

Exercise interventions: defusing the world's osteoporosis time bomb

Kai Ming Chan,¹ Mary Anderson,² & Edith M.C. Lau³

Abstract Osteoporosis is a major public health problem, affecting millions of people worldwide. The associated health care costs are growing in parallel with increases in elderly populations, and it is expected that the number of osteoporotic fractures will double over the next 50 years. The best way to address osteoporosis is prevention. Some interventions to maximize and preserve bone mass have multiple health benefits and are cost-effective. For example, modifications to diet and lifestyle can help to prevent osteoporosis, and could potentially lead to a significant decrease in fracture rates; and exercise is a valuable adjunct to programmes aimed at alleviating the risks and symptoms of osteoporosis. Practising exercise at a young age helps maximize the mineral density of bones while they are still growing and maturing, and continuing to exercise minimizes bone loss later in life. Not only does exercise improve bone health, it also increases muscle strength, coordination, balance, flexibility and leads to better overall health. Walking, aerobic exercise, and t'ai chi are the best forms of exercise to stimulate bone formation and strengthen the muscles that help support bones. Encouraging physical activity at all ages is therefore a top priority to prevent osteoporosis.

Keywords Osteoporosis/prevention and control; Fractures/prévention et contrôle; Exercise; Bone density/physiology (*source: MeSH, NLM*).

Mots clés Ostéoporose/prévention et contrôle; Fracture/prévention et contrôle; Exercice physique ; Densité osseuse/physiologie (*source: MeSH, INSERM*).

Palabras clave Osteoporosis/prevención y control; Fracturas/prevención y control; Ejercicio; Densidad ósea/fisiología (*fuelle: DeCS, BIREME*).

الكلمات المفتاحية: تخلخل العظام، الوقاية من تخلخل العظام ومكافحته؛ الكسور، الوقاية من الكسور ومكافحتها؛ الرياضة البدنية؛ كثافة العظام، فريولوجيا كثافة العظام. (المصدر: رؤوس الموضوعات الطبية، المكتب الإقليمي لشرق المتوسط).

Bulletin of the World Health Organization 2003;81:827-830

Voir page 829 le résumé en français. En la página 829 figura un resumen en español.

يمكن الاطلاع على الملخص بالعربية في صفحة ٨٢٩

Introduction

The world's osteoporosis "time bomb" is ticking, with the projected global burden of osteoporotic hip fractures expected to exceed six million by 2050 (1). Since 1990 there has been an almost fourfold increase in such fractures, with Asia set to suffer the most dramatic future increase mainly due to the projected large increase in its aged population. However, Europe and Latin and North America will not escape this fate, and now is the time for health authorities around the world to wake up and defuse the bomb by implementing osteoporosis programmes targeted at high-risk individuals.

A WHO Study Group has defined osteoporosis as "a disease characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk" (2). Osteoporosis currently affects more than 75 million people in Europe, Japan and the USA alone, with an estimated lifetime risk for wrist, hip and vertebral fractures of around 15%, very similar to that of coronary heart disease. It is well documented that the groups outlined below are at high risk of fragility fractures:

- Individuals with a previous fragility fracture.
- Individuals on prolonged corticosteroid treatment.
- Women who have undergone a hysterectomy or who have experienced premature menopause.
- Individuals with risk factors such as liver or thyroid disease.
- Individuals with a body mass index <19 kg/m².
- Smokers.
- Individuals with a history of falling.

Health authorities therefore need to develop effective strategies for the prevention of fragility fractures in such high-risk individuals.

The economic burden of osteoporosis is comparable to that of other major chronic diseases; for example, in the USA the costs associated with osteoporosis-related fractures are equivalent to those of cardiovascular disease and asthma (3–5). It has been reported that osteoporosis results in more hospital bed-days than stroke, myocardial infarction or breast cancer (6). In some countries a woman's risk of dying from hip fracture is comparable to that of her risk of dying from breast cancer (7).

