

# Focus on dietary calcium intake in a subgroup of the Italian population

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## ABSTRACT

**Purpose:** To update knowledge on dietary calcium intake in the Italian population, focusing on subjects of any age over 18 years.

**Methods:** Data were collected through consecutive surveys, carried out from 2013 to 2018 in several Italian cities, during screening events intended to promote bone health among the Italian population. A Food Frequency Questionnaire (FFQ), validated for the assessment of the intake of calcium and nutrients for bone health in adults, was administered to subjects to estimate calcium intake in all groups.

**Results:** Out of a total of 1821 FFQs filled in, 1801 provided all the information necessary for the evaluation of calcium intake (being correctly completed and indicating gender and age). Median values were significantly lower than the Italian population reference intake (PRI) values in women of all ages (range: 792 to 854.1 mg/day) and in men aged 60-74 years (854 mg/day) and over 75 years (832.1 mg/day). Young adult males (18-29 years) and adult males (30-59 years) consumed calcium in quantities close to the recommended amounts.

**Conclusions:** These results are in line with what has already been observed in subsets of the Italian population. For this reason, it is once again appropriate to reiterate the need to plan suitable campaigns to spread information and provide guidelines on adequate nutrition able to guarantee correct calcium intake.

## KEYWORDS

Calcium, FFQs, calcium intake, bone health.

## Introduction

Knowing the dietary habits of a population is important for several reasons, but mainly to understand and characterize the risk of specific nutrition-caused illnesses. The collection of information on dietary profiles at a population level is the first step towards planning the best strategies in the prevention of several chronic diseases, and proper dietary choices are major factors which can have beneficial effects on relative risk reduction<sup>[1]</sup>. Osteoporosis is a chronic disease with a multifactorial etiology, and nutrition plays an important role in osteoporosis primary prevention, as well as in supporting medical therapies.

Accurate knowledge of a person's dietary patterns may be predictive of health outcome and allow the development of strategies to counteract bad habits. To assess the nutritional status of populations, simple and easily available tools are needed. Several methods can be used to perform dietary pattern analyses in a defined population group. As stated by the European Food Safety Authority (EFSA), a Total Diet Study (TDS) provides a basis on which to estimate population dietary exposure to nutrients and contaminants. In a TDS, dietary exposure in the population for each chemical component is estimated, combining analytical results with food consumption data<sup>[2,3]</sup>. Worldwide, many TDSs have been performed<sup>[4,5]</sup>. Neverthe-

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less, specific Food Frequency Questionnaires (FFQs) can also be used to collect information on overall diet and/or on selected nutrients in a population group<sup>[6-8]</sup>.

Among the most important dietary micronutrients, calcium is a fundamental compound linked not only to bone health, but also to different physiological mechanisms at every life stage<sup>[9,10]</sup>. Thus, evaluation of dietary calcium intake can be used to take preventive actions.

Calcium is an essential alkaline earth metal first discovered in 1808, and it is the most abundant mineral in the human body. It is a major component of the skeleton, which contains more than 99% of the calcium in the body, while only a small fraction is contained in the extracellular compartment.

Calcium is an essential nutrient that plays a key role in the body, contributing to normal skeletal growth and to the devel-

opment and maintenance of bone mass. It also has many essential biological functions, being involved in muscle contraction and nerve impulse transmission <sup>[11]</sup>.

The health benefits of regular nutritional intake of calcium have long been recognized. It has been associated with protection against most bone diseases and osteoporosis, and preliminary evidence suggests potentially protective effects against overweight, obesity, diabetes, hypertension and cardiovascular disease <sup>[12-14]</sup>.

The most important preventive role of dietary calcium intake is related to bone health: calcium accounts for about 30 to 35% of bone mass and for much of bone strength <sup>[15]</sup>. The relationship between calcium intake and bone mineral density (BMD) has been widely investigated. High calcium intake influences skeletal calcium retention during bone growth and is associated with achievement of the optimal genetically programmed peak bone mass, as well as with a reduced risk of osteoporosis and lower fracture risks in adults and the elderly <sup>[15]</sup>.

Diet is the only source of calcium for the human body. Intestinal calcium absorption is a complex process that involves several mechanisms. For this reason, and because it is subject to many variables, including age, gender, health and composition of microbiota, ethnic group, and the presence of other dietary components, it cannot be precisely estimated. However, dietary recommendations on calcium intake are accurately defined in each country considering the population's needs. Intake levels vary throughout life, being higher in young people, during the time of bone formation, and in older age <sup>[10]</sup>. Unfortunately, worldwide, regardless of age and gender, calcium intake is frequently far lower than the recommended levels <sup>[15]</sup>. Identifying low calcium intake in the population is the first step towards developing appropriate prevention strategies to address this issue.

