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REVIEW

Adequacy of calcium intake in Spanish population according age groups

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Abstract

Summary This review shows the estimated calcium intake in Spain in recent years. Our results indicate that adolescents and the elderly are at risk of insufficient calcium intake. By using the national and the European recommendations, this work contributes to map and compare population's dietary calcium intake in the European countries.

Purpose and Methods The present work aims to examine calcium intake in the healthy Spanish population of any age and analyze its adequacy to the calcium Recommended Dietary Intake (RDI) for different groups in Spanish population, as well to the Adequate Intake (AI) or Population Reference Intake (PRI) estimated by European Food Safety Authority (EFSA). Forty-three studies published in the last 5 years were eligible for review.

Results and Conclusions The results show that infants and children exceed Spanish and EFSA dietary recommendations, adults meet more that 80% of the RDI and EFSA recommendations, and the estimated average calcium intake in the adolescent and elderly groups does not reach 75% of the recommended intake. Representative national studies with a common methodology to estimate calcium intake are needed.

Keywords Calcium intake · Spain · Dietary recommended intake · EFSA recommended intake

Introduction

Osteoporosis, fractures, and bone-related diseases represent one of the greatest health risks for individuals aged 50 years or more and are a major public health problem in Europe. In 2015, there were an estimated 20 million individuals with osteoporosis in the largest five EU countries and Sweden (EU6). Total fragility fractures in Spain are estimated to increase by 28.8% by 2030 [1].

There are modifiable risk factors associated with osteoporosis, most notably calcium intake. Peak bone mass is a strong determinant of osteoporosis risk in later life [2] and thus measures to improve childhood bone health to peak represent an important public health objective.

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Calcium has long been known to be essential for the maintenance of good bone health at any age [1, 2]. The Recommended Dietary Intake (RDI) for calcium for different groups in Spanish population [3], as well the Adequate Intake (AI) or Population Reference Intake (PRI) estimated by European Food Safety Authority (EFSA) [4], was designed with the aim of promoting higher bone density and avoiding osteoporotic fractures. The estimation of calcium intake by age group has been referenced in different studies [5–7]. However, in recent years, there is no reference that has explored the adequacy of calcium intake in the Spanish general population.

This narrative review aims to examine the literature on the average calcium intake of the general Spanish population. In addition, the findings on calcium intakes will be compared with Spanish and EFSA recommended calcium guidelines.

Methodology

Data sources and search strategy

To identify studies published in English or Spanish evaluating calcium intake in the general Spanish population, we searched electronically from August to September 2019 the following database: Web of Science and MEDLINE. Each database was searched with the following keywords and Booleans: calcium AND/OR intake AND/OR Spain. Due to the local nature of the study, a second search was carried out in the Spanish Warning Dissemination Network (Dialnet) with the following keyword and Boolean: calcium AND intake.

Inclusion and exclusion criteria

Primary research observational studies were eligible if they investigated calcium intake of healthy Caucasian Spanish people at any age. There were no restrictions on the sample size, sex, or physiological situation. Studies were required to publish calcium intake a day in the last 5 years (2014–2019). Studies were excluded if they assessed calcium intake in foreign people or with chronic diseases and in elite athletes. Studies reporting calcium intake during dietetic treatments or intake calcium from supplements were excluded.

Titles and abstracts of studies identified through search processes were screened for inclusion. The remaining studies were retrieved in full text and assessed for eligibility. The final decision on inclusion of studies was made by consensus of all researchers.

Data collection

Data extracted from eligible studies included authors, year of publication, population characteristics including number, gender and age of participants calcium intake assessment method, and calcium intakes.

Studies were quality rated according to the Quality Criteria Checklist primary research created by the Academy of Nutrition and Dietetics (Table 1) [8]. The Checklist included four relevance questions and ten validity questions based on the domains of Agency for Healthcare Research and Quality for research studies. If six or more of the answers are "No," the report should be designates with negative on the Evidence Worksheet. If the answers to validity questions 2, 3, 6, and 7 do not indicate that the study is exceptionally strong, the quality rating is designated as neutral. If the majority of the answers are "Yes" included 2, 3, 6, and 7 plus 1 additional "Yes," the quality rating is designated as positive.

Results

Characteristics of the studies

As shown in Fig. 1, after removal of duplicates, 299 articles were screened. The majority of studies were excluded on the basis of the title and abstract, with the 64 articles undergoing further review and 43 were eligible for critical appraisal. Different study designs have been found: descriptive cross sectional studies [6, 11–19, 23–25, 28, 30–33, 36–38, 40, 41], cross sectional studies with control group [21, 22, 34, 44], case–control studies [10, 20, 29, 43], randomized controlled trial [27, 35, 39], cohort studies [9, 26, 45, 46], one prospective study [42], and four PhD Studies [47–50].

