



Definition of Osteoporosis

Normal bone is composed of a mixture of calcium and other minerals such as magnesium and phosphate. It is also made up of collagen (protein), which forms the structural framework of bone.

Osteoporosis is a condition, which results in loss of bone strength, thus making bone more fragile and easily susceptible to fracture. Osteoporosis occurs when there is a loss of mineral content from bone mainly in the form of calcium as well as architectural loss of normal bone structure. The loss of mineral content of the bone is referred to as a loss of bone mineral density in the bone.

It is a process that affects all individuals and is a part of normal aging. All individuals if they live long enough will develop osteoporosis. Some individuals due to various illnesses or as part of hormone deficiency states will develop osteoporosis at an earlier stage in their life. After menopause women are at an increased risk of osteoporosis.

In itself, osteoporosis causes no symptoms. It is when fractures occur that the problems of osteoporosis arise.

How common is osteoporosis?

- After the age of 60 years, 1 in 2 Australian women and 1 in 3 Australian men will sustain an osteoporotic fracture.
- Of all osteoporotic fractures in Australia, 46% are vertebral fractures, 16% are hip fractures and 16% are wrist fractures.
- Hip fractures are particularly problematic as there is evidence to suggest that 50% of elderly patients sustaining a hip fracture need subsequent long-term nursing care.
- There also is an increased risk of mortality associated with hip fractures with some figures indicating that 15% of hip fractures in the elderly lead to death within 4 months of the fracture.¹



Diagnosis of Osteoporosis

DEXA

A Dual Energy X-ray Absorptiometry scan (DEXA scan) is a specialised x-ray technique, which specifically measures bone mineral density (bone mineral content) and provides the most accurate way currently available to diagnose osteoporosis. It is a specialised X-Ray and is not painful.

It is used:

- To confirm the diagnosis of osteoporosis.
- To estimate severity of bone loss.
- To determine whether the patient is responding to treatment.

It is a fast scan, has high resolution, is easily reproducible and has lower radiation dose compared to other methods.

Usually only the lumbar spine (lower back) and proximal femur (hip region) are measured.

DEXA BMD VALUES	DEFINITION
T score > -1.0 S.D	Normal bone mineral density
T score between -1.0 and -2.5 SD	Osteopaenia
T score ≤ - 2.5 SD	Osteoporosis
T score ≤ - 2.5 SD with 1 or more fragility fractures	Severe osteoporosis

(WHO Working Group Definition of Osteoporosis)²⁵

Understanding Your DEXA Study Result

T scores are complicated statistical scores, that help define on DEXA study the condition of an individual's bones. When a DEXA study is performed, the bone mineral density is measured and compared to the bone mineral density of twenty year olds of the same sex. Twenty year olds are used for comparison as they have the greatest peak bone mass.

A T score which is positive or only minus 1 standard deviation (up to 1 step below normal) from the normal bone mineral density of a 20 year old is regarded as being a normal bone mineral density, for the site that it is measured at.

If the T Score is minus 1.0 to minus 2.5 standard deviations (between 1 and 2½ steps) below the normal bone mineral density of a 20 year old, this indicates the presence of osteopaenia. Osteopaenia is not osteoporosis. It represents a stage when the bones have lost some bone mineral strength and are weaker, but not as weak as in osteoporosis. It can be regarded as the phase before the occurrence of osteoporosis.

If the T score is greater than minus 2.5 standard deviations (greater than 2½ steps) below the normal bone mineral density of a 20 year old, this indicates the presence of osteoporosis.



Causes of Osteoporosis

During childhood and adolescence, the bones within the skeleton are actively growing. By one's early 20's, growth and development of bone is complete. This phase of bone development represents the attainment of "peak bone mass". It essentially is a time when bones are at their 'strongest'.

The peak bone mass that is achieved varies from one individual to the next and primarily reflects what has occurred during growth and development in childhood and adolescence. It is also influenced by hereditary factors as well. Hence an individual who has had adequate intake of calcium, plenty of exercise and not been subjected to any sex hormone deficiencies (e.g. interruption to menstrual periods) during childhood and adolescence will likely achieve a high peak bone mass as compared to the individual who has not had favourable circumstances for bone development during childhood and adolescence.

