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Appropriate Ca dose from bicarbonate-calcium mineral water as a preventive strategy for osteoporosis

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Abstract

An adequate supply of calcium with the diet together with a physically active lifestyle can improve the quality and perhaps the amount of life in the elderly population with reduced risk of osteoporosis. Mineral water is a good source of calcium, highly bioavailable and easily assimilated and the daily consumption of hyposodic mineral waters, with a balanced content of calcium and magnesium, makes an important contribution to the intake of these minerals and can represent an important protective factor for osteoporosis.
In this review we reported relevant data related to calcium supplementation and risk of osteoporosis and analyzed the contribution of calcium bicarbonate mineral water as a valid support to integrate the diet and to achieve appropriate calcium dose.

Keywords: *Osteoporosis, calcium, mineral water.*

Osteoporosis

Osteoporosis is a systemic skeletal disease. The main factor is the low bone mass with associated increased bone fragility and risk of fractures. In the USA about 44 million individuals ≥ 50 years old (of which 30 million women) present osteoporosis problems. Prevention, detection and treatment are essential. Nowadays DXA (dual-energy X-ray absorptiometry) is the most widely technique to measure bone mineral density (BMD) and predicting in this way fractures. Several studies demonstrate that this assessment emboldens to modify lifestyle in order to contrast osteoporosis. Low calcium intake is the main factor involved in risk fractures. Data from NHANES (National Health and Nutrition Examination Survey) report that daily intake for post-menopausal women is under recommended dose according to current guidelines.

As reported by McLeod et al., knowledge of bone density can affect postmenopausal Caucasian women behaviors to assume the correct daily calcium intake, demonstrating the importance of effective screening (McLeod et al., 2007).

Osteoporosis, the progressive demineralization of the skeleton, is a typical legacy of the third and fourth age (primary osteoporosis, senile), involves the female menopausal period (primary osteoporosis, post-menopausal) and precociously may also occur (secondary osteoporosis) because of various clinical conditions (hypogonadism and endocrine-metabolic diseases) or prolonged use of drugs (corticosteroids, immunosuppressants).

The correct definition of osteoporosis has been formulated by the experts of the World Health Organization:"Osteoporosis is a disease characterized by reduced density of bone mass and microstructural alteration of bone tissue, responsible for an increased fragility and a consequent increase in the risk of fractures".

The complication of osteoporosis consist of femoral and vertebral fractures. These are events that can be attributed even to modest traumas, or, in an absurd way, to spontaneous fractures. Osteoporosis is characterized by a considerable loss of bone mass and the deterioration of the microstructure of the bone with consequent fragility of the skeleton.

In developed countries, osteoporosis is becoming a public health problem, due to the morbidity, mortality and high social cost of fractures and disability.

In Italy, according to recent data (International Osteoporosis Foundation, 2001, CEIS Survey - University of Rome Tor Vergata-Fimmg), about 5 million people suffer from osteoporosis (4.4% of women 40 to 49 years old, 41.3% of women between 70 and 79 years old).

Prevention is possible with a correct lifestyle (diet, physical activity) capable of strengthening the bone structure during childhood and adolescence, slowing down the senile decline. In the presence of risk factors, it is advisable to evaluate bone mineralization with a BMD.

However the exact role of osteoporosis in the etiology of fractures must still be precisely determined. In fact, the resistance of the bone to traumas reflects the integration between bone density and bone quality. Bone density is expressed in grams of mineral per area and is determined, in each individual, from the peak of bone mass reached and the amount of bone lost. The quality of the bone refers to architecture, turnover, and the whole sum of suffered damages and mineralization (National Institutes of Health, 2000).

Osteoporosis can affect any age, even if peak incidence is in elderly age, and may be primary or secondary (Consensus Development Conference, 1993; Consensus Development Statement, 1997; National Institutes of Health, 2000; Bollettino SIOP, 1999; Hawker, 1996; Riggs & Melton III, 1990). Bone is a living tissue with constant growth and replacement.

