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Action of beer on the bone

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Summary
Although it has been shown that excess alcohol is a significant risk factor for osteoporosis, the moderate consumption of beer appears to have beneficial effects on the bone. This review comments on the scientific evidence regarding the possible beneficial effects of beer on bone metabolism, describes which of its elements may be responsible for these positive effects, and reports that both the polyphenols and the flavonoids, among them lignane, and above all silicon, all of which are components of beer, act positively on bone metabolism and bone mass.

Key words: *alcohol, polyphenols, flavonoids silicon, bone mass, osteoporosis.*

Introduction: diet and osteoporosis

Osteoporosis is a disease of bone metabolism very common in human beings. It was initially defined by Fuller Allbright as "too little bone". Nowadays, the accepted definition by consensus is "systemic skeletal disease characterised by a reduction in bone resistance, with the consequent increase in bone fragility and susceptibility to suffering fractures."[1]. The essential elements of this definition are low bone mass and changes in its microarchitecture, which distinguish osteoporosis from other bone diseases. Any bone fracture is related to the strength of the bone, bone mass, expressed as bone mineral density (BMD), being the main contributor to this strength.

The change in microarchitecture is characterised by the loss, thinning and lack of connection between the bone trabeculae, along with a series of factors, such as alterations in remodelled bone, the geometry of the bone itself, etc., which have been grouped under the concept of bone quality[2]. All this produces a deterioration in the structural integrity of the bone and causes skeletal fragility, which results in an increase in risk of fractures.

The etiopathology of osteoporosis is multifactorial, and, although the genetics and the hormonal factors influence enormously the degree of bone loss related with age, poor nutrition, with a low intake of calcium and vitamin D[3], tobacco and excess intake of alcohol, as well as the absence of physical exercise also significantly affect this bone loss[4].

Among a number of factors, foods rich in calcium and vitamin D[5] have been shown to have a significant positive effect both on the acquisition of a good peak bone mass, and in delaying this loss of mass which appears from a certain age. Other foods rich in minerals which the bone contains such as magnesium, potassium and fluorine, or in trace elements such as zinc, copper, boron and manganese[6], are associated with bone mass, and a deficiency of these elements with reduced bone mass, or with slow consolidation of fractures.

Alcohol and bone

We know that an excess intake of alcohol is considered to be a significant risk factor for osteoporosis. The physiopathological mechanism which relates alcohol with osteoporosis is complex[7], although it appears that it would be related through a depression in bone formation and an increase in urinary excretion of calcium. This is an osteoporosis with low remodelling, whose most significant clinical expression is that which happens in cirrhotic alcoholics, and which is closely related to the duration of the consumption of alcohol. It should not be forgotten that in alcoholics, with or without hepatopathy, other changes in mineral metabolism may also be associated, included among which are a reduction in secondary vitamin D due to a deficit in hepatic hydroxylation, and a reduction in the production of the proteins bonded to vitamin D. Magnesium deficiency is another parameter to be studied in these alcoholic patients, which is accompanied by hypoparathyroidism with hypocalcemia and resistance to PTH, all of which contribute to bone loss.

However, moderate consumption of alcohol could be beneficial to the bone, both in men and in menopausal women[8-10]. In the Framingham Osteoporosis Study, extracted from the cohort of the Framingham study, Tuckery et al.[11], evaluated the femoral BMD in a group of 1,182 men, 1,289 postmenopausal women and 248 premenopausal women, relating it to the variables included in, at least, two questionnaires carried out over a 5 year period, and in which were included data regarding the quantity of beer, wine and spirits which the subjects ingested, valuing a 350 ml glass as one unit of beer, a glass of 118 ml as a unit of wine, and a 42 ml glass as a unit of spirits. In this study the men were mainly drinkers of beer and the women drinkers of wine, and when compared with the non-drinkers, the BMD in the femoral neck was, in those subjects who drank 1 or 2 units a day, between 3.4 and 4.5% higher in the men, and 5-8.3% higher in the women, compared with those who were abstemious.

