Exercise and Osteoporosis Prevention

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Introduction

Osteoporosis is a skeletal disorder characterized by compromised bone strength, predisposing the patient to an increased fracture risk. Bone strength reflects the integration of two main features: bone density and bone quality. Bone density is expressed as grams of mineral per area or volume and, in any given individual, is determined by peak bone mass and amount of bone loss. Bone quality refers to architecture, turnover, damage accumulation (eg, microfractures) and mineralization. Osteoporosis is a significant risk factor for fracture, and a distinction must be made between risk factors that affect bone metabolism and risk factors for fracture.[1]

Osteoporosis occurs in all populations and at all ages. More than 10 million Americans have osteoporosis but another 20 million or so are at risk for osteoporosis because they have low bone mass. Osteoporosis is four times more common in women than in men because of women's greater life expectancy and the hormonal changes that occur at menopause.[2] Though more prevalent in white postmenopausal females, osteoporosis often goes unrecognized in other populations.

Vertebral fractures are the most common fracture type caused by osteoporosis. The consequences of vertebral fracture include pain, disability, curvature of the spine, and loss of height. The risk of another vertebral fracture increases five-fold after the first. Wrist, hip and pelvic fractures also are common. Like vertebral fractures, the risk of another hip fracture increases almost three-fold after the first.[3]

Osteoporosis is, however, about more than broken bones; it is a chronic disease with a significant impact on physical, emotional and social well being. Women with a clinically diagnosed vertebral fracture have a 15% higher mortality rate than women without a diagnosed fracture.[4] Furthermore, women with one new vertebral fracture experience an additional 10 days per year of limited activity. Women with two or more new vertebral fractures experience five additional days of bed rest, and more than 30 additional days of limited activity have been reported. This is similar to the estimated increase in annual days of limited activity for patients with diabetes (15 days), ischemic heart disease (15 days), and arthritis (7 days).[5]

The Women's Health Initiative (WHI) study, published in July 2002, has impacted the treatment and prevention of osteoporosis. This article reviews the traditional approach to osteoporosis prevention and sets forth a more recent perspective on its prevention.

The Women's Health Initiative Study

The WHI,[6] which was conducted under the auspices of the National Heart, Lung and Blood Institute of the National Institutes of Health, focused on defining the risks and benefits of treatment strategies that could potentially reduce the incidence of heart disease, breast and colorectal cancer, and fractures in postmenopausal women. Between 1993 and 1998, the WHI enrolled 161,809 postmenopausal women (ages 50 to 79 years) into a set of clinical trials (low-fat dietary pattern, calcium and vitamin D supplementation, and two trials of postmenopausal hormone use) and an observational study at 40 clinical centers in the United States. The initial report described principal results for the trial of combined estrogen and progestin use in women with a uterus. That trial was stopped early based on the finding of increased breast cancer risk, supported by evidence of health risks that exceeded health benefits over an average follow-up of 5.2 years. A parallel trial of estrogen alone in women who have had a hysterectomy is being continued, and the planned end of this trial is March 2005, by which time the average follow-up will be about 8.5 years.

What have we learned from the WHI?

WHI investigators found small but significant increases in health risk. For every 10,000 postmenopausal women with a uterus who are taking estrogen plus progestin in any year, eight more will develop invasive breast cancer, seven more will have a heart attack, eight more will have a stroke, and 18 more will have blood clots (including eight with blood clots in the lungs) than a similar group of 10,000 women not taking these hormones. The risk to any single woman is not large, but the overall risk is significant. The initial results of WHI have become considerably more refined with the publication of additional papers from the WHI database. WHI investigators found that hormone therapy (HT) increased bone mineral density (BMD) and reduced the risk of fracture in healthy postmenopausal women in all subgroups of women examined. However, additional published data derived from

(continued on page 23)

(continued from page 20)

the WHI database indicate the following about HT.

- It does not offer significant quality-of-life benefits.[7]
- It increases the risk of stroke.[8]
- It does not improve cognitive function in women age 65 and older.[9]
- It increases the risk of probable dementia in women age 65 and older.[10]
- It may stimulate breast cancer growth and hinder diagnosis by mammography.[11]
- It is not cardioprotective and may increase the risk of coronary heart disease among generally healthy postmenopausal women, especially in the first year of use.[12]
- It may increase the risk of ovarian cancer while producing endometrial cancer rates similar to those seen with placebo.[13]

The response to WHI. Guided by patient concern over the risks of HT (which nearly rose to a fevered pitch immediately after the publication of the initial WHI report) and the need to re-evaluate their treatment practices, physicians have modified their prescribing habits based on personal assessment of the original WHI data and ongoing publications from the WHI database, statements from the National Osteoporosis Foundation, The North American Menopause Society and others, and clinical experience.

HT use is generally limited to the management of vasomotor symptoms and sleep disruption related to menopause. Decisions on the length of therapy are made by assessing seriousness of symptoms, patient response to therapy, and patient reaction when treatment is tapered. Many practices have set the outside limit for HT at 5 years, based solely on average patient exposure in the original WHI publication. However, it is possible that the optimum time for HT exposure is more or less than 5 years. That determination will have to await the results of further study. Such trials are likely to be based on the experience of women whose vasomotor symptoms can be managed only by HT, and who elect to continue on long-term HT despite the risks they may encounter.