Calcium intake assessment

Dietary assessment methods include objective observation and subjective report. The objective observation embraces a duplicate diet approach or food consumption record by a trained research staff. The subjective dietary assessment methods, which assess an individual's intake, include the 24-h dietary recall (24HR), dietary record (DR), dietary history, and Food Frequency Questionnaire (FFQ), and data are collected with the help of a trained interviewer or by self-report [51].

Depending on the study's objective, some methods seem to be more appropriate. When the objective requires quantitative estimates of intake, the 24-h recall and possibly the food record instruments are recommended [52]. However, various FFQs have been widely employed as a practical instrument since the 1990s, possibly because this method enables the assessment of long-term dietary intakes in a relatively simple, cost-effective, and time-efficient manner. Furthermore, quantitative and semi-quantitative FFQ ask responders to estimate consumed ration size in dietetic scale or grams or present standard rations [53, 54].

Table 4 shows the dietary assessment methods chosen by the authors to estimate calcium intake in the studies included in this review. The most widely used method was 24-h recall, which was utilized in eighteen out of the studies (41%). However, there are differences between the questionnaires employed regarding the number of days, days consecutively, and week and weekend days. Most of the studies collect the information by a total of 3 complete 24-h recall days divided into two weekdays and one weekend day [9, 12–16, 30]. Almárcegui et al. [9] also differentiate weekdays vs weekend days but with a total of 2 × 24-h recall. By administrating homogeneously, the recall from Monday to Sunday Bibilioni et al. [11] also differs week vs weekend days.

In 31.82% of the studies, Food Frequency Questionnaire was used as the calcium assessment method. In general, all studies have selected a validated questionnaire or have validated it previously. We have found differences on the type of questionnaire, time-specific period, and item number. Concerning the first concept, 5 FFQ were quantitative [34, 44] or semi-quantitative [22, 35, 40] ranging from 54 to 140 items. The time-specific period varies by being annual [29, 43] or monthly [20, 21].

A self-reported account of all foods and beverages consumed by a respondent over one or more days (*n*—Food Record) is the most widely used method in childhood.

Table 1 Quality of the 38 included studies, appraised on the basis of the quality rating system of the Academy of Nutrition and Dietetics [8]

Reference	Researc question clearly stated?	Selection of study participants free from bias?	Study groups comparable?	Method of handling withdrawals described?	Blinding assessors?	Procedure, comparisons, and intervening factors described in detail?	Outcomes and measures defined, valid, and reliable?	Appropiate statistical analysis?	Conclusions supported by results, with biases and limitations taken into consideration?	Bias due to study's funding or sponsorship unlikely?	Quality rating
Almárcegui et al. (2015) [9]	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Babio et al. (2017) [10]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Positive
Bibiloni et al. (2014) [11]	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Neutral
Correa Rodriguez et al. (2016) [12]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Correa Rodriguez et al. (2016) [13]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Correa Rodriguez et al. (2016) [14]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Unclear	Neutral
Correa Rodríguez et al. (2018) [15]	Yes	Unclear	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Correa Rodriguez et al. (2018) [16]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Dalmau et al. (2015) [17]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Durá Travé et al. (2014) [18]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Ejeda-Manzaneda et al. (2017) [19]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Unclear	Neutral
Escribano E et al. (2014) [20]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear	Positive
Gómez-Brutón et al. (2014) [21]	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Gutierrez-Diaz et al. (2018) [22]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Positive
Hervás et al. (2018) [23]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Neutral
Jáuregui Lobera et al. (2016) [24]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral

Table 1 (continued)

Reference	Researc question clearly stated?	Selection of study participants free from bias?	Study groups comparable?	Method of handling withdrawals described?	Blinding assessors?	Procedure, comparisons, and intervening factors described in detail?	Outcomes and measures defined, valid, and reliable?	Appropiate statistical analysis?	Conclusions supported by results, with biases and limitations taken into consideration?	Bias due to study's funding or sponsorship unlikely?	Quality rating
Jimenez Talamantes. (2017) [25]											
Julian-almarcegui et al. (2015) [26]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Labayen et al. (2018) [27]	Yes	Yes	Unclear	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Lavado-García et al. (2018) [28]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Lope et al. (2018) [29]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Positive
López-González et al. (2014) [30]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Unclear	Positive
Lopez-sobaler et al. (2017) [6]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Positive
Manzano-Varo et al. (2017) [31]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Unclear	Neutral
Marcos-Pasero et al. (2018) [32]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Morales Suarez Varela et al. (2015) [33]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Moran et al. (2015) [34]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Positive
Ojeda-Rodriguez et al. (2018) [35]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Positive
Olmos et al. (2015) [36]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Olza et al. (2017) [37]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Neutral
Ortigosa - Gómez et al. (2015) [38]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Unclear	Neutral
Pérez-Fernández et al. (2014) [39]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Positive

Table 1 (continued)