In another study carried out in 5,865 people over 65 years of age in the US within the Cardiovascular Health Study[12] the annual intake of beer, wine and other spirits was quantified, and the incidence of fractures evaluated, and in 1,567 subjects, the BMD was determined by DXA. Over the 12 years the study lasted, in comparison with the group who were abstemious, a relationship between the risk of hip fracture and alcohol intake was found. The hazard ratio for hip fracture was 0.78 (C.I. 95%, 0.61-1.00) among the consumers of up to 14 glasses a week, and 1.18 (C.I. 95%, 0.77-1.81) among those consuming 14 or more drinks per week. A relationship was also found between the BMD in the total femur and femoral neck, with a BMD approximately 5% higher (C.I. 95%, 1-9%) in those consuming up to 14 drinks a week compared with those who were abstemious. This relationship was similar in men and women.

On the other hand, a moderate intake of alcohol is associated with an acute reduction in bone resorption when a marker for bone resorption, such as CTX (carboxy-terminal telopeptide of type I collagen) is used[13].

It has been suggested that one of the mechanisms related to this beneficial effect is the presence of polyphenols in alcoholic drinks. It has been confirmed that moderate drinkers of wine have less cardiovascular disease than drinkers of other alcoholic drinks, highlighting the role of certain components of alcohol, the polyphenols, and especially resveratrol, as possible causes of this effect. The oestrogenic role of this component and its antiresorptive effect has also been related with a positive effect on the bone, and, although there are no prospective studies in humans, a recent work carried out in a model

using oophorectomised rats showed that those rats treated with resveratrol had a BMD significantly higher than the untreated rats[14].

At all times we are referring to a moderate intake of alcohol since in populational studies, it has been observed that people drinking large quantities of alcohol, including beer, had a reduction in BMD in relation to the population of non-drinkers[15].

Beer and bone health

A moderate intake of beer has been shown in a study carried out with ultrasound to have a positive effect on bone mass in postmenopausal women, as an independent variable[16]. The authors evaluated bone mass measured by ultrasound in the phalanx in a group of 1,697 healthy women, 710 premenopausal, 176 perimenopausal and 811 postmenopausal (average age 48.4 years), with a body mass index (BMI) of between 19 and 32 kg/m^2. A positive and independent relationship was found between those parameters determined by ultrasound and the following variables: age, BMI, status of gonads and intake of beer, but not with consumption of wine. The positive relationship between the ingestion of beer and bone mass may be due to various factors:

A) The role of alcohol

As we have already said, the alcohol which some beers have has a beneficial effect on bone, related to the aforementioned polyphenols which the alcohol contains.

B) Role of silicon in bone[17]

Silicon (Si), an important component of beer, appears to be the main determining factor, acting on bone formation, since the differences were minor when the results were adjusted to its consumption.

Silicon is a non-metallic element in the periodic table with a molecular weight of 28. It is the second most abundant element in the earth's crust, but it is rarely found as a free element since, due to its affinity to oxygen, it forms silica and silicate, as well as organic forms such as silicones.

The ingestion of Si varies, in most Western countries, between 20 and 50 mg per day, greater than the intake of iron or zinc. It is usually ingested as orthosilicic acid, and the most significant source of this in infancy is cereals and in adults, beer, whose intake is higher in men than in women, its concentration being low in the water we drink, although somewhat higher in rocky regions.

In a study carried out in the United Kingdom, the higher concentrations of Si in foods were found in cereals, especially in less refined cereal, and among drinks, in beer, whose cereal origin (barley) is well known[18].