Normal aging lead to a gradual loss of bone mineral density, usually over several decades, often starting from the late 30's. The higher the peak bone mass that is achieved by the early 20's, then the greater the likelihood of withstanding the effects of normal age related bone loss. Individuals with a low peak bone mass, may not withstand the effects of age related bone loss as well as those who have achieved a high peak bone mass and hence may develop osteoporosis at a younger age.

Certain medical illnesses also effect bone and can lead to the development of osteoporosis, often independent of peak bone mass.

Below is a list of medical conditions which have been associated with the development of osteoporosis.

Causes of Osteoporosis
Failure to attain adequate peak bone mass in early 20's
Chronic illness e.g chronic liver disease, chronic renal failure
Thyroid disease, particularly hyperthyroidism or excessive thyroxine replacement
Smoking
Sedentary lifestyle
Excessive caffeine intake (> 5 – 6 cups/day)
Excessive alcohol intake



Lifelong low calcium intake

Increasing age

Genetic factors and Ethnic factors (Caucasian and Asians)

Hormone deficiency states (late menarche, premature menopause, menopausal state, testosterone deficiency in males)

Vitamin D deficiency

Primary hyperparathyroidism

Prolonged immobilisation

Cushing's syndrome or disease

Corticosteroid therapy (doses of prednisolone > 5 – 7.5 mg daily or an equivalent dose of another glucocorticoid for greater than 2 months; any dose of glucocorticoid in the elderly > 65 yrs)

Malabsorptive illnesses eg Coeliac disease, Crohn's disease

Eating disorders (Anorexia nervosa, Bulimia)

Rheumatoid arthritis

Organ transplant recipients

Treatments for certain malignancies e.g breast cancer, prostate cancer



Prevention of Osteoporosis

1. Calcium

Calcium is one of the essential nutrients necessary for healthy bone development. Adequate calcium intake is necessary for the attainment of peak bone mass in the early 20's (i.e the highest level of bone strength which occurs at completion of growth) and therefore strong healthy bones, which will sustain the effects of ageing on the skeleton. Hence it is important to have a well balanced diet with adequate amounts of dairy products, which are the primary source of foods rich in calcium.

Not only is calcium important to bones, it is also important for the function of various organs within the body. There also is a certain amount of calcium which circulates within the blood, with the levels of calcium in the blood being tightly regulated. If blood calcium levels fall as may occur with inadequate calcium intake in the diet, the body will compensate for this by drawing calcium out of bones and putting it into the blood. Calcium is also excreted by the body daily. Hence, it is important to have an adequate daily calcium intake through the diet, so that bone mineral strength is not compromised.

Recommended Daily Calcium Intake		
Category	Age	Calcium (mg)
Children	1-3 years	700
	4-7 years	800
Girls	8-11 years	900
	12-15 years	1200
	16-18 years	800
Women	19-54	800
	54+	1000
Pregnancy: last 3 months		1200
Lactating		1200
Boys	8-11	800
	12-15	1200
	16-18	1000
Men	19-64	800
	64+	800

These recommendations are to be revised within the next few months.²



Calcium Requirements Throughout Life

There are critical times in life when it is vital to ensure that calcium intake through food and/or supplements are adequate.

Childhood and Adolescents

During childhood and adolescence, when the skeleton is actively growing it is essential that calcium intake meets the requirements of the growing skeleton. It is during this growth phase that the foundations for the attainment (achievement) of peak bone mass are laid. In the years following the growth phase, dietary calcium is required to maintain peak bone mass.

35 to midlife (50's)

From the mid 30s onwards bone loss starts to occur. It is part of the normal ageing process that bones lose their mineral (calcium) and collagen (protein) content. For women this process of bone loss is also accelerated further at the time of menopause. Thus if an individual starts with a high peak bone mass, their skeleton will withstand the effects of the age related bone loss better than the individual who has a low peak bone mass and who will be more likely to develop osteoporosis at a latter stage.

