Healthy lifestyle interventions in general practice Part 13: Lifestyle and osteoporosis

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Abstract

Osteoporosis is defined as a systemic skeletal disease that is characterised by low bone mass and microarchitectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fractures. Therefore, the diagnosis of osteoporosis is based on measurement of bone mineral density (BMD) using central (axial) dual energy X-ray absorptiometry (DXA), and clinical evidence of a fragility fracture (history or radiological evidence). Osteoporosis is a major public health problem, affecting about 30% of postmenopausal women of Caucasian origin, and 70% of those aged 80 years. The risk factors for osteoporosis include lifestyle factors, genetic/ethnic factors, specific diseases causing secondary osteoporosis, ageing factors, qualitative factors, and drugs that are toxic to bone. In addition, there are specific additional risk factors for falls that need to be considered. It is well established that lifestyle factors, including physical activity, nutritional intervention, psychosocial intervention, smoking cessation and other lifestyle factor interventions are key elements in the prevention and management of osteoporosis. Guidelines for these lifestyle interventions in the prevention and management of osteoporosis are reviewed.

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Introduction

Osteoporosis is defined as a systemic skeletal disease characterised by low bone mass and microarchitectural deterioration of bone tissue, with consequent increase in bone fragility and susceptibility to fractures that usually involve the wrist, spine, hip, pelvis, the ribs and humerus[1] [World Health Organization (WHO) definition]. Osteoporosis is therefore a disease characterised by compromised bone strength that predisposes to an increased risk of fracture (National Institutes of Health).[2] There are several limitations to these definitions which have recently been reviewed.[2] However, for the purposes of this review, these definitions will apply.

Diagnosis and classification of osteoporosis

As bone strength is largely determined by bone mass, the measurement of bone mass [measured as bone mineral density (BMD) or bone mineral content (BMC)] is a key element in the diagnosis and classification of osteoporosis. In recent years, the assessment of fracture risk, or the presence of a fracture, has been added to the diagnosis and classification of osteoporosis.

Table I: World Health Organization (WHO) classification of osteoporosis

Definition	BMD or BMC measurement (T score)	Presence of fragility fractures
Normal	> -1.0	None
Low bone mass	-2.5 to -1.0	None
Osteoporosis	< -2.5	None
Severe osteoporosis	< -2.5	One or more

BMD: Bone mineral density measured by DXA at the spine, total hip or femur neck
BMC: Bone mineral content
T score: Standard deviation (SD) units in relation to the young, healthy adult population

The diagnosis of osteoporosis is therefore based on two main criteria. The first is measurement of bone mineral density (BMD) of the lumbar spine, total femur and femoral neck using central (axial) dual energy X-ray absorptiometry (DXA). The second is clinical evidence of a fragility fracture (history or radiological evidence)[2]. The World Health Organization's (WHO) classification of osteoporosis, based on BMD or bone mineral content (BMC) measurements is listed in Table I.

Epidemiology of osteoporosis

Osteoporosis is a major public health problem, with about 30% of postmenopausal women of Caucasian origin, and

70% of those aged 80 years, affected by the condition.[3] Worldwide, it is estimated that there are approximately four million people who develop osteoporotic fractures each year, and that over half of these occur in Europe and the Americas.[4] The lifetime risk of any fracture is about 53% at age 50 years among women and 21% at the same age among men.[5] Thus, one in two women, and one in five men who are 50 years of age, will have an osteoporotic fracture in their remaining lifetime.[6]

Reliable data on the prevalence of osteoporosis in South Africa are not available. It is estimated that the incidence of osteoporosis in white, Asian (from the Indian sub-continent) and mixed-race populations is similar to that in developed countries.[2] However, data on fracture risk are not readily available. Black women in South Africa, like their African-American counterparts in the US, have a considerably lower incidence of osteoporosis compared to white women, but the exact reasons for this disparity are not known.