Because osteoporosis also causes back pain and loss of height, prevention of the disease and of its associated fractures

¹ Chair Professor and Chief of Service, Department of Orthopaedics and Traumatology, The Chinese University of Hong Kong, Prince of Wales Hospital, Hong Kong SAR, China (email: kaimingchan@cuhk.edu.hk). Correspondence should be sent to this author.

² Board Member, International Osteoporosis Foundation; and Bone and Joint Decade International Steering Committee Member, Lyon, France.

³ Associate Professor, Department of Community and Family Medicine, School of Public Health, The Chinese University of Hong Kong, Prince of Wales Hospital, Hong Kong SAR, China.

Ref. No. 03-002154

are essential for maintaining the health, quality of life and independence of the elderly population.

Validated diagnostic tools are available to measure bone mineral density (BMD), making possible the early detection of osteoporosis prior to fracture. Measuring BMD to predict fracture tendency is comparable to measuring blood pressure to predict stroke and substantially better than measuring serum cholesterol to predict cardiovascular disease (8). Dual energy X-ray absorptiometry (DXA) at the hip and lumbar spine is the gold standard for BMD measurement. However, measurements using less costly technologies, such as peripheral DXA and ultrasound at sites such as the radius and heel, can also be employed.

Since many vertebral fractures do not come to clinical attention, radiographic diagnosis is considered to be the best way to identify and confirm their presence (9), while their severity can be determined visually from radiographs using semiquantitative grading criteria (10).

Physical exercise for prevention of osteoporosis

Policy-makers and health professionals need to consider the economic and public health implications of osteoporosis and identify efficient prevention and management methods to reduce the increasing burden of the condition on already stressed health care systems. Despite the existence of medical interventions for osteoporosis, physical activity is highly recommended as the first step in its prevention. The preventive value of physical exercise lies not only in its potential to reduce bone loss and improve muscle strength, but also in its profound benefits on preventing falls and reducing bone fractures. Bones, like muscles, respond to stress by becoming bigger and stronger. Regular physical exercise places physical stress on the body, helps stimulate bone growth and preserve bone mass, and provides excellent general health benefits, the foremost being an increase in BMD (11–13). Therefore, for osteoporosis, the main goals of physical activity should focus on preventing falls by improving individuals' general health, balance, muscle strength, posture and postural stability.

Simple exercises such as walking can help strengthen bones and muscles. There is strong evidence that physical activity begun early in life contributes to higher peak bone mass. Peak bone mass and subsequent bone mineral maintenance are largely affected by the interplay between mechanical stress, body composition, nutrition and bone metabolism. Activities such as resistance training and weight-bearing exercises are likely to be more beneficial as they help to build bones and preserve bone mass. Examples include weight-lifting, hiking, stair-climbing, step aerobics, dancing, and other activities that require muscles to work against gravity without putting too much stress on bones and joints. In addition to increasing bone density, regular exercise has the added benefits of enhancing coordination and strengthening muscles, both of which serve to reduce the risk of falling.

Recent evidence indicates that some forms of physical activity may maintain or even increase BMD in selected populations (11–17). In this respect, much research has been performed on postmenopausal women, who are often at a high risk of developing osteoporosis due to accelerated bone loss caused by estrogen deficiency following menopause. Physical activity, in particular programmed weight-bearing exercises, may protect postmenopausal women against rapid decline in bone mass.

Recent research has demonstrated the positive health benefits of such exercises for Chinese postmenopausal women with a substantial decrease in BMD loss in the distal radius and tibial regions (18). Even though current data on the role of physical activity in preventing osteoporosis are inconclusive, it is generally agreed that regular practice of some forms of high-impact and weight-bearing exercise could improve muscle strength and aid in the prevention and treatment of osteoporosis.

