79
Women	89	89	98	98	96	96	89	89	90	90

Recommended daily intakes for Spain and Europe. Adequacy was calculated comparing with 80 % of the Spanish dietary reference value and EFSA population reference intake or adequate intake.

Calcium

The main source of calcium for the entire population was the group composed of milk and dairy products, followed by cereals and grains, and vegetables. Other groups that contributed to a lesser extent were ready-to-eat meals, fish and shellfish, fruits, and meat and meat products. All of them reach more than the 85 % of the total reported intake of calcium.

Contribution of the main food groups to the calcium intake (%)



Contrary to other countries in the European Union, the group of fish and shellfish represents an important source of calcium for the Spanish population, specifically in the adult and elderly groups.

The mean reported intake of calcium in all age groups was much lower than the Spanish and European recommendations, even when the plausible reporters of energy intake were taken separately, whose intake was higher than the whole population.

According to the Spanish National Survey of Dietary Intake (ENIDE), the calcium intake for the Spanish population was 900 mg/day for adults, with very slight differences between sexes. In the ANIBES Study, the reported intake of calcium was 698 mg/day for the whole population and 862 mg/day for the plausible reporters of energy intake.

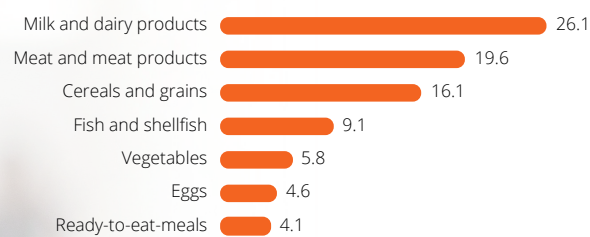
Comparing these results with those obtained in other studies at a European level, one can say that calcium intake in the group of children of the ANIBES Study was around the mean intake in Europe, whereas adolescents, adults, and older adults were closer to the lower figures. When only the plausible reporters of energy intake were considered, adolescents, adults, and older adults' calcium intakes were higher, closer to the European mean.



Phosphorus

The largest source of phosphorus for the whole ANIBES population was the group of milk and dairy products, followed by meat and meat products, cereals and grains, fish and shellfish, vegetables, eggs and ready-to-eat meals. All these food groups afforded in more than 85 % to the phosphorus reported intake.

Contribution of the main food groups to the phosphorus intake (%)

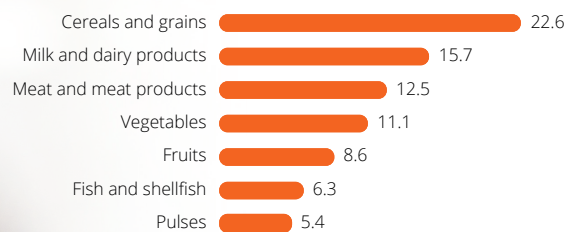


In all studied age groups, the intake of phosphorus met almost the totality of the Spanish and European recommendations. For this reason, it is neither a shortfall nor an over-consumed mineral.

Magnesium

The group of cereals and grains was the main source of magnesium, followed by the group of milk and dairy products, meat and meat products, vegetables, fruits, fish and shellfish, and pulses. All these groups supplied 80 % of the total magnesium reported intake.

Contribution of the main food groups to the magnesium intake (%)



The intake of magnesium in the ANIBES population was much lower than the Spanish and European recommendations, in both the whole population and the plausible reporters of energy intake.

According to the data from the ENIDE Study, intake of this mineral was 350 mg/day. The data from the ANIBES Study were much lower, being 222 mg/day for the whole population and 273 mg/day for the group of plausible reporters of energy intake.

Compared with the data from different surveys conducted in several countries of the European Union, the ANIBES Study population reported intakes of magnesium much lower, even when we took only as sample the group of plausible reporters.



Vitamin D

The group of fish and shellfish was the main source of vitamin D, followed by eggs, milk and dairy products, and cereals and grains. These four food groups contributed to more than 85 % of the daily vitamin D reported intake.

Contribution of the main food groups to the vitamin D intake (%)



The intake of vitamin D in the ANIBES population was by far lower than the recommendations at a national and European level, in both the whole sample and the group of plausible reporters of energy intake. Although in this study the reported intake of this micronutrient was higher than in the ENIDE Study, the percentages of the people that did not meet the level needed for adequacy of Vitamin D in both studies were very high.

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The final protocol of the ANIBES scientific study was previously approved by the Clinical Research Ethics Committee of the Autonomous Region of Madrid (Spain).