Pregnant and breastfeeding women

Pregnant women and breastfeeding women need to ensure that they have adequate calcium intake. In pregnancy, especially in the third trimester of pregnancy, calcium requirements are increased, in order to meet the requirements for bone mineralization in the foetal skeleton. Women who breastfeed also have high requirements for calcium in order to allow for milk production. Normal pregnancy and breastfeeding is associated with a certain amount of bone mineral loss, which generally recovers 6 – 12 months after the cessation of pregnancy and/or breast feeding.³

Midlife

Midlife and beyond is a time when calcium requirements are also high. When women go through menopause, there is a rapid loss of bone that is primarily due to estrogen deficiency and this process may last from 4 – 8 years after menopause.⁴

It is also known that women generally start to lose bone even in the years leading up to menopause due to the fact that estrogen levels are already starting to drop even though periods may still be occurring.⁵

It is also a time when the gastrointestinal system becomes less efficient at absorbing calcium from food and it is believed that this process is also due to the loss of estrogen. The kidney also becomes less efficient in conserving calcium. This creates a state of potential calcium loss in the blood, and the body compensates for this by drawing calcium out of the bones.⁴

Thus not only do the bones become weaker because of estrogen deficiency at menopause, they also lose more calcium. Hence the way to reduce the loss of calcium from the bones is to increase the intake of calcium from food.



Older years

In the years beyond menopause the rate of bone loss as a consequence of estrogen deficiency slows down. However, there is still a requirement for high intake of calcium through the diet so as to offset the process of calcium being drawn from the bones in order to compensate for inefficient calcium absorption from the gastrointestinal system and kidney.⁴

2. Vitamin D

This nutrient is vital for the development of healthy bones. Vitamin D serves several important functions in relation to calcium metabolism. It helps to increase calcium absorption from the gastrointestinal system and kidney and thereby make it available to body tissues and the blood. It also functions to aid with the deposition of calcium to bone.

The body's main source of vitamin D arises from the manufacture of this vitamin in the skin on exposure to sunlight. Only 10 – 15 minutes of exposure to outdoor sun on the face and arms daily, is necessary for adequate production of vitamin D. However, it is important to avoid excessive exposure from sunlight, particularly in Summer due to the risk of skin damage and skin cancers.

Dietary sources of vitamin D are poor sources of this nutrient and do not contribute significantly to vitamin D levels in the body. These sources of vitamin D from the diet arise often from foods fortified with vitamin D such as milk, soy drinks, margarine and cereals. It is also found naturally in liver, fish (tuna, salmon, sardines, herring and mackerel) and egg yolk.⁶

Certain individuals with limited exposure to sunlight are at risk of vitamin D deficiency. The institutionalised⁷, housebound elderly⁸, veiled women and dark skin individuals may be at risk of vitamin D deficiency⁹. Also individuals with illnesses of the gastrointestinal system such as Coeliac disease¹⁰ may not absorb adequate amounts of vitamin D from the diet. In high-risk individuals such as the elderly or those found to have low levels of vitamin D, vitamin D supplements are appropriate^{11;12}. In addition, if calcium intake from dietary sources is inadequate, the use of calcium supplements may be necessary.

In order to determine if you are lacking vitamin D, it is best to see your doctor and have a blood test to measure your vitamin D levels.

You should discuss with your doctor whether you require supplements of calcium or vitamin D.

3. Exercise

It is important that physical activity be undertaken throughout life. In childhood and adolescence, exercise has beneficial effects in terms of bone development and attainment of a high peak bone mass by the early 20's.

Physical activity performed in the adult years will help to maintain bone strength and improve balance and co-ordination, which may prevent the occurrence of falls when elderly.



Exercises which are beneficial for bone health

Resistance training exercises

These exercises are also known as strength training exercises. Strength training uses weights of some kind for example machines, dumbbells, ankle or wrist weights, to create resistance which helps build muscle mass and places a load (force) on the involved limb bones. It also includes exercises, which use one's own body weight as the load (eg. push-ups, whereby the load is placed through the arms and shoulders). Load placed on bone leads to increased bone formation at the site where the load is greatest.¹³ Ideally strength-training programs should be performed regularly, 2-3 times per week.

