Lifestyle factors for better bone health

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Hip and spinal fractures caused by osteoporosis are becoming more common in the ageing populations around the world, especially in Western societies.

Osteoporosis is a quantitative reduction in bone mass due to an imbalance between bone formation (osteoblasts) and bone resorption (osteoclasts).

These two processes are normally in balance and our skeleton, which stores 99% of calcium in our bodies, is replaced every 10 years. Bone stock is maximal at age 30-35 years, after which we steadily lose bone mass and strength with maximal loss of 3-4% occurring in the one year around the age of menopause in women due to the loss of the bone protective effect of oestrogen.

Primary osteoporosis, where there is no identified cause, is often due to lifestyle factors, thus prevention and treatment should primarily be focused on lifestyle approaches. If there is a history of a fragility fracture (fall from ground height), then due consideration must be given to starting medication such as a bisphosphonate. Discussion of medication is outside the remit of this review.

Genetic factors

Primary osteoporosis, like many other disorders, can be linked to multiple genes. If there is a strong family history then there is a roughly 3-5% increased risk of developing osteoporosis, but healthy lifestyle factors can still significantly reduce this risk.

The fear factor

Osteoporosis is not a painful condition unless one sustains a fracture and even these may not be painful in the spine in 60% of patients.

There was a campaign to cause fear in older people around the time new drugs came onto the market. However, there is a real concern that osteoporosis can result in a hip fracture, which is often associated with a very high mortality (1 in 5 people die within 6 months and 1 in 4 within a year of a hip fracture).

Often these fractures occur in patients with a number of chronic degenerative diseases causing general ill health and persistent inflammatory states further worsened by lack of mobility, social isolation, malnutrition and often cognitive impairment.
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Lifestyle factors
These are best discussed under the 6 pillars of lifestyle medicine starting with the most important

1. Nutrition
A diet rich in whole plant foods, whilst minimising refined and processed foods works to create an ideal environment for bone formation.

Protein
Plant sources of proteins: vegetables and legumes such as beans, lentils and soya, seeds and whole grains such as quinoa.
Plant protein has a lower potential renal acid load (PRAL) as it has a lower content of sulphur containing amino acids compared to animal sources of protein. These amino acids (methionine and cysteine) produce sulphuric acid and result in loss of calcium from the body into the urine.

This is one of the reasons why the recommended daily allowance (RDA) of calcium is higher in countries that consume the most meat and dairy.

Older adults may need higher intakes of protein, and this is usually recommended at 1-1.2g/kg per day. Soya products such as tempeh or calcium-set tofu are rich in phytosterol and as soya occupies oestrogen receptors in the bone, they promote bone strength. Aim for two portions of minimally processed soya per day – eg 1 cup of soya milk and 80g of tofu/tempeh/edamame beans.

Fat
Polyunsaturated fats, including omega-3 fatty acids, are essential for bone formation and plant-based sources such as ground flax, chia seeds, hemp seeds and walnuts should be a daily part of the diet. Grinding seeds rather than eating them in their whole form improves bioavailability and absorption.

Carbohydrates
Fruit and vegetable consumption has been shown to be beneficial for bone health with prunes especially helpful for improving bone strength.

Important micronutrients...

Vitamin D
Vitamin D helps the body absorb calcium and it is mostly made from the action of sunlight on our bodies. As the UVB rays are not strong enough to enable this between the months of October-March in the UK, a daily 10mcg supplement is required for the general population during the winter, although some groups are advised to take supplements all year round. These include pregnant and breast feeding women, those over 65 years of age, babies and young children, those with darker skin and those who spend a lot of their time indoors.

Mushrooms exposed to UVB rays are a source of vitamin D (if you are doing this at home during the summer months, be aware that UVB cannot penetrate glass so if you are placing on a windowsill, leave the window open), as are fortified foods.

Vitamin C
An adequate amount per day is present in a single orange (there is about 70mg in a medium orange and the recommended daily intake is 40mg). All citrus fruits, strawberries, blueberries and green leafy vegetables are good sources of vitamin C.

Vitamin K
This is required to make the proteins involved in forming and strengthening bone. Adult requirements are 1mcg/kg/body weight per day. Good sources include dark green leafy vegetables such as spinach, kale and Brussel sprouts, broccoli and cauliflower, blueberries.
Vitamin K2
Produced in the gut by the bacteria from fibre contained in green leafy vegetables. Vitamin K2 seems to have a role in calcification of bone matrix and regulates calcium metabolism by preventing calcification of blood vessels, especially when calcium is in excess as supplements. It may also increase bone strength without increasing bone density.

