Further food facts and bone – beyond calcium and vitamin D

What is osteoporosis?
Osteoporosis occurs when the struts which make up the mesh-like structure within bones become thin causing them to become fragile and break easily, often following a minor bump or fall. These broken bones are often referred to as ‘fragility fractures’. The terms ‘fracture’ and ‘broken bone’ mean the same thing. Although fractures can occur in different parts of the body, the wrists, hips and spine are most commonly affected. It is these broken bones or fractures which can lead to the pain associated with osteoporosis. Spinal fractures can also cause loss of height and curvature of the spine.

Most people know that both calcium and vitamin D are essential parts of maintaining healthy bones, but in fact these are only part of the story. Healthy bones need a well-balanced diet, incorporating a wide range of minerals and vitamins as well as protein from a range of different food groups. No single food contains all the essential nutrients the body needs to function well. The nutritional value of what you eat depends on the overall mixture, or balance, of foods that are eaten over a period of time.

Which foods or nutrients may affect bone strength?

Caffeine
A high intake of caffeine may increase the amount of calcium excreted in your urine. There is some evidence to suggest that more than several cups of coffee a day, maybe as many as eight, may cause a slight imbalance between calcium intake and calcium loss from the body. The effect is only modest. But, if you already have other risk factors for osteoporosis, you may want to consider limiting your intake of caffeine. Interestingly, studies suggest that tea does not have the same effect.

Protein
Protein is a vital nutrient needed for the body to perform many functions, including the production of antibodies to resist infection and the formation of new tissue. Too much or too little protein may reduce the strength of bones and increase the risk of fracture.

Too little protein
Malnutrition, and hence a lack of protein, has been shown to contribute to bone loss, the risk of falling, and the response to injury. There is some evidence that recovery from hip fracture in older people is improved by protein-rich food supplements.

Too much protein
A diet high in protein (found in some dairy products, meat and fish) is likely to increase the acidity of the blood and other body fluids, which may result in minerals including calcium being drawn out of the skeleton. Interestingly, grain foods such as bread, pasta, cereals and rice contain protein and may also have a similar effect.

Government advisors recommend that adults should avoid a protein intake of twice the Reference Nutrient Intake (i.e. 1.5g per kg of body weight per day equivalent, for example, to 90g for a 60kg woman). This recommendation was made because of links between a high protein intake and an increased risk of colon cancer. It might also be useful for bone health. Those who feel that their protein intake is higher than recommended should perhaps consider making reductions.

Few studies have examined the effect of high protein intakes on osteoporosis risks over the longer term and this remains an area of some controversy.

This leaflet covers information on specific foods or nutrients, such as minerals and vitamins, and their impact on bone health. If you would like more general information on healthy eating for bone health or information about calcium and vitamin D, please ask for a copy of our publication All About Osteoporosis.
Dairy products
This is an issue that regularly appears in the media. One of the outcomes of this debate has been a suggestion that dairy products are not a useful source of calcium because they are rich sources of protein and may actually increase risks of osteoporosis. Looking at the acidity-alkalinity story in more detail helps to explain this issue.

One way to calculate whether a foodstuff is acid or alkali is to look at its effect on the kidney where urine is made. This is described as a food’s potential renal acid load (PRAL).

All fruit and vegetables (including citrus fruits) have a negative PRAL and hence are alkali-producing. This alkalinity of fruit and vegetables in the blood plasma and urine should not be confused with the fact that citrus foods before digestion are acidic in their effect on the stomach. Meat, fish, some dairy products, and other foods such as bread, cereals, pasta and rice all have a positive PRAL, making them more acidic foods, although the extent does vary. It is important to balance out these foods by having plenty of fruit and vegetables. At least five portions daily are recommended by the Department of Health and the Food Standards Agency.

Interestingly, milk has a PRAL value of 1.0 and, therefore, is close to being neutral so the claim that milk ‘leaches’ calcium from the bones does not seem likely. Some hard cheeses such as cheddar, do have a high PRAL value although there is no evidence for the claim that cheese causes osteoporosis. It does, however, appear important that cheese is balanced with fruit and vegetables as part of a well-balanced diet including all food groups.

Milk and dairy products generally provide an inexpensive and accessible form of calcium that is well-absorbed. They also provide other micronutrients such as the vitamin B complex and zinc as well as phosphorus, which may have a part to play in bone health. Generally, dairy products can be an important source of calcium as part of a well-balanced mixed diet.