Reference	Researc question clearly stated?	Selection of study participants free from bias?	Study groups comparable?	Method of handling withdrawals described?	Blinding assessors?	Procedure, comparisons, and intervening factors described in detail?	Outcomes and measures defined, valid, and reliable?	Appropiate statistical analysis?	Conclusions supported by results, with biases and limitations taken into consideration?	Bias due to study's funding or sponsorship unlikely?	Quality rating
Roncero-Martin et al. (2018) [40]	Yes	Yes	Unclear	Yes	No	Yes	Yes	Yes	Yes	Yes	Neutral
Ruiz et al. (2018) [41]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Neutral
Sanchez Muro et al. (2015) [42]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Neutral
Valles et al. (2018) [43]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Positive
Vera V et al. (2015) [44]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Positive
Vioque et al. (2019) [45]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Neutral
Vioque et al. (2016) [46]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Neutral

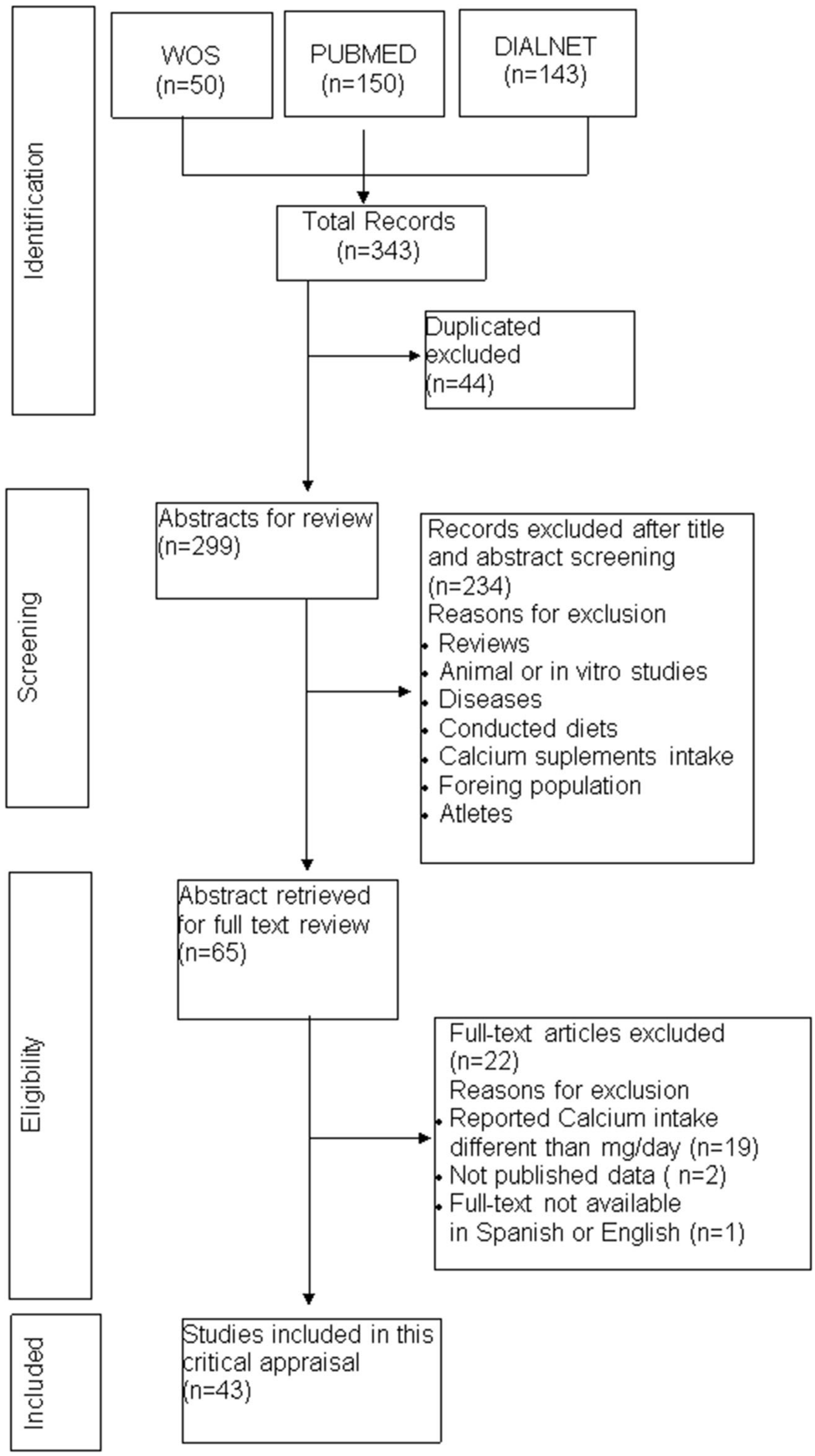

Fig. 1 Summary of searches and study selection flow. Literature flowchart

Because the instrument is open-ended, there is no limit to the number of items that can be reported. Differences regarding the collecting days number have been found varying from 2 [30, 32] to 7 [19] days. The majority of the food records lasted 3 days including 2 weekdays and one weekend day [10, 33, 37, 41]. A total of 4—Food Record were registered in Dalmau et al.'s [5] study, and 5—Food Record from Saturday to Wednesday were used in Hervás et al.'s [23] study including both week and weekend days.

