

Physical activity and its role in the prevention of osteoporosis in women

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- The two key factors in preventing osteoporosis are to:
 - increase peak bone mass that occurs prior to 20-30 years of age; and,
 - decrease the rate of bone loss that occurs after the age of 40-50 years.
- Consistent evidence shows that weight-bearing exercise during youth contributes to increased peak bone mass^{1,3} and is important for the maintenance of bone health and minimising the rate of bone loss later in life.
- The research suggests that peak bone mineral density (BMD) may be the single most important factor in delaying the development of the disease⁴.



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¹ Karlsson, M., Has exercise an antifracture efficacy in women? *Scand J Med Sci Sports*, 2004. 14(1): p. 2-15.

² Bailey, D.A., et al., A Six-Year Longitudinal Study of the Relationship of Physical Activity to Bone Mineral Accrual in Growing Children: The University of Saskatchewan Bone Mineral Accrual Study. *Journal of Bone and Mineral Research*, 1999. 14(10): p. 1672-1679.

³ Hind, K. and M. Burrows, Weight-bearing exercise and bone mineral accrual in children and adolescents: a review of controlled trials. *Bone*, 2007. 40(1): p. 14-27.

⁴ Hernandez, C.J., G.S. Beaupre, and D.R. Carter, A theoretical analysis of the relative influences of peak BMD, age-related bone loss and menopause on the development of osteoporosis. *Osteoporos Int*, 2003. 14(10): p. 843-7.

What is osteoporosis?

Osteoporosis is a disease characterised by reduced density and quality of bone, leading to weakness of the skeleton and an increased risk of fractures, particularly of the spine, hip and wrist⁵. Since osteoporosis has no symptoms, its impact is seen mainly in falls and fractures in post-menopausal women and men over 60 years of age.

Bone development and loss

Bone tissue is in a continual process of building, breaking down and rebuilding, which ensures that bones are repaired and remain strong. During periods of human growth the rate of bone formation exceeds that of bone loss. The reverse is true as age increases. Bones reach their maximum strength and density (peak bone mass) between the ages of 20 and 30 years.

Factors affecting peak bone mass include diet, calcium intake, physical activity and genetics.

After the age of about 40–50 years, the rate of bone loss increases and bone mass is lost. Bone mineral density later in life is determined by the bone mass accumulated during youth and the subsequent rate of bone loss.

The two key factors in preventing osteoporosis are to:

- increase peak bone mass that occurs prior to 20-30 years of age; and,
- decrease the rate of bone loss that occurs after the age of 40-50 years.



⁵ Department of Medicine, University of Melbourne, *The Burden of Brittle Bones. Epidemiology, Costs & Burden of Osteoporosis in Australia 2007, Osteoporosis Australia: Sydney.*

How many people have osteoporosis?

Self-reported data from the 2004–05 National Health Survey (conducted by the Australian Bureau of Statistics) suggests that almost 581,000 Australians (almost 3% of the population) have been diagnosed with osteoporosis⁶. Of these, 85% (about 433,500) are women.

The incidence of minimal trauma fractures (a consequence of osteoporosis) in Australia is increasing with the ageing population. It is estimated that one in two women and one in four men over the age of 60 will have a fracture due to osteoporosis in their lifetime. Of all reported osteoporotic fractures, 46% are vertebral, 16% are hip and 16% are wrist fractures⁵.



The burden of osteoporosis

In Australia in 2007, someone was admitted to hospital with an osteoporotic fracture every 5-6 minutes, with an average of 262 hospitalisations per day. This has increased from an average of 177 hospitalisations per day in 2001 and is set to increase significantly over coming years⁵. This data substantially underestimates the number of minimal trauma fractures occurring in Australia as the majority will not be treated in hospital. It also underestimates the number of people with osteoporosis who do not have a fracture as these are not managed in a hospital but in an outpatient setting for which there is no data available.

In 2007-08, osteoporosis was the fifth most commonly managed musculoskeletal complaint in general practice settings in Australia⁷.

⁶ Australian Institute of Health and Welfare, *Arthritis and osteoporosis in Australia 2008*. Arthritis series no. 8. Cat. no. PHE 106. 2008, Australian Institute of Health and Welfare: Canberra.

⁷ Australian Institute of Health and Welfare, *General practice activity in Australia 2007-08*. General practice series no. 22. Cat. no. GEP 22. 2008, Australian Institute of Health and Welfare: Canberra.

The cost of osteoporosis

The most recent Australian Institute of Health & Welfare estimate of the direct health expenditure on osteoporosis was more than \$304 million in 2004–05, almost 8% of the total direct health expenditure on arthritis and musculoskeletal conditions in that year. Prescription pharmaceuticals accounted for the largest proportion of this expenditure, at \$215 million (71%)⁸.