Salt
Ordinary table salt is sodium chloride. We need sodium in our diets to maintain water balance in the body, for blood pressure and also for muscle and nerve activity. However, a high intake of salt in the diet can cause high blood pressure leading to stroke, gallstone problems and heart and kidney disease. It also causes an increase in the amount of calcium lost in the urine. The effect of salt on blood pressure may also be responsible for speeding up the body’s loss of calcium. Nutritionists suggest that intakes should not exceed 6g a day which is equivalent to about 1 teaspoon, and that we should preferably aim for less. At present, the average intake in the UK is around 9g per day and the Food Standards Agency is working to help the general public reduce salt intake. This advice about reducing salt intake is based on the benefits for the heart and blood pressure, but may also have benefits for bone health.

Fizzy drinks
Phosphorus is necessary for proper bone formation but is needed in balance with calcium and is available in many foods. Phosphate, in the form of phosphoric acid, is used to add to the taste of many cola-type fizzy drinks although the amount of phosphoric acid is not very high. There has been concern that a high intake of fizzy drinks containing phosphoric acid might reduce the strength of bones although this has not been proven. There is no clear evidence proving a detrimental effect of fizzy drinks on bone health but you may want to moderate your intake and think about including more nutritious drinks or simply water if you are thirsty. There is some concern that in the UK, large quantities of fizzy drinks are now consumed, especially by children, in place of other more nutritious foods and drinks.

Phytates and oxalates
A wide range of foods contain dietary phytates and oxalates, which bind to calcium and decrease absorption. The presence of phytates and oxalates are not a significant contributor to calcium loss unless consumed in excessive quantities, and the foodstuffs they are present in remain an essential part of a well-balanced diet. Phytic acid is found in bran, wholegrain cereals and the seed coats of beans and grains. Oxalic acid is found in particularly high quantities in rhubarb and spinach. Although spinach and rhubarb are naturally high in calcium, the oxalic acid it contains affects the amount of calcium that can be absorbed and many portions of these foods would be needed to give the equivalent amount of calcium found from other sources.

Some slimming programmes suggest adding bran to food, and some people may add bran to ease constipation. Instead, try eating plenty of high fibre foods, such as fruit and vegetables, drinking lots of water and increasing exercise and mobility. Those
people who are advised to eat wholemeal products to ease constipation and aid bowel health are often worried that this may inhibit calcium absorption. However, if calcium is taken at other times of the day and not all at the same time as the wholemeal product then calcium intake is unlikely to be adversely affected, and both bone and bowel health will be maintained.

**Essential fatty acids**
The essential fatty acids (EFAs), omega-3 and omega-6, are believed to play a role in calcium absorption and metabolism in the body, although there is no scientific evidence to date on their role in bone health. Omega-3 is found in oily fish, such as mackerel and salmon, linseed oil, soya beans and walnuts. Omega-6 is found in sunflower oil, sesame oil, eggs, turkey and evening primrose oil, which can be taken as a supplement.

**Phytoestrogens**
Phytoestrogens are plant chemicals that protect plants from fungi, pests and ultraviolet radiation. In humans they behave like weaker forms of the hormone oestrogen (about 1/1000 as potent), and so may help protect against bone loss by mimicking, to a much lesser degree, the effects of the sex hormone. So far, studies have looked at the low rates of osteoporosis and breast cancer in Japanese women who traditionally consume high levels of phytoestrogens in their diet (around 40mg a day), compared to the higher rates of these diseases amongst women in the UK who have a much lower phytoestrogen intake of around 3mg a day. The difference in these disease rates may be as a result of diet or be related to other cultural factors, but so far no link between phytoestrogens and bone strength has been proven and more research into their effectiveness is needed. Phytoestrogens have been shown to have some beneficial effects in relieving short-term menopausal symptoms such as hot flushes.

As a potential natural alternative to HRT there is a huge amount of interest in phytoestrogens and many phytoestrogen-rich products are now available in supermarkets and health food shops, such as red clover supplements and the ‘lady’s loaf’, which is rich in soya and linseed. The evidence of a benefit to post-menopausal bone health has yet to be proven but there are several large studies currently being conducted.

More research into the effectiveness of phytoestrogens is needed but it seems they may slow down the breakdown of old bone by cells known as osteoclasts, while enhancing bone growth by boosting the activity of osteoblasts and other chemicals important for bone health such as calcitonin.

**Natural phytoestrogens**
There are two main types of natural phytoestrogens: Lignans are widespread, especially in high-fibre plant foods such as linseed and wheat bran. Lignans are difficult to investigate in the laboratory so little data is available on them. Isoflavones are found in soya beans, soya products like tofu, soya milk, lentils, chick peas and mung beans.