Risk factors for osteoporosis

There are a number of risk factors for osteoporosis that can be divided into the following main groups: lifestyle factors, genetic/ethnic factors, certain diseases that can cause secondary osteoporosis (hypogonadism, gastrointestinal disorders, endocrinopathies, haematological disorders, rheumatologic and immunological diseases, and others diseases such as malignancy), ageing factors, qualitative factors (abnormal bone turnover, bone geometry, small body frame), and drugs that are toxic to bone.[2] In addition, there are specific additional risk factors for falls that need to be considered.[2] For the purposes of this review, it is important to note that lifestyle factors are particularly important, and these include nutritional factors, lack of physical activity (including immobilisation, muscle weakness and poor balance), psychosocial factors, and smoking. The role of these lifestyle factors in the prevention and treatment of osteoporosis will be reviewed in this article.

General management of osteoporosis

The general approach to the management of osteoporosis has been extensively reviewed.[1,2,7-9,10-11] The first step in the management of this condition is to conduct a comprehensive clinical and laboratory assessment (history, physical examination and special investigations) to:

- Confirm the diagnosis of osteoporosis;
- Identify any underlying disease that could cause osteoporosis, or negatively affect bone health;
- Identify lifestyle factors that may cause osteoporosis, or negatively affect bone health;
- Determine the nature and severity of osteoporosis;
- Assess psychosocial issues, including patient resources.

Once the patient has been assessed, management strategies can be initiated. Lifestyle intervention is a key element of management of these patients. Pharmacotherapy for the management of osteoporosis has been extensively reviewed and recent guidelines for pharmacotherapy have been published.[1,2] A detailed discussion of the indications, type and duration of pharmacotherapy in osteoporosis is therefore beyond the scope of this review, and the remainder of this review will focus on the role of lifestyle intervention in the prevention and management of osteoporosis.

Lifestyle interventions in the prevention and management of osteoporosis

It is well established that lifestyle factors are a key element in the prevention and management of osteoporosis.[9,10,12-15] For the purposes of this review, lifestyle intervention will be discussed as follows: physical activity intervention, nutritional intervention and other lifestyle factor interventions.

Physical activity in the prevention of osteoporosis

There is good evidence that physical activity has beneficial effects on bone health throughout life[16] and the mechanisms by which exercise improves bone strength have been reviewed.[17] Physical activity that is associated with relatively high intensity loading forces (such as high-intensity resistance training, plyometrics and gymnastics) increases bone mineral accrual in children and adolescents. Once peak bone mass has been achieved, which is estimated to be at approximately 20 years of age, the main role of physical activity is the conservation, rather than the acquisition, of bone mass.[16,18] In order for an osteogenic response to occur, the mechanical loads involved in any kind of activity must be in excess of those applied to the skeleton in normal daily life.[19] Findings from randomised, controlled trials have shown that increases in BMD are possible in adulthood and that targeted bone loading, which has a site-specific effect, can result in 1-2% gains in BMD at the lumbar spine and femoral neck.[20] Similarly, studies of athletes participating in unilateral activities such as squash or tennis have reported a 13% increase in BMC in the playing, compared with the non-playing, arm.[21] The effects of different modes of exercise on BMD suggest that high-intensity progressive resistance training appears to be more effective at the lumbar spine, while high-impact training has a greater effect at the femoral neck.[22,23] The exercise prescription for optimal bone health at various age groups has been reviewed and is summarised in Table II.[16,24-25]

Table II: Exercise prescription for prevention of osteoporosis: bone health in children and adults

