5.7 Recommendations for preventing osteoporosis

5.7.1 *Background*

Osteoporosis is a disease affecting many millions of people around the world. It is characterized by low bone mass and micro-architectural deterioration of bone tissue, leading to bone fragility and a consequent increase in risk of fracture (*1, 2*).

The incidence of vertebral and hip fractures increases exponentially with advancing age (while that of wrist fractures levels off after the age of 60 years) (*3*). Osteoporosis fractures are a major cause of morbidity and disability in older people and, in the case of hip fractures, can lead to premature death. Such fractures impose a considerable economic burden on health services worldwide (*4*).

5.7.2 *Trends*

Worldwide variation in the incidence and prevalence of osteoporosis is difficult to determine because of problems with definition and diagnosis. The most useful way of comparing osteoporosis prevalence between populations is to use fracture rates in older people. However, because osteoporosis is usually not life-threatening, quantitative data from developing countries are scarce. Despite this, the current consensus is that approximately 1.66 million hip fractures occur each year worldwide, that the incidence is set to increase four-fold by 2050 because of the increasing numbers of older people, and that the age-adjusted incidence rates are many times higher in affluent developed countries than in sub-Saharan Africa and Asia (*5–7*).

In countries with a high fracture incidence, rates are greater among women (by three- to four-fold). Thus, although widely regarded in these countries as a disease that affects women, 20% of symptomatic spine fractures and 30% of hip fractures occur in men (*8*). In countries where fracture rates are low, men and women are more equally affected (*7, 9–11*). The incidence of vertebral and hip fractures in both sexes increases exponentially with age. Hip-fracture rates are highest in Caucasian women living in temperate climates, are somewhat lower in women from Mediterranean and Asian countries, and are lowest in women in Africa (*9, 10, 12*). Countries in economic transition, such as Hong Kong Special Administrative Region (SAR) of China, have seen significant increases in age-adjusted fracture rates in recent decades, while the rates in industrialized countries appear to have reached a plateau (*13, 14*).

5.7.3 *Diet, physical activity and osteoporosis*

Diet appears to have only a moderate relationship to osteoporosis, but calcium and vitamin D are both important, at least in older populations.

Calcium is one of the main bone-forming minerals and an appropriate supply to bone is essential at all stages of life. In estimating calcium requirements, most committees have used either a factorial approach, where calculations of skeletal accretion and turnover rates are combined with typical values for calcium absorption and excretion, or a variety of methods based on experimentally-derived balance data (*15, 16*). There has been considerable debate about whether current recommended intakes are adequate to maximize peak bone mass and to minimize bone loss and fracture risk in later life, and the controversies continue (*2, 12, 15–17*).

Vitamin D is obtained either from the diet or by synthesis in the skin under the action of sunlight. Overt vitamin D deficiency causes rickets in children and osteomalacia in adults, conditions where the ratio of mineral to osteoid in bone is reduced. Poor vitamin D status in the elderly, at plasma levels of 25-hydroxyvitamin D above those associated with osteomalacia, has been linked to age-related bone loss and osteoporotic fracture, where the ratio of mineral to osteoid remains normal.

Many other nutrients and dietary factors may be important for long-term bone health and the prevention of osteoporosis. Among the essential nutrients, plausible hypotheses for involvement with skeletal health, based on biochemical and metabolic evidence, can be made for zinc, copper, manganese, boron, vitamin A, vitamin C, vitamin K, the B vitamins, potassium and sodium (*15*). Evidence from physiological and clinical studies is largely lacking, and the data are often difficult to interpret because of potential size-confounding or bone remodelling transient effects.

5.7.4 *Strength of evidence*

For older people, there is convincing evidence for a reduction in risk for osteoporosis with sufficient intake of vitamin D and calcium together, and for an increase in risk with high consumption of alcohol and low body weight. Evidence suggesting a probable relationship, again in older people, supports a role for calcium and vitamin D separately, but none with fluoride.