The factors determining the peak bone mass are:

- genetic factors and familiarity, hormonal factors (estrogen and androgen levels, hormone of growth)
- nutrition (calcium intake, vitamin D and, most probably, also vitamins C and K)
- lifestyle (physical activity, exposure to UV, smoking, excessive coffee consumption)
- congenital diseases (cystic fibrosis, homocystinuria, etc.), diseases chronic and prolonged pharmacological treatments (corticosteroids).

Prevention of osteoporosis

During juvenile age, the organism has the potential to capitalize in the bone tissue the maximum calcium quantity. These are the years in which the so-called peak of bone mass and the maximum calcification possible should be reached. The continuous bone reshaping should be in balance, until the menopause for the woman and the senility for both sexes make the processes of bone resorption prevailed.

In late age the structural decline of the skeleton is the unavoidable resultant of a series of events that are difficult to restrain, due to a lifestyle with evident risk factors.

The achievement of an adequate peak bone mass and therefore the correction of the main behavioral and nutritional errors in the first period of life (20-25 years) represent priority over any other action in order to prevent osteoporosis.

The triad heredity, physical activity and nutrition, influences the destiny of our bones. Physical activity and the contribution of foods rich in calcium are the modifiable aspects for a preventive strategy of osteoporosis.

Sodium reduction may also be effective. Lin and co-workers demonstrated that the DASH diet (Dietary Approaches to Stop Hypertension) and sodium reduction improve markers of bone turnover and calcium metabolism in adults. In this study were examined the effects of two dietary patterns and three sodium levels on bone and calcium metabolism in a randomized feeding study. The DASH diet significantly reduced bone turnover, which may improve bone mineral status. A reduced sodium intake reduces calcium excretion in all diet groups and serum osteocalcin in the DASH group (Lin et al., 2003).

Calcium

Calcium is the fifth element, in order of abundance, in the earth's crust, and the fifth element among the components of the human body. In humans, 99% of calcium is found in the bones and teeth, in the form of tricalcium phosphate-hydroxyapatite, fluoride and carbonate. Calcium has the role of second messenger in extracellular fluids and cytosol, where calcium is involved in the regulation of numerous biochemical processes, as nerve transmission and muscle contraction (Del Toma & Tubili, 2001).

Calcium deficiency in the extracellular fluid is compensated by the calcium sampling derived from bone resorption. The recommended quota of calcium is not the quantity contained in the foods, but the percentage really absorbed by the organism.

It should be remembered that the presence of lactose favors the solubilization of calcium, due to lower intestinal pH; phosphates, instead, form insoluble complexes and limit calcium absorption, likewise phytates and oxalates (Del Toma & Tubili, 2001; Fairweather-Tait, 1999; Guéguen & Pointillart, 2000). If we consult the Food Composition Tables (INRAN, 2000) we can see that many vegetables have a calcium contribution even higher than that of cheeses, a notoriously rich source of calcium (Marletta & Carnovale, 2000). But vegetables have the value and the defect of containing many fibers, which are able to reduce its intestinal absorption.

The bioavailability of calcium is related to the concentration of the ionized form at the duodenal level and the first loops of the jejunum, where it is absorbed by an active and saturable transport mechanism (LARN - rev. 1996). Its absorption is increased by the presence of proteins (calcium linked to aminoacids is easily absorbed), the acidic environment of the upper digestive tract which solubilizes calcium salts (in fact prebiotic and probiotic are able to increase mineral absorption), the reduced sodium content.

Low calcium intake can negatively influence bone health in adults. A systematic review reports an interactive global map, classifying countries based on average calcium intake. Calcium intake ranges from 175 to 1233 mg/day, i.e. less than 500 mg/day in Asia, about 400-700 mg/day in Africa and South America and greater than 1000 mg/day in Northern Europe (Balk et al., 2017).