	Children and adolescents	Adulthood
Role of physical activity	Augments bone accrual	Preserves bone health
Type of physical activity	Impact-related activities (sports characterised by running or jumping, plyometric activity) Moderate-intensity resistance training in adolescents	Weight-bearing endurance activities (e.g. walking, jogging, stair climbing) Jumping activities (volleyball, basketball) Resistance training (weight training)
Intensity of physical activity	High-intensity exercise is recommended, but for resistance training < 60% of 1-repetition maximum (1RM) is recommended	Moderate to high intensity
Frequency of physical activity sessions	≥ 3 times/week	Weight-bearing endurance activities (3-5 per week) Resistance training (2-3 per week)
Duration of physical activity sessions	At least 10-20 minutes (≥ 2x per day may be more effective)	30-60 minutes per day (combination of endurance and resistance training)

Excess physical activity and osteoporosis

It is important to consider that excess physical activity can also be associated with an increased risk of osteoporosis.[26] It is well documented that athletes who train excessively, particularly in sports emphasising an aesthetic component, can develop osteopenia.[27] In particular, young female athletes can suffer from the so-called female athlete triad (menstrual dysfunction, disordered eating, low bone mass). However, a detailed discussion of this syndrome is beyond the scope of this article and has been reviewed previously.[28]

Physical activity in the management of osteoporosis

The role of physical activity in the treatment of osteoporosis has also received considerable attention. Although it has been shown that physical activity does not increase BMD, there is good evidence that it is effective in increasing muscle strength, improving balance, and improving coordination and proprioception. These positive effects are very important in reducing the risk of falling, and therefore fracture.[14,29] In addition, there is good evidence that exercise training significantly improves quality of life in osteoporosis patients.[30] Therefore, an exercise programme for osteoporosis should include stretching and strengthening exercises to target poor posture and improve balance and coordination, as well as functional ability.[31]

Although the effects walking has on BMD are inconsistent,[32] data from the Nurses' Health Study have shown that the relative risk of fracture was halved in women who increased their frequency of walking from one to four times per week over a six-year period.[33] Walking should therefore be encouraged, as long as this occurs in a safe environment that has been assessed for any potential falling risks.

As emphasised in previous articles in this series on lifestyle interventions for chronic disease, all patients should be evaluated to determine if absolute or relative contraindications to exercise training are present before an exercise programme can be prescribed.[34] In particular, as osteoporosis is a disease in the ageing population, a comprehensive medical assessment should include screening for underlying cardiorespiratory disease and other chronic disease.[35,36] Furthermore, in the case of osteoporosis, specific attention should be given to identification of the risk factors for falling so that an appropriate and safe exercise programme can be prescribed.

For the purposes of assessing the risk of fractures, the WHO established a Fracture Risk Assessment (FRAX) tool. This tool is freely available online (www.shef.ac.uk/FRAX) and combines clinical risk factors [age, gender, BMI, prior fragility fracture, parental history of hip fracture, long-term (> 3 months) history of exposure to systemic glucocorticoids, high alcohol intake (≥ 3 units per day), smoking, secondary causes of osteoporosis] and the femoral neck BMD measurement to estimate the 10-year probability of either a hip fracture or osteoporotic fracture. This tool is particularly useful for the assessment of fracture risk in patients with osteopenia.[1,2]

Therefore, the exercise prescription for the treatment of patients with osteoporosis should incorporate elements that will optimise bone loading, reduce fracture risk, and optimise exercise training for general health benefits. These elements are summarised in Table III. In patients with concomitant high- or intermediate-risk chronic diseases, or in those with a high risk of fractures, medical supervision is required during exercise training.[15] In other patients with osteoporosis (low risk of fractures or no co-morbidities that place them at a high or intermediate risk), a medically directed exercise programme is recommended.