Exercise for osteoporosis-related falls and hip fractures

Falls are a major risk factor for osteoporotic fractures — the most frequent causes of morbidity and mortality arising from the condition. Because of their weaker and fragile bones, people with osteoporosis are always at greater risk of injuring themselves when they fall. Falls increase their risk of fracturing bones in the hip, wrist, spine and other parts of the body and can have a dramatic effect on their quality of life. As such, preventing falls becomes a special concern for individuals with osteoporosis. Although there is no evidence that exercise prevents fracture, randomized clinical trials have shown that regular exercise can reduce the risk of falls by approximately 25% (19). Weight-bearing exercises that can increase bone strength and improve balance are particularly beneficial for those who are more prone to falls. Exercise regimens such as tai chi are proving useful as both a preventive and a complementary therapy for osteoporosis and its associated injuries. T'ai chi's focus on posture and low velocity movement of the body helps reduce loading on the joints of the lower limbs, particularly both the knees and ankles, which are often sites of tissue and cartilage degeneration. The gentle and slow body movements practised in this form of exercise also help to relax muscles, strengthen bones, train endurance, improve balance, flexibility and coordination, thus lessening susceptibility to falls. Weight-bearing exercises such as t'ai chi can increase muscle strength, improve balance, posture stability and body flexibility. Wolf et al. have reported that its regular practice can reduce the risk of multiple falls by 47.5% in elderly persons, and that it reduced responses associated with fear of falling and intrusiveness (20).

Recent prospective studies conducted in Denmark have shown that maintenance of leisure physical activity at a moderate level appears to provide protection against hip fracture in later life, and that decline in physical activity is associated with greater risk of hip fracture. Regular, moderate physical activity can help improve balance, strength, and coordination, thereby reducing the risk of falls and resulting injuries. It should therefore be an integral and effective part of strategies designed to reduce the incidence of osteoporotic hip fractures.

Call to action

Physical activity is vital for maintaining healthy bones throughout life and is an important factor in preventing osteoporosis, reducing falls, and decreasing the risk of hip fractures. The alarming increase in prevalence of osteoporosis apparently expresses a pressing need for a more active lifestyle among people of all ages. The key benefits of regular physical activity have been well proven — the challenge to policy-makers and health professionals is to determine how to promote it among the general population. National and local policies should be developed

and campaigns devised to improve public awareness of the need for active living, accompanied by well-conceived programmes to make physical activity easier and more rewarding. The best way we can help defuse the world's osteoporosis time bomb and

prevent unnecessary suffering and mounting health care costs is by taking action now. ■

Conflicts of interest: none declared.

Résumé

Le rôle de l'exercice dans la lutte contre l'ostéoporose ou comment désamorcer une bombe à retardement

L'ostéoporose constitue un problème de santé publique majeur qui touche des millions de gens dans le monde. L'augmentation des coûts des soins de santé qui lui sont associés va de pair avec l'augmentation du nombre des personnes âgées, et on s'attend que le nombre des fractures ostéoporotiques double au cours des 50 prochaines années. La meilleure attaque contre l'ostéoporose est la prévention. Certaines mesures visant à augmenter ou à préserver la masse osseuse offrent de multiples avantages sur le plan de la santé et sont d'un bon rapport coût/efficacité. Ainsi, des changements dans le régime alimentaire et le mode de vie peuvent contribuer à prévenir l'ostéoporose, et pourraient éventuellement diminuer de manière sensible le taux de fractures ; l'exercice, par ailleurs, est un complément précieux

aux programmes visant à réduire les risques et les symptômes d'ostéoporose. L'exercice physique pratiqué dès le plus jeune âge contribue à augmenter la densité minérale osseuse de l'enfant en pleine croissance, et sa poursuite réduit la perte osseuse à l'âge adulte. L'exercice non seulement améliore la santé des os, mais il renforce également les muscles, la coordination, l'équilibre, la souplesse et permet d'avoir dans l'ensemble une meilleure santé. La marche, l'aérobic, le tai-chi sont tout particulièrement indiqués pour stimuler la formation osseuse et renforcer les muscles de soutien. Encourager l'exercice physique à tous âges est donc une priorité absolue pour prévenir l'ostéoporose.