Adequate intakes of calcium and vitamin D constitute a preventive strategy and a fundamental part of therapeutic regimen for osteoporosis. Ideal intake ranges from 800 to 1000 mg/die, with associated Vitamin D replacement. Moreover food sources of calcium can similarly and positively affect bone density, without adverse cardiovascular effects. In fact,

several studies report increased risk of myocardial infarction, due to calcium supplements (Kränzlin, 2011).
Secondary hyperparathyroidism and bone loss are related to inadequate intake of calcium and vitamin D. The most employed strategies are supplementation with calcium and vitamin D in order to prevent fractures.
Many papers in literatures demonstrated the efficacy of this treatment. According to Shea et al., positive effects of calcium supplementation on bone density in post-menopausal women is reported, after two or more years of treatment (15 trial of 1806 patients). Another very recent study (cohort of 29 randomized trials and 3897 patients) demonstrated the efficacy of calcium implementation of 1000 mg/die (dietary calcium 408-879 mg/die associated with calcium supplementation of 500-2000 mg/die). As reported by several papers, combination of calcium and vitamin D is able to reduced fracture risk in elderly people. Furthermore also calcium supplementation alone may efficaciously in preventing osteoporosis fractures (3.5 years of treatment) (Kränzlin, 2011).
Institute of Medicine in the USA notes that 1000-1200 mg of calcium is daily demand for women and men over 50 years old with maximum limit of 2000 mg/die.
Clinical studies on adults with controlled and appropriate Ca dose (1000-1500 mg/day) reported that a correct intake reduces risk of osteoporotic fractures (Fagotti et al., 2016; Avenell, et al., 2017).
Calcium implementation is associated to risk of hypercalcaemia and related cardiovascular diseases and thus is advisable to take supplements after meals, dividing into small portions of 500 mg.
Calcium salts (calcium carbonate and calcium citrate) are generally slightly soluble and thus their absorption is difficult.
Considering that calcium supplements may cause cardiovascular problems and food sources of calcium produce similar positive effects, calcium intake from natural food sources should be encouraged (Kränzlin, 2011).
Calcium supplementation in the diet and milk intake have significant importance in achieving an adequate peak of bone mass (Matkovic et al., 1990; Sandler et al., 1985; Chan et al., 1995).
However, the intake of milk and prepuberal derivatives would have a greater effect on bone density compared to calcium supplementation alone (Chan et al., 1995; Harvey et al., 1988). This positive effect of milk and derivatives on bone mass has been attributed to the fact that they have a high calcium content but also other important nutrients (magnesium, sodium, vitamin D). Indeed milk and derivatives contain more easily absorbable and incorporable calcium form in the bones and / or is easier to take milk and derivatives rather than calcium in the form of a supplement (Celotti & Bignamini, 1999).
Unfortunately, in adolescents, consumption of milk (50-75% of the daily calcium requirement) is often replaced by other drinks or new eating habits and supplementation with dairy products are difficult to achieve because of behavioural or environmental factors (Böhmer et al., 2000).

Calcium from mineral waters

Calcium is naturally abundant in mineral waters which represent valuable caloric-free sources (Heaney and Dowell, 1994). Mineral waters with a high calcium content (over 150 mg/L) and low sodium content (less than 20 mg/L) can be considered excellent supplemental sources.
Until a few years ago, it was believed that the calcium of water was badly absorbable compared to other food sources, but a series of scientific papers, written by experts on the metabolism of calcium, has reversed this belief, in particular for calcium waters (calcium> 150 mg/l) and bicarbonate-calcium waters (bicarbonate> 600 mg/l).
Calcium of water is immediately used because is easily bioavailable. Some studies demonstrated the bioavailability of calcium in waters (Bacciottini et al., 2004; Van Dokkum et al., 1996; Wynckel et al., 1997; Couzy et al., 1995; Halpern et al., 1991). Numerous scientific works reported that high-calcium mineral waters ensure calcium absorbability equal or even better than milk (Dokkum et al., 1996; Aptel et al., 1999; Heaney and Dowell, 1994; Heaney, 2006). The advantage to getting calcium from water rather than from milk and other dairy products is that mineral water is non-caloric. And, as the researchers pointed out, many

people avoid milk because they are lactose intolerant or just don't like it. However, it is advisable to consume two liters (eight cups) of mineral water with 500 mg of calcium per liter (Greupner et al., 2017).