To our current knowledge, mean daily calcium intake in the Italian diet ranges from 738 to 829 mg/day, and milk and dairy products are the main source, providing up to 80% of the daily total <sup>[8,16]</sup>. The INRAN (Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione, i.e. Italian Research Institute for Foods and Nutrition) report on the Food Consumption Survey 2005–2006 showed that, in the adult population, 18–65 years of age, calcium intake amounts to about 800 mg/day for men and 730 mg/day for women, and 825 and 754 mg/day, respectively, for men and women older than 65 years. To our knowledge, this survey was the last observation to provide nutrient intake data for the entire Italian population. Since then, investigations of nutritional habits and levels of nutrient intake have been performed only in specific population subgroups. A recent paper, published in 2017, reports data on the dietary habits of 8944 (4768 women and 4176 men) participants aged >18 years from all over Italy, recruited in 2010–2013 (Italian Nutrition & HEalth Survey, INHES); unfortunately, it reports no data on nutrient intake and calcium intake in the general population <sup>[17]</sup>.

Data on calcium intake in the Italian population are reported for specific disease groups, such as patients with inflammatory bowel disease <sup>[18]</sup>, or adults with type 1 diabetes <sup>[19]</sup>, or in regional surveys. Castiglione and colleagues randomly collected data in a sample of 1838 individuals in the city of Catania, southern Italy, and reported that mean daily calcium intake was

803.27 mg among men and 798.23 mg among women; among the over-70s, the values were 828.9 and 778.4 mg/day for men and women, respectively <sup>[8]</sup>.

According to a recent investigation by Kehoe *et al.*, at European level, up to 50% of older adults show inadequate intake of calcium when compared with an estimated average requirement established by the EFSA. In Italy, the last National Food Consumption Survey, cited in the study by Kehoe, dates back to 2005–2006 <sup>[20]</sup>.

Against this background, a population survey was specifically designed with the aim of updating knowledge in this field and focusing on subjects of any age over 18 years.

## Materials and methods

### Study group

Data were collected in consecutive surveys performed from 2013 to 2018 in several Italian cities in northern, central and southern Italy, during screening events intended to promote bone health among the Italian population.

An information and communication campaign was designed and implemented, with the aim of disseminating clear information to all citizens during screening events. These events were promoted through the press (i.e. national and local newspapers) and social networks (e.g. Facebook).

The events targeted subjects of every age range, from the young adult population (over 18 years old) to the elderly one. By means of the communication campaign, the general population, with no exclusion criteria, was invited to take part in the prevention initiatives. The participants were recruited on a voluntary basis and their dietary calcium intake was evaluated through FFQ administration.

As a result of the events, 1821 FFQs were administered: 1039 (57.1%) to participants in northern and central Italy and 782 to participants (42.9%) in southern Italy.

### FFQ for dietary calcium intake evaluation

To estimate their calcium intake, subjects were administered a FFQ for the assessment of calcium and nutrients for bone health in adults, specifically validated for the Italian population by Montomoli *et al.* <sup>[21]</sup>. This questionnaire is composed of 16 questions that investigate consumption of 15 food items. It covers the following foods: milk, yogurt, ice cream, cheese and chocolate milk. Questions about cheese are specific in order to identify which kind of cheese is consumed by the interviewee. Different types of cheese may have different calcium contents due to factors such as raw materials, production process and aging. Therefore, this food group is divided into hard, semi-hard and soft cheeses. Moreover, intake of Parmigiano Reggiano cheese, a food rich in calcium (1159 mg/100 g) and widely used in Italian diets, was specifically investigated through two different questions: one about its use as a condiment for pasta and soup, and the other about its consumption as a single food.

The FFQ considers all the main food groups: meat, fish, eggs, cereals and bread, vegetables and fruit. It also evaluates consumption of calcium-rich natural mineral water (with a calcium content  $\geq 150$  mg per liter), as an additional source of

dietary calcium. A list of the most common Italian bottled mineral waters was attached to the FFQ for easier identification. Subjects were asked to report the frequency of consumption of each food and to indicate portion sizes. Photographs showing small, medium and large serving sizes were used to help them estimate the quantities. Consumption of each item was evaluated with weekly frequency.

Information about sex, age, weight and height was self-reported by each interviewed subject.

Dietary calcium intake was analyzed using Microsoft Excel 2010 spreadsheet software. The calcium content of each food item in the FFQ was taken from the food composition tables of the Center of Research for Food and Nutrition (CREA) and the European Institute of Oncology (IEO), and used to calculate the daily calcium intake.

Dietary calcium intakes were compared to the Population Reference Intake (PRI) values for the Italian population, reported by the Italian Society of Nutrition (SINU) in its Levels of Recommended Consumption of Energy and Nutrients (LARN) [22].