**Isoflavones**
In food, isoflavones mix with sugars to form glycosides. In soya beans the three main glycosides are daidzein, genistein and glycitein. Studies into the benefits of a phytoestrogen-rich diet have found that genistein appeared to block the oestrogen receptors in the breast whilst having an oestrogenic effect on bone and heart (a similar effect to that shown by SERMs – a group of drugs used for the treatment of osteoporosis in women). Although these results seem promising there is little data as yet on the role of isoflavones for fracture prevention, and more research into the health benefits of soya is needed.

**Men and phytoestrogens?**
In short-term studies, the results suggest that men having a phytoestrogen-rich diet does not affect hormone levels but may decrease cholesterol levels (high blood cholesterol is associated with increased risk of heart disease). Animal studies show soya may inhibit the development of tumours of the prostate. It has been suggested that high levels of oestrogen-type compounds in the environment, especially organophosphates in pesticides and plastics, may be responsible for the reported decreasing levels of male fertility. Phytoestrogens are distinctly different from environmental oestrogens in that they are not stored in the body but are broken down and excreted in urine.

**Minerals and vitamins**
There are many other vitamins and minerals apart from calcium and vitamin D which may play a role in bone health. However, there have been limited studies to date on the role of these nutrients in bone health and more research is needed. These nutrients are all readily available through a balanced diet and as long as a
wide range of foods from all the main food groups are obtained, it is likely that you will be getting enough. If you have a well-balanced diet you should not need to take a general vitamin or mineral supplement for your bones.

**Boron**

Boron may have a role to play in bone health. One study of boron has shown possible positive effects on bone; however, more research would be needed to confirm this. Fruit, vegetables and beverages, such as soft and alcoholic drinks, are major sources of boron, with milk containing smaller amounts.

**Copper**

About 19 per cent of the body’s copper is found in the skeleton. It affects bone metabolism in two ways. It slows down the activity of both osteoblasts and osteoclasts, and it helps to build bone. It is vital to get a balance between copper and zinc as too much of one can affect the work of the other. Found in nuts, seeds, fruit, beans, sunflower oil, mushrooms and crab.

**Magnesium**

A deficiency of magnesium may be a risk factor for osteoporosis. The body uses magnesium for calcium metabolism and the synthesis of vitamin D. Recent studies have shown that magnesium may work positively in reducing bone loss by suppressing the rate at which bone renews itself. However, measuring magnesium levels in the body is not easy and how far low magnesium levels contribute to the risk of breaking bones in old age is unknown. Found in green vegetables, nuts and dairy produce.

**Manganese**

Little research has been undertaken into the role of manganese in bone health. However, animal studies have found that dietary deficiency of manganese can induce osteoporosis. Found in nuts, seeds, black pepper, meat and tea.

**Potassium**

Potassium-rich foods can reduce the ‘acidity’ associated with some foods and reduce the loss of calcium through urine. Potassium also helps to balance the effect of salt on the kidneys. There is growing interest in its role as an important nutrient for bone health, though more research is needed. Bananas are a particularly rich source of potassium.

**Vitamin B complex**

Vitamin B is important for making normal collagen (connective tissue) and deficiencies of either may have a detrimental effect on bone health, although further research is needed. A recent study has shown that high levels of homocysteine – an amino acid produced by the body – are associated with an increased risk of a broken hip. Increasing intake of vitamins in the B complex, including folic acid, has been shown to reduce homocysteine levels, so potentially this could reduce risks of a broken hip.

There is insufficient evidence to recommend supplementation, and there are concerns that supplementation with folate in elderly people might mask vitamin B12 deficiency, but it would make sense to encourage consumption of a mixed, balanced diet with sufficient levels of folic acid and vitamin B2 (riboflavin), B6 and B12.

Foods to include would be green leafy vegetables, carrots, avocados, apricots, nuts, bananas and egg.

**Vitamin C**

Vitamin C helps keep cells healthy in the body and also increases the absorption of iron from food. The recommended amount to consume daily is 40mg. Research studies have suggested it may help to keep bones strong. Vitamin C deficiency causes scurvy, well known in history as a disease among sailors who lacked fruit and vegetables on long voyages. It is unlikely in the UK in those eating a well-balanced diet including fruits and vegetables. Vitamin C is found in a wide range of fruit and vegetables including citrus fruits, berries, potatoes, tinned and fresh tomatoes.