Described assessment instruments are used indiscriminately at any age except in childhood (0–9 years old); then, the preferred method was Food Record. So we observed how

López-Sobaler [6] utilized Food Record among children to estimate calcium intake and 2 days 24-h recall within adolescents.

The ENALIA [6] and the ANIBES [7, 41] studies followed the "EU Menu" guidance recommendations [55]. The "EU Menu" guidance is a document developed to facilitate the collection of more harmonized food consumption data from all EU Member States in 2009.

In all the revised studies, calcium intake from foods and beverages were determined by using the Spanish food composition data bases.

Adequacy of calcium intakes by the Spanish population

The recommended intake (RDI) for different groups for the Spanish population (Table 2) and those established by the EFSA (Table 3) have been used to determine the adequacy of calcium intakes by the Spanish population nutritional adequacy of calcium was measured by the following relation: mean daily intake of the calcium/RDI of calcium × 100.

Considering the negative effects and harm to human health of exceeding the upper levels (UL) of calcium intake, no intake above the maximum recommended levels established by EFSA [4] has been observed among any age group.

Infants and toddlers

The estimated mean (min–max) calcium intake was 612.6 mg/day (350.2–772.2) when considering the total number of children from 0 to 6 months ($n = 632$) and exceeds the RDI (Table 2). The recommended calcium intake should meet the individual needs of the 97.5% of the age group that considered

Table 2 Spanish calcium RDI sorted by age [3]

Category age (years)	Ca RDI (mg/day)	% Studies reaching RDI
0–6 months	400	66.67
7–12 months	525	100
1–3 years old	600	100
4–5 years old	700	100
6–9 years old	800	100
10–19 years old	1300	0
20–49 years old	1000	18.18
50–59 years old	1200[F]/1000[M]	12.5[1]
≥ 60 years old	1200	0
Pregnancy	1300	0

[F] Female

[M] Male

[1] To calculate compliance (%) for the 50–59 years old age group it is been applied female recommendations

Table 3 EFSA calcium reference intake sorted by age [4]

Category age (years)	Ca PRI (mg/day)	% Studies reaching EFSA PRI
7–11 months	280[a]	100
1–3 years old	450	100
4–10 years old	800	93
11–17 years old	1150	7
18–24 years old	1000	0
≥ 25 years old	950	36.84
Pregnancy	950	33.33

Abbreviations: EFSA Calcium Population Reference Intake [4]

[a] Adequate Intake (mg/day) EFSA

they are only indicative amount. These results suggest that most of the study participants ingest the amount they need and some may exceed it. In the study carried out by Zaragoza [48], the estimation of calcium intake by children was well controlled since it came only from formula feeding. However, in the Dalmau et al. [17] study, calcium from breast milk was also taken into account to estimate calcium intake. As the calcium concentration in breast milk depends on several factors that are difficult to control, it may partly explain the differences in calcium intake indicated in both studies.

Following the Spanish age classification, three studies have been found in which the calcium intake in children aged between 7 and 12 months is estimated [6, 17, 48]. Whether considering each of the studies separately (Table 4) or as a whole ($n = 668$), it is observed that the average calcium intake (713.86 mg/day) exceeds the recommendations of the Spanish health authority and the EFSA (Tables 2 and 3) López-Sobaler et al. [6] point out that the average intake of Ca is higher in boys than in girls (733 vs 690 mg/day).

The estimated average calcium intake in the age group of 1 to 3 years also exceeds the recommendations of the Spanish health authority and the EFSA (Tables 2 and 3). This occurs in each of the studies [6, 17, 42, 48] reviewed (Table 4) and, therefore, in the whole of the surveyed sample ($n = 2062$) whose average calcium intake was 888.7 mg/day. It should be noted that the high calcium intake reported by Sanchez-Muro et al. [42] may be due to the authors using a different questionnaire to estimate calcium intake than the rest of the authors. The ENALIA Study [6] shows data divided by gender, 218 boys and 189 girls. Mean calcium intake was higher in boys (928 ± 178.5 mg/day) than girls (879 ± 161.9 mg/day).