### Statistical analysis

Statistical analysis was performed on 8 subgroups obtained by stratifying the whole study group by gender and age (18-29, 30-59, 60-74,  $\geq 75$  years). Age, weight, height and BMI were expressed as means (with standard deviation); total dietary calcium intake was expressed as median. Differences in dietary calcium intake between each subgroup and the respective PRI were calculated using the Wilcoxon test among medians. All analyses were performed using the Statistical Package for Social Sciences software, version 20 (SPSS, Chicago, IL, USA), with  $p < 0.05$  set as the threshold for statistical significance.

Analyses were performed on the total study group, both as a whole and divided by gender and four age ranges: 18-29, 30-59, 60-74, and over 75 years. Analysis of all the data collected revealed that about 1.3% of anthropometric and socio-demographic values were missing.

## Results

Results of the total sample show that the men had a mean age of  $55.30 \pm 17.90$  years and the women a mean age of  $55.53 \pm 13.69$  years; weight was  $76.29 \pm 11.11$  kg in the men and  $62.86 \pm 10.89$  kg in the women; height was  $1.73 \pm 0.08$  m in the men and  $1.61 \pm 0.07$  m in the women.

BMI was found to be in the normal or overweight range, for both males ( $25.5 \pm 3.5$ ) and females ( $24.3 \pm 4.3$ ).

Table I reports descriptive analyses, referring to the 8 subgroups created by dividing the whole sample by gender and age ranges. Out of a total of 1821 FFQs filled in by the subjects, 1801 reported all the information necessary for the evaluation of calcium intake (these FFQs were correctly completed and reported gender and age). Of these 1801 valid FFQs, 1455 were filled in by females (80.8%) and 346 by males (19.2%).

For the analysis of calcium intake, given the presence of extreme values (i.e. too low or too high, likely due to failure to understand the FFQ questions), the median was used instead of the mean value.

Table II details daily calcium intake, as a median, compared with the PRI for each age range.

The median values were significantly lower than the relative PRI for the Italian population, across all the age groups in the women and in two age groups among the men (60-74

**Table I** Age, weight, height and BMI of the participants divided by age ranges. The data are reported as mean and standard deviation.

MALES					FEMALES			
Age	n	Weight (Kg)	Height (m)	BMI	n	Weight (Kg)	Height (m)	BMI
18-29	36	$73.54 \pm 10.72$	$1.77 \pm 0.07$	$23.28 \pm 2.67$	88	$58.4 \pm 8.71$	$1.65 \pm 0.07$	$21.33 \pm 2.34$
30-59	138	$77.63 \pm 11.54$	$1.76 \pm 0.07$	$24.88 \pm 3.09$	742	$62.35 \pm 10.75$	$1.63 \pm 0.06$	$23.6 \pm 4.04$
60-74	125	$76.5 \pm 11.59$	$1.7 \pm 0.06$	$26.38 \pm 4.04$	541	$64.38 \pm 11.26$	$1.59 \pm 0.06$	$25.56 \pm 4.41$
$\geq 75$	47	$74.04 \pm 8.11$	$1.67 \pm 0.06$	$26.44 \pm 2.99$	84	$62.4 \pm 10.09$	$1.56 \pm 0.07$	$25.67 \pm 3.78$

**Table II** Calcium intake as median compared with PRI in each age group (Wilcoxon test). Significance is considered for  $p < 0.05$ .

MALES (N=346)					FEMALES (N=1455)			
Age	n	Calcium intake (mg/day)	PRI	p-value	n	Calcium intake (mg/day)	PRI	p-value
18-29	36	973.6	1000	0.551	88	854.1	1000	$p < 0.001$
30-59	138	884.8	1000	0.117	742	825.1	1000	$p < 0.001$
60-74	125	858	1200	$p < 0.001$	541	828.1	1200	$p < 0.001$
$\geq 75$	47	832.1	1200	$p < 0.001$	84	792	1200	$p < 0.001$

years;  $\geq 75$  years). On the other hand, younger adult males (18–29 years) and adult males (30–59 years) were found to consume calcium in quantities close to the recommended amounts.

## Discussion

It has long been recognized that having a good, healthy diet, adequately rich in calcium, notably increases BMD and protects against the onset of osteoporosis and related fracture risks [23,24]. Recently, the EFSA Panel on Dietetic Products, Nutrition and Allergies concluded that a cause and effect relationship has been established between dietary intake of calcium and normal bone development, both in the general population and, in particular, in children and adolescents [25]. Moreover, the EFSA confirmed the health claim that calcium is “essential for proper structure and development of bones, teeth and nails” [26].

