Lifestyle factors for better Bone health *for health professionals*

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Promoting Sustainable Health and Nutrition

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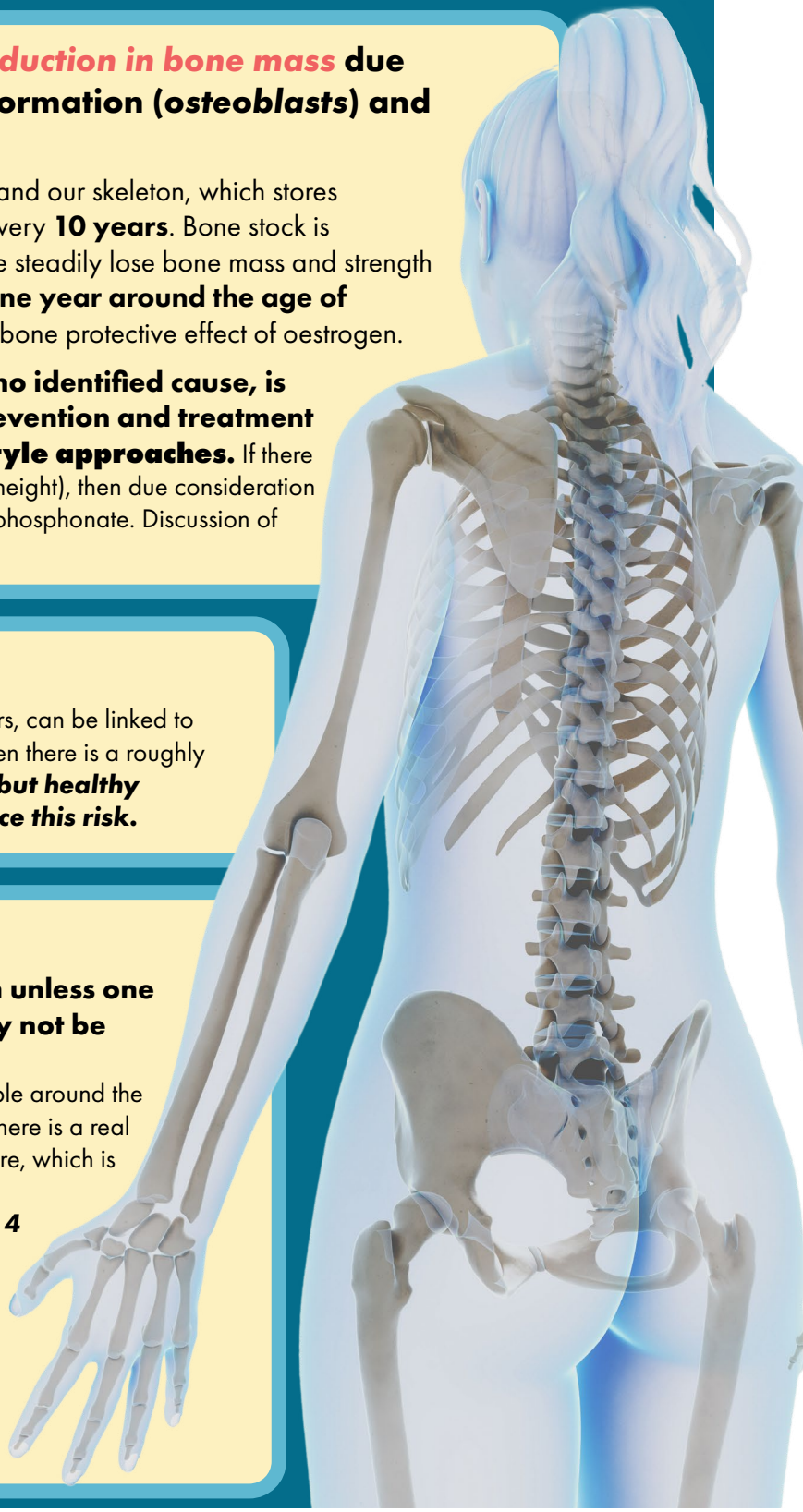
Hip and spinal fractures caused by osteoporosis are becoming more common in the ageing populations around the world, especially in Western societies.

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 **1-1.2 gram/kg per day**. Soya products such as tempeh or calcium-set tofu are rich in phytonutrients 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.***

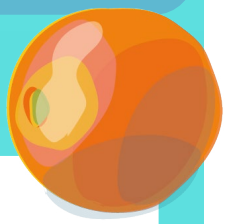
Fat

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... Vitamins



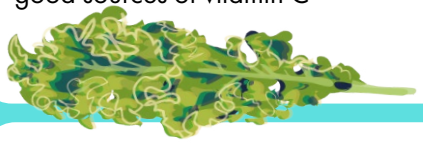
Vitamin D

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.*

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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.*

Important micronutrients... Minerals

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

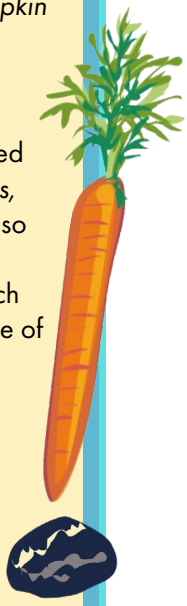
250mg per day is optimum for bone health and is found in adequate amounts in *nuts and seeds.* (**RDA for men = 300mg women = 270mg**.)

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.*

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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 underestimated, 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 Buetner*, 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.*

Key take home messages

1. **Consider a predominantly whole food plant-based diet rich in fruits, vegetables, whole grains, legumes. Consume two portions of minimally processed soya every day.**
2. **Supplement vitamin D, especially in the winter and autumn months.**
3. **Ensure an adequate intake of calcium via dietary sources.**
4. **Combination of exercises are good for bone strength, especially weight bearing exercises and strength training and resistance exercises.**
5. **Avoid substances that increase calcium loss such as smoking, coffee in excess, sugar sweetened beverages especially cola drink, alcohol, and excess salt.**

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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.

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

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

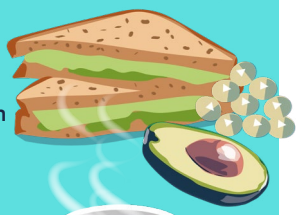
Practical ways to increase your calcium intake

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.

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