Resumen

El ejercicio como medio de desactivación de la bomba de relojería mundial que es la osteoporosis

La osteoporosis constituye un importante problema de salud pública que afecta a millones de personas en todo el mundo. Sus costos sanitarios están aumentando conforme crece la población de edad avanzada, y se prevé que el número de fracturas osteoporóticas se duplique a lo largo de los próximos 50 años. La mejor forma de abordar el problema de la osteoporosis es la prevención. Algunas intervenciones destinadas a incrementar y conservar la masa ósea reportan múltiples beneficios para la salud y son rentables. Por ejemplo, las modificaciones de la dieta y del estilo de vida pueden ayudar a prevenir la osteoporosis, y podrían dar lugar a una importante reducción de las tasas de fracturas; el ejercicio es un valioso complemento de los programas

destinados a reducir el riesgo y aliviar los síntomas de la osteoporosis. La realización de ejercicio durante la juventud ayuda a aumentar la densidad mineral ósea mientras los huesos todavía están creciendo y madurando, y su continuación reduce la pérdida ósea en fases posteriores de la vida. Además de mejorar la salud ósea, el ejercicio fortalece los músculos, la coordinación, el equilibrio y la flexibilidad, y mejora la salud en general. El caminar, el ejercicio aeróbico y el taichi son las mejores formas de ejercicio para estimular la formación ósea y fortalecer los músculos que ayudan a sostener los huesos. Por consiguiente, el fomento de la actividad física a todas las edades constituye una prioridad absoluta para prevenir la osteoporosis.

ملخص

الرياضة البدنية هي الأمل في تعطيل القنبلة الموقوتة لتخلخل العظام في العالم

تخفيف مخاطر وأعراض تخلخل العظام . وتساعد ممارسة الرياضة في الصغر على بلوغ المستوى الأمثل لكثافة المعادن في العظام في مرحلة نمو ونضج العظام، كما أن استمرار ممارسة الرياضة يجد من فقدان العظام للمعادن في مراحل الحياة التالية. فممارسة الرياضة تحسّن صحة العظام وتزيد من قوة العضلات وتتناسقها وتوازنها ومرونتها، وتحسّن أيضاً الحالة الصحية العامة. ويُعتبر المشي وممارسة رياضة اعرابة في الهواء الطلق وممارسة التاي تشي (التي تشمل الحركة البطيئة للعضلات) أفضل أشكال التدرجات التي تنشيط عمليات تكوّن العظام وتقوي العضلات الداعمة للعظام. ومن ثمّ يُعتبر تشجيع النشاط البدني في جميع الأعمار من أهم العوامل التي تقي من تخلخل العظام.

الهدف: يُعدّ تخلخل العظام أحد مشكلات الصحة العمومية الرئيسية التي تؤثر في ملايين من الناس في جميع بلدان العالم. وتزداد التكاليف التي تتكبدها نُظُم الرعاية الصحية بسبب تخلخل العظام مع تزايد عدد المسنين. ومن المتوقع أن يتضاعف عدد حالات الكسور الناجمة عن تخلخل العظام خلال السنوات الخمسين القادمة. وتُعدّ الوقاية أفضل وسيلة لمعالجة تخلخل العظام. وقد ثبت أن بعض التدخلات التي تستهدف زيادة كتلة العظام وحفظها لها فوائد صحية متعدّدة ومردودية عالية. فعلى سبيل المثال، قد يؤدي تغيير النظام الغذائي ونمط الحياة إلى الوقاية من تخلخل العظام، وإلى خفض ملامس في معدلات الكسر؛ كما تمثّل ممارسة الرياضة البدنية جزءاً قيماً مكملاً للبرامج التي تستهدف