Vitamin B12
Needs to be supplemented in all vegans and all people above the age of 50. It has a role in preserving bone density by its action on homocysteine metabolism. Its main role is to prevent neurological damage and therefore falls and fractures as a result. Fortified foods include non-organic plant milks and yoghurts, nutritional yeast and marmite.

Calcium
Because bone and teeth are the main storehouses of calcium, it is intuitive to think of calcium as being the ‘vital mineral’. Blood calcium levels are kept within a very narrow range with many hormones, and vitamin D, working in harmony to fine tune this. Calcium has a vital role in muscle and nerve function in addition to being of structural importance in bone. Despite the dairy industry overemphasising the importance of milk as an essential source of calcium, there are plenty of plant sources of calcium, which are devoid of the potential negative impacts of dairy consumption.

The consumption of cow’s milk and dairy does not correlate with bone health, and in fact countries that consume the most dairy, such as Sweden, have some of the highest rates of hip fracture. The possible mechanism for this may be the oxidative stress caused by galactose, formed from the breakdown of lactose in dairy. Dairy has a higher proportion of methionine and cysteine (sulphur containing amino acids), which is ultimately metabolised to sulphuric acid. This acidity is not good for bone formation. Calcium in best obtained from the diet rather than supplementation in tablet form as this results in high levels of elemental blood calcium. Calcium supplementation has been shown to predispose to renal stones and coronary heart disease due to deposition in atherosclerotic plaques. See below for more information on calcium in a plant-based diet.

Magnesium
250mg per day is optimum for bone health and is found in adequate amounts in nuts and seeds. (RDA for men = 300mg women = 270mg.)

Important micronutrients...

Minerals

Phosphorous
This mineral works with calcium to build and maintain bones and is regulated in part by Vitamin D. Adult requirements are 550mg/day and good sources include beans, chickpeas, lentils, soya, nuts, pumpkin seeds.

Silicon
Is important for bone formation and recommended at 40mg/day. It is found in green beans, carrots, nuts and seeds, whole grains, and cereals. It is also found in beer probably in the processing of hops and barley and men seem to find it easier to reach the RDA than women (not a recommended source of silicon!). There is no defined RDA in the UK.

Inositol
This is a carbohydrate found in fruits such as cantaloupe and prunes and is essential in bone formation. Prunes are also rich in phenolics and vitamin K.

Zinc, Copper, and manganese
These are required in small amounts and are easily obtained in most balanced diets.

‘Calcium thieves’
Certain dietary and lifestyle factors result in calcium loss and are referred to as calcium thieves. These factors are more prevalent in Western societies, contributing to the higher RDA of calcium. Smoking, alcohol consumption, coffee (more than 3-4 cups a day), sugar-sweetened beverages and fizzy drinks, especially cola drinks that have caffeine as well as phosphoric acid, result in calcium loss. Excess salt in food has a similar effect.
2. Exercise
The focus on calcium consumption has taken away the importance of regular, daily exercise and activity, which is vital for bone health.

Osteoporosis is predominantly a disease of our sedentary modern-day lifestyle. It was virtually unknown a few centuries ago. Even very active people tend to focus on one form of exercise rather than doing a variety of. It is recommended that all adults undertake at least 150 minutes per week of moderately vigorous physical activity.

Walking maintains bone density but does not help to increase it unless one wears weighted jackets and wrist and ankle weighted bands to increase the joint reaction force.

Multicomponent exercises, especially including some form of resistance training, at least three times a week are recommended.

Impact exercises such as jogging, skipping, star jumps, and stair climbing are all helpful. Whole body vibration plates are also helpful in increasing bone strength and density as well as reduce falls risk through muscle strengthening and improvement of balance. Even in post-menopausal women there is some evidence of improvement in bone density.

3. Restorative sleep
We sleep to survive. Good quality sleep is essential for bone formation through regulation of circadian ‘clock’ genes. Lack of restorative sleep makes us poorly motivated to exercise. Its importance is often underestimates, especially by men!

4. Stress management
While bone responds positively to mechanical stresses, it is also negatively affected by stressful situations causing the release of cortisol which is known to break down bone. Managing this kind of stress is essential to even bone health.