Nutritional intervention in the prevention and management of osteoporosis

Adequate nutrition is essential for the normal development and maintenance of the skeleton[39] and therefore plays a vital role in both the prevention and management of

Table III: Exercise prescription for the treatment of osteoporosis

Roles of physical activity in osteoporosis	Maintenance of bone mass or reduction of the rate of bone loss Reduce fracture risk Exercise for general health benefits
Types of physical activities[12,16,37]	*Reducing the rate of bone loss:* Weight-bearing exercise (e.g. walking, jogging) General muscle strengthening (upper body, trunk, lower body) *Reducing fracture risk:* Posture correction and back strengthening (standing back bend or seated posture correction, pectoral stretch) Balance and proprioceptive exercises (stand facing the wall for support, bend right knee and balance on left leg for 20-30 seconds and alternate/repeat) Core stability (pelvic tilt, pelvic tilt progression, bridging) and hip and trunk stabilisation (hip abduction, hip extension) Quadriceps strengthening (leg extension sitting on a chair, chair rise and lowering) General muscle strengthening (upper body, trunk, lower body) *Exercise for general health:* Endurance type activity (walking, swimming, cycling) General stretching and range of motion (upper and lower body stretches) General muscle strengthening (upper body, trunk, lower body)
Intensity of physical activity[16,38]	Endurance-type activity (60-80% of symptom/sign limited maximal exercise test) General muscle strengthening (upper body, trunk, lower body) (moderate intensity, 70-90% 1-RM, 2-3 sets of 8-12 repetitions)
Frequency of physical activity sessions[16]	Endurance-type activity (most days of the week) General stretching and range of motion (daily) General muscle strengthening (2-3 times/week
Duration of physical activity sessions[16]	Combining all exercise types (40-60 minutes per session)
Special precautions in patients with osteoporosis[12,15,37]	*Give attention to reduce risk of falling such as:* Vision correction Inspection and management of household, workplace and exercise floor areas to eliminate tripping hazards Reviewing medication that may affect balance, coordination and adherence to exercise (oestrogen and bisphosphonates may cause nausea and diarrhoea) Consider devices to reduce the impact of falling (hip protectors) *Minimise the risk of fractures:* Avoid flexion-based exercises (abdominal crunches, lifting heavy weights with twisting and bending) *Other considerations:* Severe kyphosis may affect the respiratory response to exercise as well as gait and balance Anxiety about falling may exist; non-weight-bearing exercises such as stationary cycling may be indicated

osteoporosis.[40] Although diseases of the bone have complex aetiologies, determining the modifiable factors, especially nutrition-related factors, could assist in the improvement of bone health throughout the entire lifecycle[39] and minimise development of these diseases by providing adequate amounts of nutrients. Dietary elements may influence bone metabolism through altering bone structure, impacting the rate of bone metabolism, affecting the endocrine and paracrine systems, as well as the metabolism of calcium and other elements that are involved in bone health.[39] These dietary elements range from vitamins and minerals, to macronutrients and bioactive food components.[39] Important nutritional considerations that play a role in the prevention and management of osteoporosis will now be briefly reviewed.

The role of calcium in the prevention and management of osteoporosis

The normal growth and development of the skeleton, and achievement of optimal peak bone mass, is reliant on adequate calcium, which will further determine the rate of bone loss associated with ageing.[39] Calcium is one of the main minerals involved in bone formation. When calcium intake is not adequate, calcium homeostasis is maintained by drawing on mineral from the bone to maintain the serum calcium ion concentration.[39] Throughout the ages, evidence of the importance of calcium for bone health has been convincing.[39] Comparing BMD at various ages, it is apparent that a higher calcium intakes has been associated with a higher BMD.[40]

Daily reference intakes for calcium are illustrated in Table IV and important sources of calcium are listed in Table V. It is important to note that the efficiency of calcium absorption varies with age. Absorption is greatest in infants and adolescents, is variable in adults, and declines with age, contributing to an increased risk for hip fracture.