Children

In the child, even more than in the adult, the calcium needs are highly variable from one individual to another. Therefore, making recommendations and proposing general guidelines for feeding children is much more difficult. Consequently,

Table 4 Mean calcium intake sorted by RDI age groups

Reference	Age (months/years) (age range) mean ±SD	Intake assessment	Number (%F)	Intake (mg/day) mean ±SD
Infants and toddlers				
0–6 months				
Zaragoza-Jordana et al. (2015) [48]	3 months	FR	241	716.6 ± 112.2
Dalmau et al. (2015) [17]	(0–6 months)	FR	172	350.2 ± 34.55
Zaragoza-Jordana et al. (2015) [48]	6 months	FR	219	772.2 ± 235.3
7–12 months				
Lopez-sobaler et al. (2017) [6]	(6–12)	FR	292 (52.73)	712
Dalmau et al. (2015) [17]	(7–12)	FR	176	596.1 ± 34.45
Zaragoza-Jordana et al. (2015) [48]	12 months	FR	200	833.5 ± 346.8
1–3 years old				
Lopez-sobaler et al. (2017) [6]	(1–3 years)	FR	407 (46.43)	904
Dalmau et al. (2015) [5]	(13–24 months)	FR	626	795.1 ± 18.7
Zaragoza-Jordana et al. (2015) [48]	24 months	FR	180	864.9 ± 315.4
Sanchez Muro et al. (2015) [42]	1.8 ± 1	FFQ	85 (37.64)	1108 ± 189.20
Dalmau et al. (2015) [5]	(25–36 months)	FR	584	858.6 ± 18.8
Zaragoza-Jordana et al. (2015) [48]	36 months	FR	180	802.1 ± 260.2
Children				
4–5 years old				
Vioque et al. (2016) [46]	(4–5 years) 4.34 ± 0.1	24-h recall	169 (51)	784 ± 205
Zaragoza-Jordana et al. (2015) [48]	4 years	FR	143	814.9 ± 220.3
Zaragoza-Jordana et al. (2015) [48]	5 years	FR	123	849.8 ± 239
6–9 years old				
Vioque et al. (2019) [45]	(7–9 years) 7.6 ± 0.1	24-h recall	156 (45.51)	898 ± 240
Marcos-Pasero et al. (2018) [32]	(6–9 years)	FR	221 (52.48)	922.02 ± 220.22
Lopez-sobaler et al. (2017) [6]	(4–8 years)	FR	418 (49.52)	930
Zaragoza-Jordana et al. (2015) [48]	6 years	FR	126	871.1 ± 250.2
Vera V et al. (2015) [44]	6.3 ± 1.1	FR	32 (43.75)	1989 ± 553
Morales Suarez Varela et al. (2015) [33]	(6–9 years) 7.95 ± 1.12	FR	710 (52.39)	922[a]
Zaragoza-Jordana et al. (2015) [48]	8 years	FR	151	857.1 ± 235.4
Escribano E et al. (2014) [20]	7.02 ± 0.13	FFQ	144 (51.38)	866.3 ± 385.70
Adolescents				
10–19 years old				
Ruiz et al. (2018) [41]	(9-12 years)	FR	213	627.6[a]
Ojeda-Rodriguez et al. (2018) [35]	10.7 ± 2.4	FFQ	26 (69.23)	1208.2 ± 315.30
Ojeda-Rodriguez et al. (2018) [35]	11.49 ± 2.5	FFQ	81 (60.49)	1203.4 ± 361.70
Labayen et al. (2018) [27]	10.6 ± 1.1	24-h recall	74	635 ± 200
Ruiz et al. (2018) [41]	13–18 years	FR	210	584[a]
Correa Rodriguez et al. (2018) [15]	(9–19 years) 16.45 ± 3.74	24-h recall	1060 (65.75)	788.66 ± 421
Hervás et al. (2018) [23]	(18–21 years) 18.74 ± 0.77	FR	156 (60.89)	893 ± 287
Lopez-Sobaler et al. (2017) [6]	(9–13 years)	24-h recall	470 (48.29)	992[a]
Olza et al. (2017) [7]	(9–12 years)	FR	213 (40.84)	826 ± 17
Babio et al. (2017) [10]	(10-13 years) 12.1 ± 1.4	FR	45 (57.77)	649 ± 232
Olza et al. (2017) [7]	(13–17 years)	FR	211 (35.07)	817 ± 23
Lopez-Sobaler et al. (2017) [6]	(14–17 years)	24-h recall	275 (42.90)	1004[a]
Babio et al. (2017) [10]	(14–23 years) 18.1 ± 2.8	FR	53 (64.15)	708.6 ± 280.60
Jimenez Ortega et al. (2016) [50]	10.23 ± 0.91	FR	564 (52.25)	978.9 ± 216.7
Correa Rodriguez et al. (2016) [14]	19.11 ± 3.57	24-h recall	781 (66.45)	837.85 ± 377.04

Table 4 (continued)