In a publication by the International Osteoporosis Foundation and Osteoporosis Australia the direct cost associated with osteoporosis and related fractures each year in Australia are estimated to be \$1.9 billion. This includes hospitalisation, pharmaceutical treatment and rehabilitation costs⁵.

Medibank members with osteoporosis

In the 2007-08 financial year, there were 1,785 hospital admissions among Medibank members with a primary or secondary diagnosis of osteoporosis.

Medibank members with osteoporosis stay longer in hospital (average stay of 14.4 days) compared to those members without osteoporosis (average stay of 5.6 days).

Admissions for Medibank members with osteoporosis in 2007-08

Table 1

Type of admission	Number of overnight admissions	Number of same day admissions
Osteoporosis with a fracture	793	291
Osteoporosis without a fracture	402	299
Total	1195	590

⁸ Australian Institute of Health and Welfare, *Arthritis and osteoporosis in Australia 2008*. Arthritis series no. 8. Cat. no. PHE 106. 2008, Australian Institute of Health and Welfare: Canberra.

Exercise is thought to strengthen skeletal bones through gravitational forces or muscle pull producing strains within the skeleton. If a strain is detected as greater than the optimum strain, then bone formation will occur⁹.

There is consistent evidence that weight-bearing exercise during youth contributes to increased peak bone mass¹⁻³ and provides the mechanical stimuli or 'loading' important for the maintenance of bone health and to minimise the rate of bone loss later in life.

It has been predicted from epidemiological modelling that a 10% increase in peak bone mass could significantly delay the onset of osteoporosis and reduce the risk of osteoporotic fractures later in life.

One model showed that a 10% increase in peak bone mineral density was predicted to delay the development of osteoporosis by 13 years. Additionally, it suggests that peak bone mineral density (BMD) may be the single most important factor in delaying the development of the disease⁴.

Another study using modelling from epidemiological studies predicted that a 10% increase in peak bone mass would reduce the risk of fragility fractures after the menopause by 50%¹⁰.

The pattern of bone growth and loss over a life-time demonstrates that bones reach their maximum strength and density (peak bone mass) between the ages of 20 and 30 years. A key focus for preventing osteoporosis is to increase the peak bone mass that occurs prior to 20-30 years of age.

The gain in bone mineral content before and during puberty is higher than the amount that is lost during the rest of the lifespan and is an ideal period to further increase peak bone mineral density².

During the two years around peak bone mineral content velocity, 26% of adult total body bone mineral is built up. A longitudinal study over six years found that physically active girls have a 17% greater total body bone mineral content than their inactive peers². Furthermore, activity such as ball games, dance, resistance training and jumping exercises result in significant increases in bone mineral accumulation especially during pre-pubescence (average increases of 0.9-4.9%) and early pubescence (average increases of 1.1-5.5%)³.

Further evidence of the role of exercise amongst girls in preventing osteoporosis is a two-year study of 99 girls between 7-9 years of age, published in 2006. This study showed that the annual gain in bone mineral content, BMD and bone size was significantly greater in girls who participated in 200 minutes of physical activity per week (such as ball games, running, jumping and climbing) compared to girls who did 60 minutes per week of the same type of exercise.



⁹ Lanyon, L.E., *Functional strain as a determinant for bone remodelling. Calcif Tissue Int, 1984. 36 Suppl 1: pS56-61.*

¹⁰ Bonjour, J.P., et al., *Gene-environment interactions in the skeletal response to nutrition and exercise during growth. Med Sport Sci, 2007. 51: p. 64-80.*