In addition to the quantity of calcium consumed, factors affecting its absorption, and its subsequent availability for use in bone health, should also be taken into consideration.[39] Calcium is absorbed at similar efficiencies from many foods with calcium, calcium-fortified foods, and dietary

Table IV: Daily reference intakes (DRIs) for calcium

Life stage groups	Calcium (mg/day)
Infants	
0-6 months	210
7-12 months	270
Children	
1-3 years	500
4-8 years	800
Adult males	
9-13 years	1 300
14-18 years	1 300
19-30 years	1 000
31-50 years	1 000
51-70 years	1 200
> 70 years	1 200
Adult females	
9-13 years	1 300
14-18 years	1 300
19-30 years	1 000
31-50 years	1 000
51-70 years	1 200
> 70 years	1 200
Pregnancy	
≤ 18 years	1 300
19-30 years	1 000
31-50 years	1 000
Lactation	
≤ 18 years	1 300
19-30 years	1 000
31-50 years	1 000

Table V: Sources of calcium in selected foods

Food/portion	Calcium (mg)
Tofu, ½ cup	434
Yoghurt, low fat or fat free, 1 cup	415
Sardines in oil, drained, 90g	372
Collard greens, cooked, 1 cup	357
Ricotta cheese, ½ cup	337
Fat-free milk, 1 cup	302
Full-cream milk, 1 cup	291
Custard, 1 cup	297
Buttermilk, 1 cup	286
Rhubarb, cooked, 1 cup	212
Cheddar cheese, 30g	204
Spinach, cooked, 1 cup	200

supplements. However, calcium is poorly absorbed from foods such as spinach, rhubarb, sweet potatoes and dried beans that are rich in oxalate, a potent inhibitor of calcium absorption. Phytate, which is abundant in raw beans, soy isolate, nuts and grains, inhibits calcium absorption to a lesser degree. The amount of calcium absorbed from calcium-fortified soy milk is lower than that absorbed from cow's milk and emerging evidence suggests a positive role for non-digestible oligosaccharides (inulin-type fructans) in enhancing calcium absorption.[39]

If adequate calcium intakes are not obtained from the diet, then calcium supplements are warranted[40] and this has been shown to positively impact bone density.[41] This should be taken in doses of < 500 mg at a time, as absorption decreases with greater calcium loads.[40] Calcium is better absorbed with foods; therefore it is advised to take it with meals.[40] Calcium bioavailability from calcium supplements depends on the anion used. Per tablet, calcium carbonate contains more calcium (40%) than calcium citrate (23%).[40] Intakes of up to 2 500 mg/day have been proven to be safe.[40] Noteworthy to mention are the results from a randomised controlled trial where calcium supplementation in postmenopausal women was found to be associated with an increased trend in the rates of cardiovascular events.[42] The authors suggest that the benefits of calcium supplementation should be balanced against these detrimental effects. The potential risks associated with excessive calcium supplementation are:

- Contamination of bone meal or dolomite supplements with cadmium, mercury, arsenic or lead;
- Urinary tract or renal calculi in susceptible individuals;
- Hypercalcemia or milk alkali syndrome from extremely high intakes (> 4 000 mg/day);
- Deficiency of iron and other mineral divalent cations resulting from decreased absorption;
- Constipation.

The role of Vitamin D in the prevention and management of osteoporosis

Vitamin D is an additional dietary constituent that plays an important role in bone health. Vitamin D is obtained by synthesis in the skin as a result of sunlight exposure, or from the diet. Dietary sources of vitamin D include fortified milk, fatty fish (salmon, herring, and sardines), liver, and egg yolk. Where sunshine exposure is limited, supplementation may be necessary, especially in winter months. Calcium and vitamin D supplements are often given together to elderly people to reduce the circulating concentration of parathyroid hormone (PTH) in order to improve BMD. Vitamin D supplementation of 1 000 units/day is safe, which is considerably below the upper limit (UL) of 2 000 units/day. There is ample evidence of the benefits of calcium and vitamin D supplementation in preventing bone loss in older postmenopausal women.[40,43] Vitamin D supplementation has further been associated with a reduction in the number of falls.[40] Adequate Vitamin D intake is important, but excess should be avoided due to the induction of hypercalcemia and the risk of soft-tissue calcifications, especially in the kidneys. Brief and casual exposure of the face, arms and hands to sunlight is thought to be equivalent to 200 units of vitamin D. Recommended daily dosages for vitamin D are summarised in Table VI.