Weight-bearing exercise and High impact exercise

Weight bearing exercise refers to exercises, which are performed in the standing position and involves loads (forces) being placed through the leg bones and spine. Examples of weight-bearing exercise include walking, running, tennis and dancing. Studies to evaluate the effects of weight bearing exercise such as walking have not shown as drastic an improvement in bone mass unless this activity is performed as a high intensity activity (eg walking at a fast pace, jogging etc).¹⁴

High impact exercises generally refers to weight bearing exercise which involves more load placed through the leg bones and spine during landing after lifting ones own body weight off the ground. Examples of this form of exercise includes running, skipping, jumping, team sports (eg netball) and high impact aerobics.

There is evidence to suggest that both high impact loading and resistance type (strength training) exercise probably provides the most benefit for improving bone mineral density.¹³⁻¹⁹ However, there is no data, which shows that these exercises actually reduce the incidence of fractures.²⁰

Exercises with minimal effects on bone health

Bike riding and swimming where there is minimal load placed on bone has minimal effect in improving bone mass. However, these forms of exercise are beneficial in terms of improving cardiovascular health and muscle strength.²¹

4. Importance of Hormones

The sex hormone estrogen plays a vital role in the development of the skeleton in females.

Adolescence

During puberty the increased levels of the sex hormones lead to an increase in size and bone mass of the skeleton.²² Ongoing production of estrogen is vital in adolescent females and young women so as to maintain bone mass. Reduced exposure to estrogen during life as can occur when there are absent or infrequent menstrual cycles, delay in the onset of the first period or early menopause will affect the attainment of peak bone mass and maintenance of bone mass.

Preceding menopause

Even in the years immediately preceding menopause there can be a drop in estrogen levels that leads to a fall in bone mineral density.⁵



Menopause

Menopause is associated with a dramatic fall in estrogen levels that result in significant loss of bone mass, which can last from 4 to 8 years after the onset of menopause. This bone loss initially mainly affects the spinal column (vertebrae). Usually, however, most bone is lost in the first 3 years after menopause and then the rate of bone loss slows. During the first 3 years after menopause, women may lose up to approximately 2% of bone mass per year especially in the spinal bones (vertebral bones).^{5;23,24} The extent of bone loss in hips and wrist may be similar or slightly less.^{5;23,24} Once women have passed through this rapid rate of bone loss, the rate of bone loss significantly slows and women generally can expect to lose approximately less than 1% of bone density at the hip per year, with the rate of change in the spine being even slower.^{5;23,24}



Management of Osteoporosis

Lifestyle factors

Even when osteoporosis is diagnosed, lifestyle factors are still important in the management of this condition.

Exercise

Exercise that is appropriate to the woman's stage of life is still recommended regardless of age. It is important for women to discuss exercise options with their treating doctor to ensure that it is safe to take part in an exercise program.

Calcium

Healthy bones require adequate nutrition. Women need to ensure that they have adequate calcium intake that meets the requirement for their particular age. If women are unable to have an adequate intake of dairy products, which are the major source of calcium in the diet, there may be a requirement for calcium supplements. It is best for women to discuss this option with their treating doctor.

Vitamin D

It is important to have adequate levels of vitamin D. Vitamin D levels can be measured through a simple blood test. Most vitamin D comes from exposure of skin to sunlight for 10 – 15 minutes daily. Sunlight provides the best source of vitamin D. Dietary sources of vitamin D are not the major source of vitamin D.

For many individuals it is not advisable to recommend sun exposure to increase the levels of vitamin D due to the potential harmful effects of sunlight on skin. In this situation, if measured vitamin D levels are not at an optimal level, then it may be necessary to take a vitamin D supplement. In addition if dietary calcium intake is poor, a combined tablet, which contains both calcium and vitamin D, may be taken. If a separate Vitamin D supplement and calcium supplement are to be taken, it is important to have these medications at different times in the day. For instance if the calcium supplement is taken in the morning then the vitamin D supplement would need to be taken in the evening and vice versa. This will improve the absorption of both these nutrients. It generally does not matter what time in the day you have either your calcium or vitamin D supplement.

Your treating doctor is in the best position to recommend whether you need to take vitamin D and/or calcium supplements.

Avoid smoking

To protect bones it is advisable not to smoke. Women who smoke, lose bone density faster than women who do not smoke.²⁶



Drug Therapies for Osteoporosis

Hormone Therapy

Hormone therapy at the time of menopause may be beneficial for protecting bones.