Optimal calcium intake is also essential for the effectiveness of anti-osteoporosis medications administered to patients at high risk of fragility fractures. According to several international guidelines, it is preferable to optimize dietary calcium rather than prescribe calcium supplements, which are linked to many side effects, such as gastrointestinal symptoms [27].

As no recent specific observations about calcium intake in Italy were available, our investigation was conducted with the aim of exploring the current situation regarding certain groups within the Italian population.

As regards the population over 60 years of age, at higher risk of diseases of bone metabolism such as osteoporosis and fragility fractures, the results of this study reflect what has already been highlighted in previous studies in other settings, and is consistent with findings reported the world over [15]. Dietary intake in the elderly should reflect the changed nutritional needs of this population: intake of macro- and micronutrients needs to be increased to the recommended levels, in a way that does not increase caloric intake and that preserves lean mass.

Malnutrition in the elderly is currently common, not only in residential settings and hospitals, but also among elderly people at home. Malnutrition refers to low intake of both protein and micronutrients, such as calcium, and it is associated with functional impairment that initiates a sequence of negative consequences. These can range from a decline in muscle mass and strength to sarcopenia and frailty [28].

The exclusion of certain foods from the diet may sometimes be justified. Meat, for example, is often eliminated due to chewing issues, or dairy products are excluded from the diet, especially in the female population, because of weight gain issues or possible plasma cholesterol increases [29,30]. As reported by Lombardi-Boccia *et al.*, in the Italian diet, about 60% of dietary calcium should come from milk and dairy products, 20% from fresh vegetables and nuts, and the rest from drinking water or other discrete sources [16]. Furthermore, the importance of phosphorus, proteins (especially casein), potassium, magnesium, zinc, vitamin D, vitamin A, and vitamin C in maintaining the physiological calcium balance is well known, and milk and dairy products are the main food sources of most of these nutrients [31]. If the quantity of dairy products in the diet is greatly reduced, calcium intake will decrease too, and skeletal

health will be seriously jeopardized. A lower-than-recommended calcium intake, as found in all our female groups and in our elderly males, can lead to an increased risk of osteoporosis. A different situation was detected in the two groups of men younger than 60 years. From our findings, in those two groups the median levels of calcium intake identified (880 mg/day in the 30–59 years and 970 mg/day in the 18–29 years groups) are closer to the recommended ones and better than values previously observed in Italy. In fact, the INRAN survey of 2005–2006 showed that the average intake in the male population was around 800 mg/day, and the paper published in 2018 by Castiglione and colleagues reported almost the same observation, that is, a mean calcium intake in the male population of 803 mg/day [8]. The higher values found by our surveys could be due to the fact that younger males taking part in screening events are more motivated to have an optimal lifestyle and to follow a proper diet, which leads to a calcium intake more in line with the recommendations.

This study has some limitations, but also some strong points. It involved a heterogeneous group of subjects and not a truly representative sample of the Italian population. In fact, no specific sampling procedure, such as stratified sampling, was adopted and no exclusion criteria were applied.

Moreover, the females outnumbered the males. This could be due to the fact that women are more sensitive to bone health issues, since osteoporosis has always been a health problem more relevant to them than to men. For this reason, too, the whole study group cannot be considered representative of the Italian population. On the other hand, the involvement of males could be a very important aspect, considering that one in five men aged 50 years or over will suffer an osteoporotic fracture.

Finally, the subjects could not be stratified, for subgroup analysis, on the basis of pathologies or of underlying conditions making them vulnerable to calcium deficiency (such as celiac disease and lactose intolerance), because this information was lacking. Nevertheless, the data were collected during screening events aimed at the Italian population as a whole, and the subjects who took part in them were highly motivated. Moreover, the voluntary participation of subjects from different cities across Italy, from North to South, and of every age range, provided a representative and interesting picture of daily calcium intake through the Italian diet.

## Conclusions

In conclusion, this investigation provides an important update on calcium intake in the general Italian population. It produced no substantial differences compared with previous results, showing that calcium intake is still insufficient and below the Italian recommendations, particularly in elderly people. The results of this survey may make a significant contribution to the building of global charts showing the average dietary intake of calcium in the adult population. In light of these results, it is once again appropriate to reiterate the need to plan suitable campaigns (also specifically targeting the male population) to spread information and provide guidelines on adequate nutrition able to ensure correct calcium intake.

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**Authorship:** B.P. and M.L.B. conceived the study; B.P. and L.C. designed the study; S.Q., and L.G. performed the survey; L.G., S.Q. and G.G. contributed to preparing the materials and the analysis tools; B.P. and G.G. analyzed the data; B.P., S.Q., L.C. and M.L.B. wrote the paper and approved the version to be published.

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