Table VI: Recommended daily dosages of Vitamin D

Age group	Vitamin D (IU/d)
Pubertal children (4-8 years)	No data
Adolescents (9-18 years)	No data
Women (19-50 years)	400
Women (over 50 years)	800
Pregnant and lactating women	400
Men (19-50 years)	400
Men (over 50 years)	800

The role of other nutritional factors in the prevention and management of osteoporosis

Phosphorous/phosphate intake

An adequate phosphorus intake is important for optimal bone-building during growth periods, and suboptimal levels will impair the formation and mineralisation of bone.[40] When consumed in normal quantities, [recommended daily allowance (RDA) 700 mg/day], phosphorous intake does not seem to have an impact on bone homeostasis, however, excessive intakes, especially in combination with low calcium intake, are detrimental to skeletal homeostasis[40] as the calcium-to-phosphate ratio will be altered. Too much phosphate compared to calcium lowers the serum calcium ion concentration, which then stimulates PTH. If this pattern of intake becomes chronic, bone loss is thought to follow over long periods of time.[40] The phosphorous-to- calcium ratio, at any age, is more important than the intake of phosphorous in isolation.[40] In general, eating provides a constant amount of phosphate (roughly 1 000-1 200 mg/day for females and 1 200-1 400 mg/day for males) and foods high in phosphorous include meat, poultry, fish and cereals.

Magnesium intake

More than 50% of the magnesium in the body is found in bone tissue. Magnesium dietary deficits seem to have little effect on bone tissue, but adequate intakes of magnesium do improve BMD.[40] For healthy individuals, the recommended intake is 420 mg/day for women and 320 mg/day for men.[40] Magnesium is found in most foods, including vegetables, fruits, legumes, grains, nuts, seeds, dairy and animal products. Like calcium, the efficiency of magnesium absorption is inversely proportional to the amount consumed. Dietary phosphate decreases the amount of magnesium absorbed, but the body maintains its magnesium balance by decreasing the amount lost through urinary excretion. Magnesium may relieve the constipation associated with calcium supplementation.[40]

Sodium intake

A high sodium intake, particularly in association with a low calcium intake, can contribute to osteoporosis because this results in increased renal calcium excretion.[40] Moderate salt intake is recommended, and should meet the American Heart Association's guideline of 2 400 mg per day.[40] Adequate calcium intakes will allow for more liberal use of sodium. Reduced bone turnover has been reported in relation to the Dietary Approach to Stop Hypertension (DASH) diet.[40]

Potassium intake

Potassium intake can influence calcium homeostasis, particularly the urinary conservation and excretion of calcium. Low-potassium diets increase urinary calcium losses, while high-potassium diets reduce it. Potassium is found in several vegetables, fruits, legumes and milk, and tends to have alkaline characteristics. High potassium intake, primarily from fruits and vegetables, is associated with higher baseline BMD and less bone loss.

Vitamin K intake

Vitamin K is an essential micronutrient for bone health[39,41] and is involved in the carboxylation of osteocalcin and further reduces urinary calcium excretion.[41] Vitamin K intakes are positively associated with bone density and lower intake is a predictor of fracture risk.[40] An optimal intake of this fat-soluble vitamin is therefore important for bone health, for maintaining calcium homeostasis and for reducing the risk of fractures. Dietary sources of Vitamin K include dark green leafy vegetables (spinach, broccoli and dark lettuce), fruits, margarine and plant oils and in grains and dairy products (a small amount). A healthy balanced diet, with adequate amounts of fruits and vegetables, will provide sufficient amounts of vitamin K for most of the population.[40]