The Women's Health Initiative Trial (published July 2002 and October 2003) has shown that hormone therapy does reduce the incidence of fractures at the hip and vertebrae (spinal bones) in postmenopausal women.^{27,28} However, long-term hormone therapy is associated with other risks of heart disease, breast cancer, pulmonary embolism (blood clots in the lung) and deep vein thrombosis (blood clots in the leg veins).²⁷

Hence, although hormone therapy has beneficial effects on bone health, it should be prescribed primarily for the short-term treatment (less than 5 years) of menopausal symptoms in women who are progressing through menopause. The use of hormone therapy for disease prevention is not recommended. However, some women may elect to use hormone therapy and this needs to be done in consultation with the treating physician and with the woman understanding the risks and benefits of this therapy.²⁹

It is also important to realise that hormone therapy only protects your bones whilst on the treatment. Once hormone therapy is ceased, the rate of bone loss will return to the same level it was before starting hormone therapy.³⁰

Bisphosphonates

Bisphosphonates are a class of drug, which function to decrease bone loss.

The currently available bisphosphonates in Australia, which are recommended for the treatment of Osteoporosis, are Fosamax (Alendronate), Actonel (Risedronate) and Didrocal (Etidronate & Calcium).

Fosamax and Actonel

Both Fosamax and Actonel have been found to reduce the incidence of vertebral (spinal bones) and hip fractures.^{31,32} These drugs also reduce the risk of fracture at other sites in the body. The effects of these drugs on risk of fracture usually start within 6 – 12 months of commencing therapy.

These medications are generally well tolerated. They have been associated with side effects of heartburn, abdominal discomfort and ulceration of the oesophagus (food pipe). Ulceration of the oesophagus is one of the side effects that is most concerning. Hence, these medications must be taken first thing in the morning on an empty stomach, with a full glass of water and the individual needs to remain either sitting upright or standing for the next 30 minutes. After this time, normal activities and eating can be resumed. The incidence of oesophageal ulceration is extremely low when these medications are taken correctly.

These medications can be taken either daily or once weekly. There is an increasing trend for prescribing these medications once weekly as it improves compliance and it is likely to further reduce the incidence of gastrointestinal upset.²⁹ It is advisable that these medications are used cautiously in those with significant reflux esophagitis (heartburn) and those with a hiatus hernia. These drugs are



not well absorbed; hence it is important to take them on an empty stomach. It is also recommended not to take calcium at the same time of day as calcium may interfere with the absorption of the medication.

Didrocal

Didrocal (Etidronate and Calcium) is administered in a somewhat different way to the other medications. This preparation is administered cyclically. For a 2 week period the active tablet Etidronate is taken morning and night. This is then followed by an 11 week period where a calcium tablet is taken morning and night. This cycle is then repeated. This medication is generally well tolerated and does not have the problems with side effects of the upper gastrointestinal system such as heartburn or oesophageal ulceration. There may be side effects of diarrhoea or nausea. Generally this drug has been found to be effective in increasing bone mineral density and reducing the incidence of vertebral fractures (spinal column). This medication is probably best suited to women with osteoporosis of the spine.³³

If women are unable to tolerate the oral forms of the bisphosphonates, there is the option to have these forms of medication given intravenously in an intermittent fashion. In this setting it is necessary for women to be under the care of a specialized physician or osteoporosis clinic.

In order for these medications (bisphosphonates) to be effective in increasing bone mineral density and reducing the likelihood of fracture, women need to ensure that they have an appropriate intake of calcium either through diet or supplements and that they also have adequate vitamin D levels. For women taking didrocal, there is no need to take additional calcium supplements, as these are already included in this preparation. There still may be a requirement for additional Vitamin D supplementation if the measured Vitamin D levels are low.

Other Considerations

Bisphosphonates are primarily prescribed for women (and men) who have osteoporosis as defined on a bone DEXA scan and a history of an osteoporosis related (low trauma) fracture. In this setting the cost of these medications is subsidized by the Australian PBS.