References

1. Cooper C, Campion G, Melton LJ III. Hip fractures in the elderly: a worldwide projection. *Osteoporosis International* 1992;2:285-9.
2. *Assessment of fracture risk and its application to screening for postmenopausal osteoporosis: report of a World Health Organization Study Group*. Geneva: World Health Organization; 1994. WHO Technical Report Series No. 843.
3. *Osteoporosis fast facts*. Washington (DC): National Osteoporosis Foundation. Available from: URL: <http://www.nof.org/osteoporosis/stats.html> .
4. *Economic cost of cardiovascular diseases*. Dallas (TX): American Heart Association. Available from: URL: <http://www.americanheart.org/statistics/10econom.html> .
5. National Heart, Lung and Blood Institute. *Data fact sheet: asthma statistics*. Washington (DC): US Department of Health and Human Services.
6. Lippuner K, von Overbeck, Perrelet R, Bosshard H, Jaeger P. Incidence and direct medical costs of hospitalisations due to osteoporotic fractures in Switzerland. *Osteoporosis International* 1997;7:414-25.
7. Cummings SR, Black DM, Rubin SM. Lifetime risks of hip, Colles's or vertebral fracture and coronary heart disease among white postmenopausal women. *Archives of Internal Medicine* 1989;149:2445-8.
8. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* 1996 312:1254-9.
9. Genant HK, Li J, Wu CY, Shepherd JA. Vertebral fractures in osteoporosis: a new method for clinical assessment. *Journal of Clinical Densitometry* 2000;3:281-90.
10. Genant HK, Wu CY, van Kujik C, Nevitt MC. Vertebral fracture assessment using a semiquantitative technique. *Journal of Bone and Mineral Research* 1993;8:1137-48.
11. Dalsky GP, Stocke KS, Ehsani AA, Slatopolsky E, Lee WC, Birge SJ Jr. Weight-bearing exercise training and lumbar bone mineral content in post-menopausal women. *Annals of Internal Medicine* 1988;108:824-8.
12. Lau EMC, Woo J, Leung PC, Swaminathan R, Leung D. The effect of calcium supplementation and exercise on bone density in elderly Chinese women. *Osteoporosis International* 1992;2:168-73.
13. Marcus R, Drinkwater B, Dalsky G, Dufek J, Raab D, Slemenda C, et al. Osteoporosis and exercise in women. *Medicine and Science in Sports and Exercise* 1992;24(6 Suppl):S301-7
14. Virvidakis K, Georgiou E, Korkotsidis A, Ntalles K, Proukakis C. Bone mineral content of junior elite competitive weightlifters. *International Journal of Sports Medicine* 1990;11:244-6.
15. Taaffe DR, Robinson TL, Snow CM, Marcus R. High-impact exercise promotes bone gain in well-trained female athletes. *Journal of Bone and Mineral Research* 1997;12:255-60.
16. Bass S, Pearce G, Bradney M, Hendrich E, Delmas PD, Hanrind A, et al. Exercise before puberty may confer residual benefits in bone density in adulthood: studies in active prepubertal and retired female gymnasts. *Journal of Bone and Mineral Research* 1998;13:500-7.
17. Etherington J, Harris PA, Nandra D, Hart DJ, Wolman RL, Doyle DV. The effect of weight-bearing exercise on bone mineral density: a study of female ex-elite athletes and the general population. *Journal of Bone and Mineral Research* 1996;11:1333-8.
18. Qin L, Au SK, Choy YW, Leung PC, Neff M, KM Lee, et al. Regular Tai Chi exercise may retard bone loss in postmenopausal women: a case-control study. *Archives of Physical Medicine and Rehabilitation* 2002; 83:1355-9.
19. *NIH consensus development conference statement: osteoporosis prevention, diagnosis, and therapy, 27-29 March 2000*. Available from: URL: http://consensus.nih.gov/cons/111/111_intro.htm.
20. Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu TS, et al. Reducing frailty and falls in older person: an investigation of Tai Chi and computerized training. *Journal of the American Geriatrics Society* 1996;44:489-97.