Can exercise prevent postmenopausal osteoporosis?

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There has recently been increased interest in the prevention, treatment and rehabilitation of osteoporosis. Being predominantly a problem of the elderly, it is likely to grow out of proportion in the near future – in 1950 our planet housed 200 000 000 individuals aged over 65 years; in the year 2025 it will be inhabited by 1 100 000 000 people of that age range¹. The goal must therefore be effective prevention of osteoporosis; exercise is a possible option with certain clear advantages, such as low cost and freedom from negative side effects, but it is an option that is sometimes neglected².

Inactivity, peak bone mass

Physical inactivity is one of the recognized risk factors for osteoporosis; the doubling of rates of hip fracture in the past 30 years is thought to be partly caused by the drastic decrease of habitual activity³. Experimental findings support the hypothesis. Disuse, immobilization, denervation paralysis or prolonged space flight are all associated with marked bone loss^{4–16}. Most notably, bed rest leads to a rapid and severe demineralization with a reduction in bone mass of about 1% per week. Much evidence shows that exercise can prevent osteoporosis and hip fractures. Physically active individuals have higher bone densities than do age-matched controls, as shown in cross-sectional studies²⁰. Peak bone mass is usually attained around menopause, and is substantially higher in trained compared with untrained individuals^{21–26}. Similarly, prospective trials demonstrate that pre-menopausal women can train to reach a higher peak bone mass²⁷. A recent study on a sizeable ($n=352$) population of perimenopausal activity revealed a clear positive correlation between exercise and bone density²⁸. Bone mineral content can be significantly increased by regular exercise in middle-aged²⁹ and elderly women³⁰. Among other possible benefits, exercise reverses postmenopausal bone loss and reduces the risk of injury from falling³¹. A meta-analysis of six trials showed that exercise reduces the incidence of hip fracture by about 50%³.

Intensity of exercise

Prescribing exercise to individuals at risk is, therefore, appropriate and may allow a reduction in

medication and thus avoidance of the side effects of drug treatments.

Mild exercise probably gives no protection. Walking 7 miles (11 km) per week³², daily extension exercises³³, or aerobics^{34,35} do *not* increase bone mineral content in a clinically relevant way. More intense training, however, does seem to work^{36,37} – running or playing ball games twice a week for 1 h results in an increase of 3.5% in bone mineral content after 8 months³⁸. Vigorous exercise such as jogging, rowing and stair climbing is followed by a 5.2% increase in lumbar bone mineral content after 9 months³⁷. If continued for 4 years, such an intensive programme will totally reverse the involutionary bone loss after menopause³⁸.

Forms of exercise

Weight-bearing exercises appear to yield the most bone gain^{3,29,33,39}. Load-bearing is one primary function of the skeleton, and bone can adapt to changes in functional load by increasing its density and resistance.

Pure (intensive) aerobic training may well have an effect^{39–41}, but poor compliance is a problem of clinical exercise trials³⁵ and can reduce the benefit. Weight-bearing and aerobic exercises, with emphasis on the playful element, are most likely to encourage compliance and produce a clinically beneficial effect⁴¹. More studies are required to define the optimal programme more closely.

Mechanisms

The mechanisms by which exercise can induce a response are unclear. The response of the bone is clearly to the strain that is applied, and so local mechanisms may be postulated. Mechanical stress might generate an electric signal⁴² creating alkaline conditions locally, which in turn favour new bone generation⁴³. An involvement of prostaglandins⁴⁴ or effects on vitamin D metabolism⁴⁵ might also play an important role.

Therapy

Preliminary studies suggest that regular exercise could be used as a treatment in patients whose bone mass is already reduced. One study showed that intense loading exercises for 50 min three times a week for 5 months were followed by a 3.8% increase in bone mineral content, which is clinically relevant compared with the 2% loss in control individuals over the same time⁴⁶. Another trial demonstrated

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that low-impact aerobic exercise did not prevent the age-related bone loss³⁵, but the compliance in this programme was very poor.

Discussion

Regular exercise has a place in the prevention and, possibly, in the treatment of postmenopausal osteoporosis. Further studies are needed to identify optimal exercise regimens and define more closely the mechanisms by which exercise operates.

There are many other beneficial effects of exercise⁴⁷, and we should advise our patients accordingly.