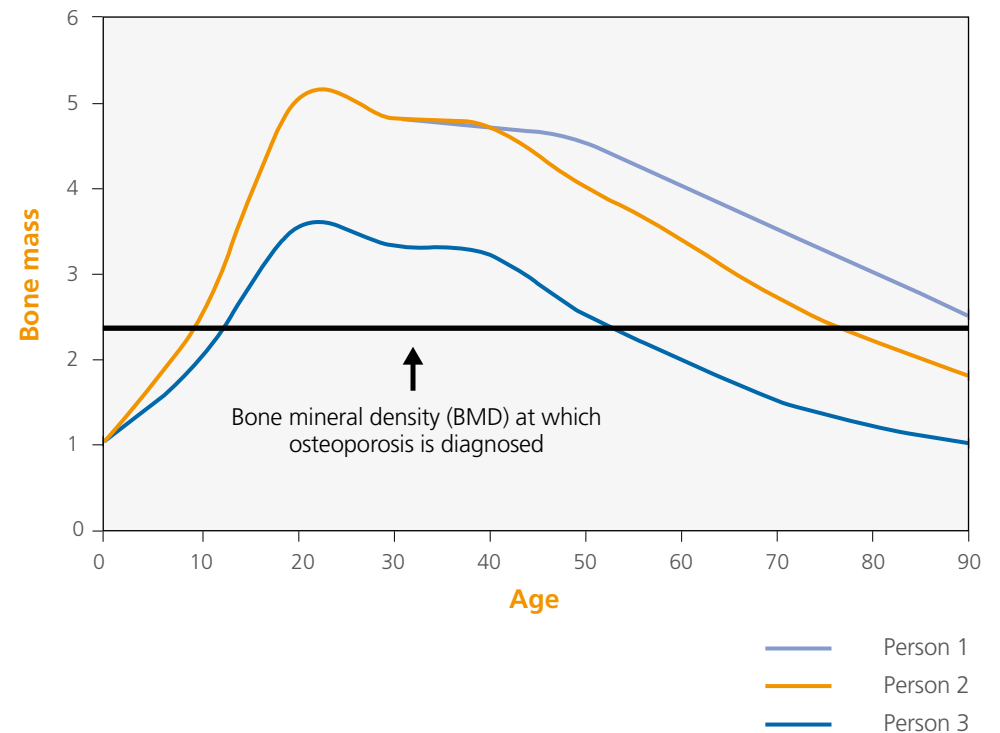
Effect of physical activity in women

Once peak bone mass has occurred, there is a need to slow the rate at which bone loss occurs. There is strong evidence that aerobic and strength/resistance activities are effective forms of weight-bearing exercise to minimise bone loss and osteoporosis. Consistent data from randomised controlled trials show that exercise training programs can prevent or reverse almost 1% of bone loss per year in both pre- and post-menopausal women¹¹⁻¹⁷.

Figure 1 on the opposite page illustrates how BMD is built up and then falls with age and shows how different patterns of bone growth and loss effect the development of osteoporosis. As a general trend, the diagnosis of osteoporosis occurs at a much earlier age in sedentary women than active women¹⁸.



Figure 1: Change in bone mass over time



¹¹ Kelley, G.A., *Aerobic exercise and bone density at the hip in post-menopausal women: a meta-analysis*. *Prev Med*, 1998. 27(6): p. 798-807.

¹² Wolff, I., et al., *The effect of exercise training programs on bone mass: a meta-analysis of published controlled trials in pre- and post-menopausal women*. *Osteoporos Int*, 1999. 9(1): p. 1-12.

¹³ Wallace, B.A. and R.G. Cumming, *Systematic review of randomised trials of the effect of exercise on bone mass in pre- and post-menopausal women*. *Calcif Tissue Int*, 2000. 67(1): p. 10-8.

¹⁴ Vainionpaa, A., et al., *Intensity of exercise is associated with bone density change in pre-menopausal women*. *Osteoporos Int*, 2006. 17(3): p. 455-63.

¹⁵ Berard, A., G. Bravo, and P. Gauthier, *Meta-analysis of the effectiveness of physical activity for the prevention of bone loss in post-menopausal women*. *Osteoporos Int*, 1997. 7(4): p. 331-7.

¹⁶ Kelley, G., *Aerobic exercise and lumbar spine bone mineral density in post-menopausal women: a meta-analysis*. *J Am Geriatr Soc*, 1998. 46(2): p. 143-52.

¹⁷ Bonaiuto, D., et al., *Exercise for preventing and treating osteoporosis in post-menopausal women*. *Cochrane Database Syst Rev*, 2002(3): p. CD000333.

¹⁸ International Osteoporosis Foundation and Osteoporosis Australia, *Invest in Your Bones: Make it or Break it*. 2006, International Osteoporosis Foundation and Osteoporosis Australia: Nyon, Switzerland.

Person 1 is physically active throughout her entire life. She achieves a “normal” peak bone mass and has a modest rate of bone loss with age. She does not reach a stage where osteoporosis occurs.

Person 2 is physically active early if life but then relatively sedentary. She reaches “normal” peak bone mass, but has a relatively high rate of bone loss and eventually develops osteoporosis at the age of 80.

Person 3 is physically inactive throughout life. She has a low peak bone mass and a ‘normal’ rate of bone loss, but reaches a stage of osteoporosis at a much younger age of 65 years.

Types of exercise

It is difficult to quantify the exact dose of exercise necessary for enhancing bone density, as there are countless variations in frequency, intensity, duration and type.

While there are few studies in girls, it seems that physical activity involving ball games, gymnastics, running and jumping increase bone density. In women the best available evidence suggest that aerobic exercise and resistance training are the best forms of weight-bearing exercise to prevent osteoporosis in pre- and post-menopausal women.



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