Vitamin A (retinol) intake

Vitamin A, a fat-soluble vitamin, plays an important role in growth and bone remodelling[40] and consumption is therefore beneficial to bone growth and maintenance. The recommended dietary intake of vitamin A for females is 800 µg/day retinol equivalent (RE) and for males, 1000 µg/day.[40] Vitamin A should preferably be consumed in the form of carotenoids to prevent overconsumption in the fat-soluble form, as this may result in toxicity that can contribute to hip fractures.[40] Food sources high in beta-carotene are carrots, oranges, sweet potato and dark-green leafy vegetables, such as spinach. No adverse effects of vitamin A from fruits and vegetables (carotenoids) have been reported.[40]

Vitamin C intake

Vitamin C is an essential co-factor involved in the formation of collagen.[40] Positive associations have been shown for vitamin C and bone mass, as well as fewer fractures

reported with higher vitamin C intakes.[40] Good dietary sources include citrus fruit and juices made from citrus fruits, broccoli, tomato products, peppers and green leafy vegetables. The daily requirements for vitamin C are 75 mg/day and 90 mg/day for adult women and adult men respectively.[40] Recommended intakes of five or more servings of fruits and vegetables should supply enough vitamin C for bone health.[40]

Other trace mineral intake

A number of trace minerals, including fluoride, boron, copper, zinc, iron, zinc and manganese, also play a role in bone health. A detailed discussion of the role of these trace elements is beyond the scope of this article and has already been reviewed.[40]

Nutritional lifestyle considerations that can negatively affect bone health

There are a number of nutritional lifestyle considerations that can negatively affect bone health. These include special diets, excess alcohol intake, excess caffeine intake and excess carbonated beverages.

Vegetarian diets

Vegetarian diets can meet daily protein requirements, but may provide less calcium than animal-protein-based diets. Vegetarian diets could also result in a reduced lifetime exposure to oestrogens, which could increase the risk for osteoporotic fractures. However, of benefit in optimising the functioning and health of bone cells are the polyphenols and other plant antioxidants that are abundant in plant foods. Many bone-healthy nutrients are found in fruits and vegetables. Potassium is considered an especially powerful protector of bone because of its role in generating alkaline ash.[44]

Excess alcohol intake

High doses of alcohol intake (more than 2-3 drinks a day) have been reported to have adverse effects on the skeleton.[45] It is also important to note that poor dietary intake and cigarette smoking frequently accompany heavy alcohol consumption and, as such, may be contributing factors.

Excess caffeine intake

The relationship of moderate consumption of caffeine with the development of osteoporosis has not been clearly established. Excessive caffeine intake may have a negative effect on BMD. It is advised that older individuals with low calcium intakes should increase their consumption of calcium, while moderating their caffeine consumption to 300 mg per day.[43] Caffeine occurs naturally in a range of foods such as coffee, tea and chocolate. Recently, it has also been added to some carbonated beverages and so-called "energy" drinks. The average quantity of caffeine in selected beverages is listed in Table VII. In general, the recommendation is to not have more than the equivalent of 3-4 cups of coffee a day.

Table VII: The average quantity of caffeine in selected beverages

Beverage	Average caffeine content
Average cup of instant coffee	75 mg
Average cup of coffee	100 mg
Average cup of brewed coffee	100 mg
Average cup of tea	50 mg
Regular cola drink	up to 40 mg
Regular energy drink	up to 80 mg
Normal bar of chocolate	up to 50 mg
Green tea (180 ml)	about 35 mg

The role of body weight as a risk factor for osteoporosis

Research indicates an increased risk for fractures in individuals with a low or excessive body weight. Both are important risk factors that can negatively affect BMD. Therefore, maintaining a BMI within the normal range (18.5-24.9 kg/m^2) is recommended for overall health, and to prevent bone loss.