Strength of evidence with fracture as outcome

There is considerable geographical variation in the incidence of fractures, and cultural variation in the intakes of nutrients associated with osteoporosis and the clinical outcome of fracture. In Table 18, where the evidence on risk factors for osteoporosis is summarized, it is important to note that the level of certainty is given in relation to fracture as the outcome, rather than apparent bone mineral density as measured by dual-energy X-ray absorptiometry or other indirect methods. Since the Consultation addressed health in terms of burden of disease, fractures were considered the more relevant end-point.

Table 18
Summary of strength of evidence linking diet to osteoporotic fractures

Evidence	Decreased risk	No relationship	Increased risk
Convincing	Vitamin D		High alcohol intake
Older people[a]	Calcium		Low body weight
	Physical activity		
Probable		Fluoride[b]	
Older people[a]			
Possible	Fruits and vegetables[c]	Phosphorus	High sodium intake
	Moderate alcohol intake		Low protein intake (in older people)
	Soy products		High protein intake

[a] In populations with high fracture incidence only. Applies to men and women older than 50–60 years, with a low calcium intake and/or poor vitamin D status.
[b] At levels used to fluoridate water supplies. High fluoride intake causes fluorosis and may also alter bone matrix.
[c] Several components of fruits and vegetables are associated with a decreased risk at levels of intake within the normal range of consumption (e.g. alkalinity, vitamin K, phytoestrogens, potassium, magnesium, boron). Vitamin C deficiency (scurvy) results in osteopenic bone disease.

5.7.5 *Disease-specific recommendations*

In countries with a high fracture incidence, a minimum of 400–500 mg of calcium intake is required to prevent osteoporosis. When consumption of dairy products is limited, other sources of calcium include fish with edible bones, tortillas processed with lime, green vegetables high in calcium (e.g. broccoli, kale), legumes and by-products of legumes (e.g. tofu). The interaction between calcium intake and physical activity, sun exposure, and intake of other dietary components (e.g. vitamin D, vitamin K, sodium, protein) and protective phytonutrients (e.g. soy compounds), needs to be considered before recommending increased calcium intake in countries with low fracture incidence in order to be in line with recommendations for industrialized countries (*18*).

With regard to calcium intakes to prevent osteoporosis, the Consultation referred to the recommendations of the Joint FAO/WHO Expert Consultation on Vitamin and Mineral Requirements in Human Nutrition (*18*) which highlighted the calcium paradox. The paradox (that hip fracture rates are higher in developed countries where calcium intake is higher than in developing countries where calcium intake is lower) clearly calls for an explanation. To date, the accumulated data indicate that the adverse effect of protein, in particular animal (but not vegetable) protein, might outweigh the positive effect of calcium intake on calcium balance.

The report of the Joint FAO/WHO Expert Consultation on Vitamin and Mineral Requirements in Human Nutrition made it clear that the recommendations for calcium intakes were based on long-term (90 days) calcium balance data for adults derived from Australia, Canada, the European Union, the United Kingdom and the United States, and were

not necessarily applicable to all countries worldwide. The report also acknowledged that strong evidence was emerging that the requirements for calcium might vary from culture to culture for dietary, genetic, lifestyle and geographical reasons. Therefore, two sets of allowances were recommended: one for countries with low consumption of animal protein, and another based on data from North America and Western Europes (*18*).