There is also evidence to suggest that these medications may also prevent fractures in women with osteoporosis who do not have a history of fracture. There is evidence that the use of these medications in individuals on long-term corticosteroid therapy (eg prednisolone) also helps to prevent the development of osteoporosis. However, subsidized funding of these medications by the Australian PBS for these particular indications is not available. However, Actonel has been listed for use by the RPBS (for veterans) for the prevention of corticosteroid-induced osteoporosis. This drug can be used in individuals who have not had a fracture. However, there are certain criteria that the individual needs to satisfy in order to be prescribed Actonel for corticosteroid-induced osteoporosis.

There are many unresolved issues with regards to the use of these medications. One issue is with regard to length of therapy that is needed. There are few studies using these medications beyond 7 years of therapy, although there is a recently published study with Fosamax, in which the drug was used safely for 10 years. Most physicians would therefore recommend using these medications until such a time that there is improvement in bone mineral density measurements and for only a few years. Hopefully as more studies become available and the duration of the studies is longer, then recommendations for longer-term use can be made.

Another issue is in regards to using these medications to prevent osteoporosis. This is not recommended, as studies to date have not shown a benefit in terms of preventing fractures in women



who have osteopaenia (reduced bone mineral density as determined by a DEXA study, which is not as severe as that of osteoporosis).

Evista (Raloxifene)

This medication is known as a selective estrogen-receptor modulator. In other words it acts at some sites in the body like estrogen but at other sites of the body it functions as an anti-estrogen. In bone it works as an estrogen and leads to an increase in bone mass (density). In the breast and uterus it works as an anti-estrogen and therefore does not stimulate the breast or uterine lining. Due to its anti-estrogen effects in the breast, it reduces the incidence of breast cancer.

Primarily this medication has been shown to reduce the incidence of vertebral fractures (spinal column).³⁴ The evidence for this medication having a significant effect on fractures at other sites of the body is lacking.

The side effects of this therapy include hot flushes. This therapy is therefore problematic for premenopausal women and women who are currently going through menopause, as it may worsen menopausal symptoms. This therapy is best reserved for postmenopausal women who have gone through the menopause. The other side effect of this therapy is a slightly increased risk of deep vein thrombosis. Hence, women who are on this medication need to consider stopping this therapy if they are going to be immobile for sometime, such as during long airline flights or during hospital admission. The medication can be resumed once mobility is regained. Any woman who has significant risk factors for a clotting disorder should not be prescribed this therapy.

In order for this therapy to be effective it is essential that women have adequate vitamin D levels and adequate dietary calcium intake. It may be necessary to have supplements of calcium and vitamin D if measured vitamin D levels are low or dietary calcium intake is inadequate.

Other potential therapies

Tibolone (Livial)

This therapy is a different form of hormone therapy for treating menopausal symptoms. Tibolone may not have the same stimulatory effects on the breast as standard forms of hormone therapy. However, this has yet to be evaluated in properly conducted clinical trials. There is evidence that it has beneficial effects on bone and leads to an increase in bone mineral density.³⁵ Studies are currently underway to evaluate the effects of this medication in terms of preventing osteoporosis in postmenopausal women and assessing whether it is effective in preventing fracture.

Parathyroid Hormone

This therapy has recently become available in Australia as of November 2003. It is not as yet listed for use by the PBS. This hormone is administered daily via a subcutaneous (just below the skin) injection. It functions to increase bone formation³⁶ and also absorption of calcium from the gut and kidney. Calcium and vitamin D supplements may be necessary with this medication and if this is to be done it needs to be monitored under the care of a specialist physician. Most of the studies with this medication have only been for up to 2 years. There appears to be a clear benefit in terms of reducing all types of fractures in postmenopausal women, except for hip fractures.^{37,38} Due to the expense and



limited access of this therapy, it is not readily available to all Australians. Its prescription for use is confined to specialists in osteoporosis.

Strontium

This medication is not yet available in Australia, but may be released for use within the next few years. Strontium is a trace element that is naturally found within soft tissues, blood, teeth and bone. Its' mode of action is unclear, but it seems to lead to decreased bone loss and may enhance bone formation. Studies with this medication in postmenopausal women have shown a reduction in both vertebral (spinal), hip and other fractures.^{39, 40} It also appears to be well tolerated, but may be associated with side effects of diarrhoea. Like other osteoporosis therapies, there may be a requirement for additional vitamin D and calcium supplements if measured vitamin D levels are low or dietary calcium intake is insufficient.