Heaney (Heaney, 2006) analyzed all data in literature and confirms comparable absorbability of calcium in both mineral waters and milk (under the same conditions). In most of the studied waters, the counter-ion of calcium is bicarbonate, which is important because at the same ingested calcium load, it can vary its bioavailability (for example, the high-sulphate waters provoke a greater increase of urinary calcium). Then high bicarbonate-calcium rich waters are preferable (Heaney, 2006).

Böhmer and co-authors analyzed six publications in literature regarding calcium absorption from mineral waters (Van Dokkum et al., 1996; Wynckel et al., 1997; Couzy et al., 1995; Halpern et al., 1991; Guillemant et al., 2000; Heaney and Dowell, 1994). RDA are dependent on age and sex. Last studies reported 1000-1500 mg/die for children and adolescents, perimenopausal women and elderly. In these cases, normal diet is not sufficient to ensure desiderable calcium amount. It's necessary to integrate with dairy products and supplements, facilitating patient compliance. In this scenario, the calcium-rich mineral waters can be inserted as alternative. It's necessary to calculate absorption fraction, defined as the relationship between absorbed calcium and dietary calcium intake. Böhmer and co-authors remind that absorption factors in calcium waters are similar to and, in some cases, even better than dairy products (Böhmer et al., 2000), mostly if sodium is found in small concentration (Na^+ within 20 mg/L). Sodium can increase calcium urinary elimination and negatively affects calcium absorption capacity. There is a physiological correlation between calcium and sodium. Therefore people should be choosing low sodium water as hyposodic diets promote calcium absorption.

Acqua Lete®

Among Italian mineral waters, Acqua Lete® allows an adequate calcium-supply (315 mg/L) easily absorbed and it is characterized by high CO_2 content, high bicarbonates (1020 mg/L) and low sodium concentration (5.15 mg/L). RDA calcium for an adult is 800 mg.

An habitual consumption of natural effervescent mineral Acqua Lete®, thanks to its high calcium value and the reduced sodium content, is the most natural way to provide an adequate supply of calcium to our body. Bicarbonate waters may neutralize acid secretion, accelerate gastric empting, provoke the release of gastric peptides and for these reasons are ideal for hydrochloric-peptic hypersecretion and gastro- esophageal reflux disease. During sport bicarbonate waters are able to restore liquids and salts and counterbalance metabolic acidosis (Brancaccio et al., 2011).

In line with the classification of mineral waters under Fixed Residue Acqua Lete® has average mineralization (FR 800 mg/L). The content of sodium (Na^+) is less than 20 mg/L, suitable for low-sodium diets. Mineral water classification based on chemistry and related therapeutic effects (D.M. 29/12/2003) defines mineral content. Water is bicarbonate when the content of bicarbonate (HCO_3^-) is higher than 600 mg/L. Moreover water possesses antinflammatory action, if is bicarbonate – alkaline, instead is able to facilitate digestive process and antispasmodic if it is bicarbonate – calcic. Acqua Lete® presents as a negative prevailing ion bicarbonate and as positive prevailing ion calcium (Ca^{2+}) is said water facies bicarbonate - calcic (Piazzese, 2015). This water can be considered a calcium diet source with adjuvant action in osteoporosis therapy, preventing pathologies related to calcium deficiency. pH value (6.4), the presence of bicarbonates and CO_2 create an acidic intestinal environment, positive for better calcium salts solubilisation and thus better calcium absorption.

Conclusion

Calcium intake is inadequate in the various age groups, because of an incorrect diet or some factors that may significantly reduce its absorption.

The consumption of water rich in calcium (200 mg/L) represents an important protective factor in the prevention of osteoporosis.

In this contest, bicarbonate-calcium mineral water could give appropriate calcium dose,

representing a highly bioavailable and caloric-free source.

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