Reference	Age (months/years) (age range) mean ±SD	Intake assessment	Number (%F)	Intake (mg/day) mean ±SD
Julian-almarcegui et al. (2015) [9]	12.5 ± 17.5	24-h recall	187	810.56 ± 260.2
Almárcegui et al. (2015) [26]	14.21 ± 2.66	24-h recall	57 (35.08)	564.55 ± 232.02
Durá Travé et al. (2014) [18]	(9–12 years)	24-h recall	353	911.7 ± 174.1
Gómez-Brutón et al. (2014) [21]	11–18 years	FFQ	52 (44.23)	853[a]
Adulthood				
20–49 years old				
Correa Rodríguez et al. (2018) [16]	20.46 ± 2.69	24-h recall	550 (69.27)	800.157 ± 349.90
Correa Rodríguez et al. (2018) [12]	(18 - 25 years) 20.38 ± 2.67	24-h recall	605 (69.3)	827.45[a]
Gutierrez-Diaz et al. (2018) [22]	46.50 ± 11.47	FFQ	14 (78.57)	1260.04 ± 307.79
Lavado-García et al. (2018) [28]	45 ± 6	FFQ	675 (100)	1051 ± 443
Ejeda-Manzaneda et al. (2017) [19]	(21–23 years) 21.4 ± 0.7	FR	210 (100)	799.5[a]
Jimenez Talamantes (2017) [25]	(19–30 years)	24-h recall	192 (52.61)	734.4 ± 330.1
Jimenez Talamantes (2017) [25]	(31–50 years)	24-h recall	460 (49.97)	749 ± 339.1
Jáuregui Lobera et al. (2016) [24]	(20–47 years) 21.16	24-h recall	50 (100)	786.53 ± 402.56
González Gomis et al. (2015) [49]	(20–30 years) 23.4 ± 2.3	FR	171 (50.24)	948.6 ± 436.3
Correa Rodriguez et al. (2015) [13]	(18–25 years) 20.41 ± 2.36	24-h recall	305 (73.11)	827.6 ± 347.60
50–59 years old				
Roncero-Martin et al. (2018) [40]	(23 - 81 years) 50 ± 9	FFQ	523 (100)	1053.7 ± 417.7
Lavado-García et al. (2018) [28]	59 ± 8	FFQ	1190 (100)	1045 ± 442
Lope et al. (2018) [29]	56 ± 12	FFQ	558 (100)	922.7 ± 303.30
Jimenez Talamantes (2017) [25]	(51–70 years)	24-h recall	395 (49.62)	734.2 ± 342.4
Moran et al. (2015) [34]	59.73 ± 9.28	FFQ	30 (100)	1077.32 ± 472
Olmos et al. (2015) [36]	(< 60 years) 55 ± 3	FFQ	711	644 ± 352
Pérez-Fernández et al. (2014) [39]	50.39 ± 2.96	FFQ	105 (100)	1287 ± 497.9
Pérez-Fernández et al. (2014) [39]	50.87 ± 2.84	FFQ	100 (100)	1299 ± 536.9
López-González et al. (2014) [30]	(44–76) 58.1 ± 8.3	24-h recall	78 (100)	829.5 ± 257.2
Elderly				
≥ 60 years old				
Valles et al. (2018) [43]	63.3 ± 11.8	FFQ	3950 (48.91)	495.9 ± 148.1
Ruiz et al. (2018) [41]	(65–75 years)	FR	205	474.5[a]
Olza et al. (2017) [7]	(65–75 years)	FR	206 (51.94)	645 ± 19
Olmos et al. (2015) [36]	(60–75 years) 67 ± 5	FFQ	844	626 ± 345
Olmos et al. (2015) [36]	(> 75 years) 80 ± 3	FFQ	256	631 ± 339
Jimenez Talamantes (2017) [25]	> 70	24-h recall	159 (51.57)	746 ± 311.4
Pregnancy				
Manzano-Varo et al. (2017) [31]	28.9 ± 6.7	FFQ	44	758.6 ± 360.7
Zaragoza Noguera et al. (2017) [47]	(22–45 years) 34.1 ± 4.4	24-h recall	197	1173 ± 568
Ortigosa-Gómez et al. (2015) [38]	28.9 + 6.7	FFQ	44	908.8 ± 322.3
Others				
Olza et al. (2017) [7]	(18–64)	FR	1655 (40.36)	689 ± 7
Bibiloni et al. (2014) [11]	(16–65)	24-h recall	1200 (58.5)	1027.9[a]
Bibiloni et al. (2014) [11]	(16–65)	24-h recall	1350 (58.88)	918.2[a]

Abbreviations: *FR* Food Record, *FFQ* Food Frequency Questionnaire

[a] SD are missing when mean intake has been calculated from the studies' data

between 4 and 9 years of age, recommendations are made in the Spanish RDI tables considering different age ranges from those of EFSA. Seven studies have been reviewed to find out the calcium intake in children between 4 and 9 years old [6, 20, 32, 33, 44–46] (Table 4). Zaragoza-Jordana et al. [48] report calcium intakes in children of 4, 5, 6, and 8 years old.