**Vitamin K**

Vitamin K plays a role in the production of fully-formed osteocalcin, one of the proteins used in building bone. It is also important in helping broken bones heal themselves. People with osteoporosis have been found to have lower levels of this vitamin indicating it plays an important role preventing the disease. Further studies into the benefits of vitamin K on bone health are needed. Good sources of vitamin K include broccoli, cauliflower, soya beans, and dark green leafy vegetables.

**Silicon**

Silicon has a role to play in keeping bones and connective tissues healthy. It is found in many tissues in the body although how much is needed in the diet is unclear. Deficiency in humans has never been found.
One study has shown men and younger women with a high intake of silicon in the diet had denser bones. Silicon is found in oats, barley and rice. It is also found in beer and many fruits and vegetables.

**Zinc**

Zinc regulates the secretion of the hormone calcitonin from the thyroid gland, which influences bone turnover (the way bones are maintained and kept strong). Zinc is necessary for the action of alkaline phosphatase, which is vital for bone mineralisation and skeletal growth. Zinc deficiency is found as a side effect of alcohol abuse and hypogonadism (low levels of sex hormones); both risk factors for osteoporosis. Zinc is found in eggs and red meat, Brazil nuts, pecans and yoghurt.

**Vitamin A**

Vitamin A is a fat soluble vitamin. It helps to maintain healthy skin and mucous membranes which can reduce infections of the nose, throat, lungs and urinary tract. It is also needed for good night vision, development of the baby in the womb and bone development. Severe deficiency of this vitamin can cause changes in the eye which can lead to blindness. It can also lead to an increased susceptibility to respiratory tract infections and skin complaints. Vitamin A is stored in the liver but can lead to toxicity if taken in excess. Signs of this would be skin scaling, joint pains, liver enlargement and nausea but vitamin A toxicity is usually fully reversible.

There are many forms of vitamin A, which do not have the same potency of action in the body. Vitamin A is present in animal sources, especially liver, and in supplements in a form known as pre-formed retinol. Vitamin A from plant sources is present as carotenoids. Carotenoids are often highly coloured and give fruits and vegetables their characteristic red, orange and yellow colours. These can be partially converted in the body to retinol and therefore can act as vitamin A. When estimating the total intake of vitamin A from the diet, all these different forms of vitamin A have to be included to give an estimate of total vitamin A intake in microgram retinol equivalents (RE).

Rich sources of vitamin A include cod liver oil, halibut liver oil, raw carrots, butter, margarine, cheddar cheese, eggs, milk, beef and pig kidneys. The reference nutrient intake for adults is 700 micrograms RE per day for men and 600 micrograms RE per day for women. It is advised that vitamin A supplements and liver should be avoided by pregnant women because of possible effects of high vitamin A intakes on the unborn baby. Several studies have also indicated that there may be a link between a high dietary intake of vitamin A and risks of breaking a hip because of osteoporosis, although other dietary factors may be linked to the level of vitamin A and have an effect on the risk of breaking bones. Other studies did not confirm any link between vitamin A intake and bone health. This evidence applies to vitamin A present in foods as pre-formed retinol (as found in animal products, especially liver, and dietary supplements) and not to the forms of vitamin A found in vegetables, known as carotenoids. Interestingly, intakes of retinol in the UK are much lower than in Sweden where the study showing effects on risks of broken hips took place.

The UK’s Scientific Advisory Committee on Nutrition has reviewed the evidence and concluded that a daily intake of retinol contributing less than 1,500 micrograms RE to total vitamin A intake on a regular basis is unlikely to increase risks of breaking a hip. Most people in the UK do not eat more than this amount of retinol regularly unless they frequently eat liver, liver products or take vitamin A supplements. For those who do, or who have osteoporosis, it may be prudent to consider limiting consumption to less than 1,500 micrograms of retinol a day.

**Retinol may be expressed on your supplement in international units (iu).**

1,000 iu = 300 micrograms

- Older people might want to limit their consumption of liver and vitamin A supplements to keep their intake below 1,500 micrograms of retinol per day.
- If you are taking different vitamin and mineral supplements, add up the amount of vitamin A in the supplements.
- Vitamin A as carotene in vegetables is not going to cause these potential problems.
The National Osteoporosis Society is the only UK-wide charity dedicated to improving the prevention, diagnosis and treatment of osteoporosis and fragility fractures. The Charity receives no Government funding and relies on the generosity of individuals to carry out its vital work.

For osteoporosis information and support contact our Helpline:

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