5. Avoidance of risky substances
Alcohol and smoking both have negative effects on bone formation.

6. Forming and maintaining healthy relationships
According to Dan Buettner, author of the Blue Zones, it is more difficult to change habits and easier to change one’s environment. Making friends with people who like exercise or outdoor activity is a healthful way of getting the benefits of this.
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Calcium fact sheet

The UK adult reference nutrient intake for calcium is **700mg**. For those with osteoporosis, coeliac disease and inflammatory bowel disease it is increased to at least **1000mg**.

<table>
<thead>
<tr>
<th>Calcium content (mg)</th>
<th>Food and portion size</th>
</tr>
</thead>
<tbody>
<tr>
<td>108</td>
<td>Rocket (50g)</td>
</tr>
<tr>
<td>85</td>
<td>Spinach (50g)</td>
</tr>
<tr>
<td>35</td>
<td>Broccoli (80g)</td>
</tr>
<tr>
<td>90</td>
<td>Kale (60g)</td>
</tr>
<tr>
<td>6</td>
<td>Avocado (1/3 50g)</td>
</tr>
<tr>
<td>110</td>
<td>Tahini (15g)</td>
</tr>
<tr>
<td>35</td>
<td>Sunflower seeds (30g)</td>
</tr>
<tr>
<td>280</td>
<td>Calcium set tofu (80g)</td>
</tr>
<tr>
<td>150</td>
<td>Nigari set tofu</td>
</tr>
<tr>
<td>63</td>
<td>Baked beans (150g)</td>
</tr>
<tr>
<td>62</td>
<td>Chickpeas (150g)</td>
</tr>
<tr>
<td>240</td>
<td>Fortified plant milk (200mls)*</td>
</tr>
<tr>
<td>150</td>
<td>Fortified plant yoghurt (125g)*</td>
</tr>
<tr>
<td>113</td>
<td>Almond butter (30g)</td>
</tr>
<tr>
<td>31</td>
<td>6 almonds</td>
</tr>
<tr>
<td>50</td>
<td>1 dried fig (20g)</td>
</tr>
<tr>
<td>25</td>
<td>Raisins (25g)</td>
</tr>
<tr>
<td>130-150</td>
<td>Fortified breakfast cereal (30g)</td>
</tr>
<tr>
<td>54</td>
<td>Wholemeal bread – 2 large slices (100g)</td>
</tr>
</tbody>
</table>

Achieving these increased requirements can be more challenging on a plant-based diet, as although legumes and leafy greens contain reasonable amounts, the oxalates and phytates contained in many of these foods reduce the absorption.

It is possible to increase the availability by soaking and sprouting grains and legumes but in reality time constraints may hinder this.

For this reason, additional calcium supplementation needs should be assessed on an individual basis following a dietary assessment.

Note:

* Variations may occur between brands, please check.
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Example menu to achieve general calcium requirements (approximate values)

**Breakfast**
Porridge made with fortified plant milk, topped with 30g mixed seeds and 6 almonds = **306mg**

**Lunch**
Beans on toast = **117mg**

**Dinner**
Marinated calcium set tofu served with baked veg and a portion of green leafy vegetables = **370mg**

**Total = 793mg**

For those needing higher intakes, add:

1 chopped dried fig to your porridge = **50mg**
1 fortified yoghurt = **150mg**
1 snack of chopped fruit drizzled with almond butter = **120mg**
Drizzle baked vegetables with **30g tahini = 110mg**

**Total = 1223mg**

Practical ways to increase your calcium intake

Always ensure plant milk and yoghurts are fortified, aim minimum **400mls daily**

Drizzle 1tbsp of tahini over baked vegetables

Aim for two portions of fortified soy daily – **200mls soya milk in porridge or on fortified breakfast cereal plus 80g calcium set-tofu will provide approximately 520-650mg calcium**

Try a sliced apple drizzled with **30g almond butter – total 120g calcium (including the apple)**

Make a mashed chickpea and avocado sandwich for lunch – total **122mg**

Homemade cocoa with fortified milk – **156mg** (if using cacao)

Note: calcium supplements are not recommended unless prescribed and monitored by your doctor.

References


Bolland MJ, Grey A, Avenell A, Gamble GD, Reid IR. Calcium supplements with or without vitamin D and risk of cardiovascular events: reanalysis of the Women’s Health Initiative limited access dataset and meta-analysis BMJ 2011 Apr 19;342