References

- Kane WJ. Osteoporosis, osteomalacia, and Paget's disease. In: Frymoyer JW, ed. *The Adult Spine*. New York, USA: Raven, 1991: 648.
- Smith R. Osteoporosis after 60. *Br Med J* 1990; **301**: 452-3.
- Law MR, Wald NJ, Meade TW. Strategies for prevention of osteoporosis and hip fractures. *Br Med J* 1991; **303**: 453-9.
- Albright F, Burnett CH, Cope O, Parson W. Acute atrophy of bone (osteoporosis) simulating hyperparathyroidism. *J Clin Endocrinol Metab* 1941; **34**: 711-6.
- Whedon GD, Shen E. Metabolic studies in paralytic acute anterior poliomyelitis. II. Alterations in calcium phosphorus metabolism. *J Clin Invest* 1957; **36**: 966-81.
- Issekutz B, Blizzard JJ, Burkhead NC, Rodahl K. Effect of prolonged bed rest on urinary calcium output. *J Appl Physiol* 1966; **21**: 1013-20.
- Geiser M, Trueta J. Muscle action, bone rarefaction, bone formation. *J Bone Joint Surg [Br]* 1958; **40-B**: 282-311.
- Howard JW, Parson W, Bigman RS. Studies on patients convalescent from fracture. 3. The urinary excretion of calcium phosphorus. *Bull Johns Hopkins Hosp* 1945; **77**: 291-313.
- Deitrick JE, Whedon GD, Sherr E. Effects of immobilization upon various metabolic physiologic functions of normal men. *Am J Med* 1948; **47**: 3-36.
- Minaire P, Meunier PJ, Edouard C, Bernard J, Courpron P, Pournet J. Quantitative histological data on disuse osteoporosis. Comparison with biological data. *Calcif Tissue Res* 1974; **17**: 57-63.
- Nilsson BE. Post-traumatic osteopenia. A quantitative study of the bone mineral mass of the femur following fracture of the tibia in man using americium-241 as a photon source. *Acta Orthop Scand* 1966; **91**: 1-55.
- Westlin NE. Loss of bone after Colles' fracture. *Clin Orthop Rel Res* 1974; **20**: 194-9.
- Mazess RB, Wheadon GD. Immobilization and bone. *Calcif Tissue Int* 1983; **35**: 265-7.
- Young DR, Niklowitz WJ, Brown RJ, Jee WSS. Immobilization-associated osteoporosis in primates. *Bone* 1986; **7**: 109-17.
- Whedon GD, Lutwak L, Reid J et al. Mineral nitrogen metabolic studies on Skylab orbital space flights. *Trans Assoc Am Physicians* 1974; **87**: 95-110.
- Smith MC, Rambout PC, Vogel JM, Whittle M. Bone mineral measurement in experiment M078 in biomedical records from Skylab. *NASA Publication* 1977; 183-90.
- Rambout PC, Coode AW. Skeletal changes during space flight. *Lancet* 1985; **2**: 1050-2.
- Mack PB, LaChance PA, Vose GP, Vogt FB. Bone demineralization of foot and hand of Gemini-Titan IV, V, VII astronauts during orbital flight. *Am J Roentgenol* 1967; **100**: 503-11.
- Vogel JM. Bone mineral changes in the Apollo astronauts. In: Mazess RB, ed. *Proceedings of the International Conference on Bone Mineral Measurements*. Bethesda, USA: U.S. DHEW, 1973; 352-61.
- Dalen N, Olsson KE. Bone mineral content and physical activity. *Acta Orthop Scand* 1974; **45**: 170-4.
- Jones JJ, Priest JD, Hayes WC, Tichenar CC, Nagel DA. Humeral hypertrophy in response to exercise. *J Bone Joint Surg [Am]* 1977; **59-A**: 204-8.
- Nilsson BE, Westlin NE. Bone density in athletes. *Clin Orthop* 1971; **77**: 179-82.
- Huddleston AL, Rockwell D, Kulund DN, Harrison RB. Bone mass in lifetime tennis athletes. *JAMA* 1980; **244**: 1107-9.
- Aloia JF, Cohn SH, Babu T, Abesamis C, Kalice N, Ellis K. Skeletal mass body composition in marathon runners. *Metabolism* 1978; **27**: 104-7.
- Lane NE, Bloch DA, Jones HH, Marshall WH Jr, Wood PD, Fries JF. Long-distance running, bone density osteoarthritis. *JAMA* 1986; **255**: 1147-51.