The following conclusions were reached:

- There is no case for global, population-based approaches. A case can be made for targeted approaches with respect to calcium and vitamin D in high-risk subgroups of populations, i.e. those with a high fracture incidence.
- In countries with high osteoporotic fracture incidence, a low calcium intake (i.e. below 400–500 mg per day) (*15*) among older men and women is associated with increased fracture risk.
- In countries with high fracture incidence, increases in dietary vitamin D and calcium in the older populations can decrease fracture risk. Therefore, an adequate vitamin D status should be ensured. If vitamin D is obtained predominantly from dietary sources, for example, when sunshine exposure is limited, an intake of 5–10 μg per day is recommended.
- Although firm evidence is lacking, prudent dietary and some lifestyle recommendations developed in respect of other chronic diseases may prove helpful in terms of reducing fracture risk. These include:
  - increase physical activity;
  - reduce sodium intake;
  - increase consumption of fruits and vegetables;
  - maintain a healthy body weight;
  - avoid smoking;
  - limit alcohol intake.
- Convincing evidence indicates that physical activity, particularly activity that maintains or increases muscle strength, coordination and balance as important determinants of propensity for falling, is beneficial in prevention of osteoporotic fractures. In addition, regular lifetime weight-bearing activities, especially in modes that include impacts on bones and are done in vigorous fashion, increase peak bone mass in youth and help to maintain bone mass in later life.

References

1. Consensus Development Conference. Diagnosis, prophylaxis, and treatment of osteoporosis. *American Journal of Medicine*, 1993, **94**:646–650.
2. Prentice A. Is nutrition important in osteoporosis? *Proceedings of the Nutrition Society*, 1997, **56**:357–367.

3. Compston JE. Osteoporosis. In: Campbell GA, Compston JE, Crisp AJ, eds. *The management of common metabolic bone disorders*. Cambridge, Cambridge University Press, 1993:29–62.
4. Johnell O. The socioeconomic burden of fractures: today and in the 21st century. *American Journal of Medicine*, 1997, **103**(Suppl. 2A):S20–S25.
5. Royal College of Physicians. Fractured neck of femur. Prevention and management. Summary and recommendations of a report of the Royal College of Physicians. *Journal of the Royal College of Physicians*, 1989, **23**:8–12.
6. Cooper C, Campion G, Melton LJ. Hip fractures in the elderly: a world-wide projection. *Osteoporosis International,* 1992, **2**:285–289.
7. Melton LJ III. Epidemiology of fractures. In: Riggs BL, Melton LJ III, eds. *Osteoporosis: etiology, diagnosis, and management*, 2nd ed. Philadelphia, Lippincott-Raven, 1995: 225–247.
8. Eastell R et al. Management of male osteoporosis: report of the UK Consensus Group. *Quarterly Journal of Medicine*, 1998, **91**:71–92.
9. Yan L et al. Epidemiological study of hip fracture in Shenyang, People's Republic of China. *Bone*, 1999, **24**:151–155.
10. Elffors L et al. The variable incidence of hip fracture in southern Europe: the MEDOS Study. *Osteoporosis International*, 1994, **4**:253–263.
11. Maggi S et al. Incidence of hip fracture in the elderly: a cross-national analysis. *Osteoporosis International*, 1991, **1**:232–241.
12. *Osteoporosis: clinical guidelines for prevention and treatment*. London, Royal College of Physicians, 1999.
13. Kannus P et al. Epidemiology of hip fractures. *Bone*, 1996, **18**(Suppl.1): 57S–63S.
14. Lau EM, Cooper C. The epidemiology of osteoporosis: the oriental perspective in a world context. *Clinical Orthopaedics and Related Research*, 1996, **323**:65–74.
15. Department of Health. *Nutrition and bone health: with particular reference to calcium and vitamin D. Report of the Subgroup on Bone Health, Working Group on the Nutritional Status of the Population of the Committee on Medical Aspects of Food and Nutrition Policy.* London, The Stationery Office, 1998 (Report on Health and Social Subjects, No. 49).
16. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. *Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride.* Washington, DC, National Academy Press, 1997.
17. NIH Consensus Development Panel on Optimal Calcium Intake. Optimal calcium intake. NIH Consensus Conference. *Journal of the American Medical Association*, 1994, **272**:1942–1948.
18. *Vitamin and mineral requirements in human nutrition. Report of the Joint FAO/WHO Expert Consultation.* Geneva, World Health Organization, (in press).