The content of silicon in beers varied between 6.4 and 56.5 mg/l, with an average of 30 mg per litre, being greater in those beers made form barley than in those made from wheat[19]. With two beers usually being the equivalent of a little less than half a litre in our country, an individual may obtain 15 mg of this nutrient by drinking two beers. Hops, a normal component of beers, has more Si than the grain, thus making a greater contribution of silicon[19]. During the brewing process, the great majority of the silicon stays in the grain which is used; however, when the grain is subject to aggressive manipulation during the brewing process, this may facilitate a greater extraction of silicon from the grain which is then incorporated into the beer. The authors also say that the lightest malts had more silicon than the darker ones, such as black or toasted malt.

Effect of silicon on bone

There are many studies, both experimental and in humans, in which a positive effect of Si in the bone has been observed, and showing that its administration produces in a positive effect on bone mass. Since the initial findings of Schwartz et al.[20] on the potential role of silicon in bone and connective tissues, there has been much research carried out into the potential role of dietary silicon[17]. Numerous cell and tissue culture studies have attempted to study the action mechanism of silicon in bone. Carlisse et al.[21], using chondrocites and tibial epiphysis from chicken embryos, showed that the silicon increases the synthesis of the bone matrix, and that the increase the activity of prolyl hydroxylase, the enzyme related to the synthesis of collagen, was dependent on the dose of silicon. A study carried out in human osteoblasts[22] has confirmed that silicon increases osteoblast proliferation, the synthesis of the extracellular matrix, the activity of alkaline phosphatase and the synthesis of osteocalcin. More recently, using orthosilicic acid, a positive effect on bone formation has been observed, with a positive action by silicon on cell differentiation and the synthesis of type 1 collagen, as well as an increase in mRNA of these proteins, suggesting a potential role in genetic transcription[23,24].

In the aforementioned Framingham cohort study[25] the association between the ingestion of silicon and BMD in the lumbar spine and in four locations in the hip was examined in 1,251 men and 1,586 pre- and postmenopausal women, aged between 30 and 87 years, adjusting the results for all factors which it is known may have an influence on BMD and on nutritional intake. It was observed that the dietary intake of silicon was associated positively, and significantly, with BMD in the hip in men and premenopausal women, but not in postmenopausal women. It was also observed that there was a significant association with BMD in the lumbar spine in men, concluding that a high ingestion of silicon in younger men and women could have a positive impact on the health of the skeleton, especially in cortical bone.

However, the authors warned that many other studies have shown that the consumption of more than one or two alcoholic drinks a day may be

damaging to health. The advice of the authors would be "drink beer, but in moderation" since this consumption "contributes to an improvement in silicon levels, and thus, in your health".

We know also the beneficial role of bone implants which contain silicon in the repair of bone. Implants which contain silicon secure themselves better than those that don't, due to the spontaneous formation of a biologically active layer of a substance similar to apatite on their surface[26].

Oral supplements of silicon have been shown to be beneficial in patients with low bone mass and who are osteoporotic, with a tendency being observed to an increase in markers for bone formation, especially P1NP (N-terminal propeptide of type I collagen), as well as an increase in femoral BMD[27].

C) Role of the phytoestrogens

Another of the mechanisms related to the beneficial effects of the moderate ingestion of beer on the bone could be due to its phytoestrogen content. Due to the similarity both structural and functional of these with 17-beta estradiol, interest in these substances has increased recently. In a study carried out in the United Kingdom the amount of phytoestrogens in various foods, including tea, coffee, alcoholic drinks, nuts, seeds and oils was quantified. It was found that beers, except bitter, were the foods which contained the most phytoestrogens, around 71µg/100g, especially lignane[28].

Finally, there is a conviction that beer drinkers are, generally more obese, but when the BMI is adjusted for other risk factors for obesity it is found that it is highly improbable that the intake of beer is related to BMI[29].

In summary, we have available various experimental and clinical studies in which it is concluded that the moderate ingestion of beer, due to its high flavonoid and silicon content, could have a positive effect on BMD, causing it to increase. More prospective studies are necessary in order to evaluate its possible effect in reducing fractures.

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