- Montoye HJU, Smith EL, Ferdon DF, Hawley ET. Bone mineral in senior tennis players. *Sci J Sports Sci* 1980; **2**: 26-32.
- Gleeson PB, Broptas E, LeBlanc A, Schneider VS, Evans HJ. Effects of weight lifting on bone mineral density in premenopausal women. *J Bone Miner Res* 1990; **5**: 153-8.
- Zhang J, Feldblum PJ, Fortney JA. Moderate physical activity and bone density among perimenstrual women. *Am J Public Health* 1992; **82**: 736-8.
- Chow A, Harrison JE, Notarius C. Effect of two randomized exercise programs on mass of healthy postmenopausal women. *Br Med J* 1987; **295**: 1441-4.
- Smith E, Reddan W, Smith P. Physical activity and calcium modalities for bone mineral increase in aged women. *Med Sci Sports Exerc* 1981; **13**: 60-4.
- Fiataronc MA, Marks EC, Ryan ND, Meredith CN, Lipsitz LA, Evans WJ. High intensity strength training in nonagenarians: effects on skeletal muscle. *JAMA* 1990; **263**: 3029-34.
- Sandler R, Canley J, Hom D. The effects of walking on the cross-sectional dimensions of the radius in postmenopausal women. *Calcif Tissue Int* 1987; **41**: 65-9.
- Sinaki M, Wunker HW, Offord KT. Efficacy of non-loading exercises in prevention of vertebral bone loss in postmenopausal women: a controlled trial. *Mayo Clinic Proc* 1989; **64**: 762-9.
- White MK, Martin RB, Yeater RA, Butcher RL, Radin EL. The effects of exercise on the bones of postmenopausal women. *Int Orthop* 1984; **7**: 209-14.
- Prince RL, Smith M, Dick JM et al. Prevention of postmenopausal osteoporosis. A comparative study of exercise, calcium supplementation, and hormone-replacement therapy. *N Engl J Med* 1991; **325**: 1189-95.
- Aloia JF, Cohn SH, Ostuni JA, Canc R, Ellisk. Prevention of involuntary bone loss by exercise. *Ann Intern Med* 1978; **9**: 356-8.
- Ayalon J, Simkin A, Leichter J, Raifmann S. Dynamic bone loading exercises for postmenopausal women. *Arch Phys Med Rehabil* 1987; **68**: 280-3.
- Krolner B, Toft B, Nielsen SP, Tondevold E. Physical exercise as prophylaxis against involuntary vertebral bone loss: a controlled study. *Clin Sci* 1983; **64**: 541-6.
- Dalsky GP, Stocke KS, Ehsani AA. Weight bearing exercise and lumbar bone mineral content in postmenopausal women. *Ann Intern Med* 1988; **108**: 824-8.
- Smith EL, Gilligan C, McAdam M, Ensign CP, Smith PE. Deferring bone loss by exercise intervention in premenopausal and post-menopausal women. *Calcif Tissue Int* 1989; **44**: 312-21.
- Preisinger E, Alacamlıoglu Y, Schneider B, Bosina E, Heytmanek G, Metka M. Does regular exercise prevent bone loss? *Eur J Phys Med Rehabil* 1991; **1**: 70-3.
- Eriksson C. Streaming potentials and other water-dependent effects in mineralized tissues. *Ann N Y Acad Sci* 1974; **238**: 321-38.
- Patt GH. The influence of pH on growth of bone in tissue culture. *Proc Soc Exp Biol Med* 1948; **68**: 288-93.
- Bindema I, Somejen D, Shimshan Z, Harell A. Role of prostaglandins in bone remodelling induced by physical forces. In: Menciael J, Robin GC, Makin M, Steinberg R, eds. *Osteoporosis*. Chichester, UK: John Wiley, 1982: 192-9.
- Bell NH, Godsen RN, Henry DP, Shary J, Epstein S. The effects of muscle-building exercise on vitamin D mineral metabolism. *J Bone Miner Res* 1988; **3**: 369-73.
- Simkin A, Ayalon J, Leichter J. Increased tubular bone density due to bone-loading exercises in postmenopausal women. *Calcif Tissue Int* 1987; **40**: 59-63.
- Ernst E. How exercise prolongs life. *Eur J Phys Med Rehabil* 1991; **1**: 79-81.