Table VIII: Summary: beneficial and potentially detrimental nutritional factors associated with bone health[41]

Beneficial nutritional factors	Potentially detrimental nutritional factors
Calcium	Alcohol in excess
Copper	Caffeine in excess
Zinc	Sodium in excess
Fluoride	Fluoride in excess
Magnesium	Insufficient protein or in excess
Phosphorous	Phosphorous in excess
Potassium	Insufficient vitamin A or in excess
Vitamin C	Omega-6 fatty acids in excess
Vitamin D	
Vitamin K	
B vitamins	
Omega-3 fatty acids	
Protein	
Novel bioactive food components	
Whey-derived peptides	
Phytoestrogens	
Non-digestible oligosaccharides	
(especially inulin-type fructans)	

*Some nutrients could be categorised as being both beneficial and detrimental depending on dietary exposure level: insufficient, or in excess.

Summary: nutritional interventions in the prevention and management of osteoporosis

In summary, nutritional interventions play an important role in bone health, particularly during childhood and adolescence, when the largest proportion of adult bone mass is accrued.[39] Increased emphasis is placed on a preventative approach, including nutritional strategies, when addressing osteoporosis.[39] Beneficial and potentially detrimental nutritional factors associated with bone health are summarised in Table VIII.

Finally, practical recommendations for optimising nutritional lifestyle interventions for bone health are as follows:

- Ensure an adequate calcium intake (supplementation may be indicated);
- Ensure adequate vitamin D intake (supplementation may be indicated);
- Ensure adequate intake of other minerals and trace elements (supplementation may be indicated);
- Follow general healthy dietary guidelines that include diet variety;
- Limit excessive caffeine intake (limit tea and coffee to 3-4 cups daily);
- Limit excessive intake of alcohol (< 2-3 units per day);
- Reduce sodium intake;
- Maintain a healthy body weight;
- Increase the consumption of vegetables and fruit.

Other lifestyle interventions for osteoporosis

The primary elements of lifestyle modification, over and above weight-bearing exercise and nutrition, involve smoking cessation and reduction in alcohol intake as preventative measures. Smoking is a very consistent contributor to the risk of chronic disease, including osteoporosis. Therefore, in this regard, education of patients at the primary health level is crucial. However, it is important to note that simply educating patients about the link between smoking and illness is often not sufficient to alter behaviour. Smoking is less a lifestyle "choice" than an automatic and unconsciously driven addictive behaviour.

Engaged clinicians who are familiar with the psychological dynamics involved are likely to provide dynamic counselling and smoking cessation strategies. They often utilise active interventions which might include behavioural techniques (smoke-enders, Alan Carr, hypnotherapy), psychotherapeutic addiction management (especially when there is cross-addiction), in addition to medication such as Bupropion (Zyban®) and nicotine replacement (patches, gum). Regular follow-ups and encouragement from doctors are essential to alter smoking behaviour, especially if a relapse occurs.

Fall prevention programmes are also important and have been previously mentioned. The elderly are especially at risk. Falls occur as a result of:

- Loss of traction (e.g. slippery surface);
- Loss of footing (e.g. using a stool as a ladder);
- Impaired vision;
- Impaired balance;
- Diseases affecting circulation, sensation, mobility, or mental alertness;
- Certain medication (e.g. anti-hypertensive drugs, diuretics and sedatives) causing drug-related side-effects, such as dizziness, confusion/disorientation and slow reflexes.

There is little evidence for a rational approach to fall prevention, over and above educating patients at risk.[46] One aspect to consider is integration of body awareness practices with physical activity programmes in the elderly. Many of these techniques are gentle and relatively easy to perform with guidance and practice, such as Hatha yoga, qigong, tai chi, mindfulness-based body scanning and Pilates. Patients who have an increased felt-sense of their own bodies, both proprioceptively and interoceptively, might well modify behaviour and be aware of the physical contexts which place them at risk for a fall. While this approach has not been vigorously explored, a preliminary study at Temple University's Gait Study Center reports that yoga improves stability and balance in women over age 65.

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