In all these ages, the average calcium intake exceeds the Spanish and EFSA recommendations and the variability of intake in each group is very wide since the SD exceeds 200 mg/day. Lopez et al. [6] Marcos et al. [32] and Morales-Suarez-Varela et al. [33] assess calcium intake within a wide age range and estimate similar mean calcium intakes. Escribano et al. [20] and Vioque et al. [45] also report similar average calcium intakes in groups of children 7 years of age and somewhat lower than the previous ones. However, it is necessary to highlight the Vera et al. [44] study, which reports an average calcium intake much higher than the rest of the reviewed authors. The justification could be found in the fact that the sample studied was small and the food collection intake was for 7 days, when the rest of the studies were carried out with larger samples and the record of ingested food did not exceed 3 days. Regardless of the sample size or questionnaire used to estimate calcium intake, all authors report average calcium intakes that exceed the recommendations of both the Spanish health authority and the EFSA. Three studies [6, 32, 33] separate the average calcium intakes by sex and observe a small difference favorable to the male sex.

Adolescence and youth

We included 17 Studies [6, 9, 10, 14, 15, 18, 21, 23, 26, 27, 35, 37, 41, 50] enrolling a total of 4611 children from 10 to 19 years old. Mean (min–max) sample size was 256 (26–1060) (Table 4). The majority of the studies 88.2% estimate that the average calcium intake mean (min–max) 641.29 mg/day (564.5–978.9) is lower than the intake recommendations indicated for the Spanish and/or EFSA (Tables 2 and 3) Only 47% of studies differentiate calcium intake from males and females. In all of them, it is observed that the mean calcium intake, mean (min–max), made by men 944 mg/day (808.6–1147) is higher than that of women 807 mg/day (708–949.2).

Adulthood

The recommended calcium intakes in Spain for both men and women aged 20 to 49 years old is similar (Table 2). We have selected 9 studies [12, 13, 16, 22, 24, 25, 28, 49, 56] where Ca intake is estimated at these ages with a total of 3232 subjects with a number of estimates between 14 and 675. The mean calcium intake (min–max) of the respondents was 878.4 mg/day (734.4–1260) which represents 87.84% of the RDI. Of the studies, 18.8% reach both Spanish and EFSA recommendations with a compliance percentage of 112.55 and 121.63, respectively. Mean (min–max) age of these studies was 45.75 (45–46.5) years old. Of the studies, 77.7% report an insufficient calcium intake reaching 72% of Spanish recommendations. Of the studies, 55.5% differentiate calcium intake by gender. Moreover, 33.3% of the studies only have female representation. Mean (min–max) calcium intake was 39.26 mg/day higher within men than women being 858 (776.1–1013.1) and 818.74 (696.8–1051) mg/day, respectively.

50–59 years old

To evaluate calcium intake in the Spanish population aged 50–59 years old, 8 studies [25, 28–30, 34, 36, 39, 40] were found. Of the studies, 75% have only female representation and only one author differentiates calcium intake by gender. The fact that the vast majority of the studies were carried out only in women may be linked to the vital menopause period. To establish calcium recommendations within this age category is complicated due the impaired calcium absorption and the individual variation in body composition at this age. As a result, the Spanish and EFSA recommendations differ (Tables 2 and 3). Even though in Spain daily calcium intake recommendation differs by gender (Table 2), we consider female's recommendations (1200 mg Ca/day) as the reference to explain the results due to the percentage of representation of gender in the sample $n = 2780$ women and $n = 199$ men. Mean (min–max) calcium intake is 988 mg/day (644–1299) which represents the 82.33% of compliance of the Spanish recommended intake and 104% of The EFSA recommendations. Of the studies, 50% report lower Ca intake than both Spanish and EFSA recommendations and only 12.5% of the studies reach Spanish RDI.

Elderly

≥ 60 years old

To evaluate calcium intake in the population over 60 years old, we have selected 6 studies [25, 36, 37, 41, 43]. Calcium recommended intake for this age group differs between the Spanish and European Authorities (Tables 2 and 3). None of the studies reaches either the Spanish or the EFSA recommendations (Table 4). Mean (min, max) calcium intake for the total population ($n = 5620$) is 603.1 mg/day (495.9–746). This represents the 50.26% of compliance with the Spanish RDI and the 63.48% with the EFSA recommendations. Of the studies [25, 37], 33% differentiate intake by gender. We have not found differences in calcium intake by gender in this age group. Mean Ca intake (mg/day) for men is 694.3 and for women, 696.65.

Pregnancy

We included 3 studies [31, 38, 47] enrolling a total of 285 pregnant women. Calcium recommended intake for this group differs between the Spanish and EFSA authorities (Tables 2 and 3) due to the increased needs linked to the gestation process and the individual body composition changes. Mean (min–max) calcium intake for pregnant women is 946.8 mg/day (758.6–1173), which complies with 72.83% of the Spanish recommendations and 99.66% of the EFSA recommendations.

Discussion

This narrative review describes the average calcium intake in the Spanish population and analyzes its adequacy to the national and EFSA recommended intakes by age.

The results in the average Ca intake, although many articles have been analyzed, have very wide ranges and standard deviations. This may be due to the methodology followed by the authors. Calcium intake was assessed by different methodologies, including food frequency questionnaires, recall, and diet records, which have well-recognized differences and limitations [51, 57]. Thus, FFQ could be a good instrument to estimate dietary intake or to rank individuals but would not be valid for estimating nutrient intake. The number of food items included, the portion size estimation, and the food composition table used are factors related to the validation protocol that can affect the estimation of nutrient intake [58]. It is well known that FFQ will overestimate the intake [9, 58]. Furthermore, the 24-h recall tends to underestimate the intake, especially in elderly and children, and relies on subject memory and reservher capacity to describe and collect ingredients and food preparation [59]. Food Record, among other limitations, requires a high cooperation of the respondents, the repetition of the registration to analyze the usual diet vs the current diet, and the alteration of the habitual diet due to having to register the food [60].

This review highlights that calcium intake in Spain has been studied in all age groups recently, although the quantity and quality of articles differ. Thus, we have found in childhood two national representative studies (Alsama [5] and Enalia [6]) and one for adolescents, adults, and elderly (The ANIBES Study [37]).

The estimated average calcium intake meets or exceeds Spanish RDI among infants, toddlers, and children. These results are in agreement with The CHOP Study [61] that showed a very high percentage of children from 0 to 8 years old presenting an adequate calcium intake among five European countries. Especially at risk of insufficient calcium intake are adolescents 10–19 years and 11–17 years according to Spanish RDI and EFSA PRI age group, respectively. Diethelm et al. [62] in 2014 through the HELENA Study also showed low intakes of calcium in European adolescents.

Dietary calcium intake in adults reaches 80% of the Spanish recommendations. This is in accordance with Román Viñas et al. [58], a european study that showed a prevalence of inadequacy above 21% of the population in calcium in the adults and the elderly. However, the Nordic and Institute of Medicine nutrient recommendation were applied as reference.

This review displays that the elderly's health in Spain might be at risk due to low dietary calcium intake, as the compliance of calcium intake in the age group barely reaches the 50% of the spanish recommendations. Low dietary calcium intake in the elderly is associated with several health related problems, bone fragility [1], cardiovascular diseases and strokes [63], aged-related eye diseases [64], and others. Further investigation in this field is needed as we did not take into account calcium supplements intake. However, there is a need to increase dietary calcium intake in the elderly because calcium supplementation is a rising concern regarding adverse cardiovascular events [65].

In the review, we have found wide differences in the degree of compliance with the recommendations among some population groups depending on the dietary recommended intake reference used. This might be due to the differences within the age ranges and calcium recommended amount for each category. These differences are a result of the methodology applied to establish the DRVs.

Calcium intake trend may be decreasing among the Spanish population from the year 2000. According to the results of the ENCAT 2003 study [66], the mean calcium intake in adults was 100 mg/day higher than the estimated average calcium intake found in this review. Bibiloni's et al. [11] prospective study of the Balearic Islands indicated that the average calcium intake in adults decreased 109.9 mg/day from 1999–2000 to 2009–2010. However, calcium intake shown in the National Survey of Dietary Intake ENIDE Study [67] 2011 in adults (18–44 years) and the results of this review (20–49 years) are similar intakes. Furthermore, comparing women aged 45–64 years and 50–59 years, calcium intake has increased 148.71 mg/day. As shown, more frequent updates of calcium intakes in Spain are necessary.

Limitations Our study did not account for the use of supplements of vitamins and minerals, so the results of this study are limited to the dietary intake of calcium. Another limitation is that the reproducibility of this review might be affected because most studies are regional or local. Furthermore, many differences in study designs and methodologies and sampling variability have been found. Last, the estimated mean calcium does not report the distribution of intakes or the prevalence of people with low calcium intake.

Strengths By providing a global overview of the average calcium intake in Spain nowadays, this study serves as a roadmap, which points out the age groups of the population at risk of low dietary calcium intake and gives useful information to set health policies and appropiate approaches.

In conclusion, this review compiled available data on average national dietary calcium intake in the Spanish population. The key findings are that calcium intake is low (averaging less than 603.06 and 840.84 mg/day) in the elderly and the adolescents, respectively. Calcium intake has been reported in all age groups; however, further investigation is needed. This work draws attention to age groups where measures to increase calcium intake are likely to have skeletal benefits.

Compliance with ethical standards

Conflicts of interest None.

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