Until the WHI, women remained on HT long after vasomotor symptoms had subsided, primarily to prevent osteoporosis. However, the cautions now associated with HT have resulted in a mass movement away from HT as part of a program to prevent or manage osteoporosis. Currently, efforts to prevent and manage osteoporosis must be refocused on nutrition, exercise and nonhormonal drug therapies. The remainder of this article focuses on exercise.

Effects of Exercise

Regular physical activity has numerous health benefits for individuals of all ages. While the positive effect of exercise training in youth and young adulthood on peak bone mass has been demonstrated, the effects of exercise on BMD have also been documented in several populations of women and using several different exercise interventions.[14-17] In a recent meta-analysis[15] Wolff et al reported the results of random and nonrandom exercise training studies, and found that almost 1% of the bone loss per year could be reversed or prevented in pre- and postmenopausal women who trained. The approach in these studies has, in large part, been the use of high-impact activities such as jumping, strengthening activities such as weight lifting, or a combination of these methods. In the study by Kerr et al[14] less repetition and higher loads were effective in increasing BMD in postmenopausal women, and lighter loads with many repetitions were not as effective. Overall, results show that exercise helps prevent the loss of BMD and may even result in small gains depending on whether additional interventions (such as HT or calcium and vitamin D supplementation) are used and whether the intensity of the exercise is sufficient to stimulate the bone-building process.

Despite the modest effect of exercise on BMD, it is clear that exercise late in life, even beyond 90 years of age, can increase muscle mass and strength two-fold or more in frail individuals. There is convincing evidence that exercise in elderly persons also improves function and delays loss of independence and, thus, contributes to quality of life. Randomized clinical trials of exercise have been shown to reduce the risk of falls by approximately 25%, but there is no experimental evidence that exercise affects fracture rates. It also is possible that regular exercisers might fall differently and thereby reduce the risk of fracture due to falls.

Going, Lohman, Houtkooper and co-workers[18] studied the effects of exercise on BMD in a 12-month trial of multiple approaches to therapy in 320 early postmenopausal women. The Bone, Estrogen and Strength Training (BEST) study[18] included women who were taking HT for 1 to no more than 5.9 years, as well as women who had not used HT. Participants were randomized to exercise or no exercise. Women who used HT followed regimens prescribed by their primary care providers. Most women took oral estrogen (32%) or estrogen and progesterone (51%). Another 12% received transdermal estrogen or estrogen and progesterone. All participants received 800 mg /day of elemental calcium as calcium citrate. Total body and regional BMDs (g/cm^2) were measured by dual-energy X-ray absorptiometry. The details of the study's exercise program were published in "The BEST Book: The Prevention Of Osteoporosis With Exercise."[19] Photos of all recommended exercises and detailed instructions on the amount of weight to lift are included.

Exercise subjects trained three days per week (nonconsecutive days) in community facilities with supervision by study trainers who were trained in the study exercise protocol and who met

weekly with an investigator. Exercise sessions included stretching, balance and aerobic weight-bearing activity for warm-up, strength training, an additional weight-bearing circuit of moderate-impact activities (such as walking or jogging, skipping or hopping) and stair-climbing/step boxes with weighted vests.

The researchers concluded that regional BMD can be improved at clinically relevant sites in postmenopausal women who participate in aerobic, weight-bearing activity combined with weight-lifting. The response was significant at more sites in women who used HT, suggesting a greater benefit with HT and exercise compared to HT alone. The response was also greater, especially at the hip, for those who lifted more weight throughout the year.[20]

An important area that has not been adequately investigated is identifying the minimum intensity required for a given mode of exercise that will have a meaningful effect on bone. No dose-response studies have been undertaken to address this, but retrospective analysis of the amount of weight lifted during the course of the BEST study[18] suggests that there may be an optimal intensity that may vary depending on the exercise, presumably because the cortical and trabecular content of bones and their relative sensitivity to external stimuli vary. Another scarcely studied area is the long-term effect of exercise training on bone. To date, the longest resistance-training study using an intensity great enough to produce changes in bone at clinically relevant sites was 18 months in duration.[16] It is not known whether the response a woman experiences in the first 12 to 18 months of exercise will persist if the training is continued, or if the effect will plateau. There also is the possibility that some women may experience a delayed response to training. Because the duration of exercise-training trials has been relatively short, the pattern of response of BMD to long-term exercise training has been impossible to document. The BEST study is following women for 4 years, and preliminary findings indicate a long-term effect of exercise for these individuals who continue strength training.

Designing an Exercise Program

To obtain the full benefit available from training, four types of exercise should be included in any exercise program.

- Strength training exercises make older adults strong enough to do the things they need to do, as well as the things they like to do. In order to effect bone density, the training must progress to heavier weights, as outlined in *The BEST Book*.[19]
- Endurance activities increase heart rate and breathing for extended periods of time. They improve the health of the heart, lungs and circulatory system, and help prevent or delay some diseases.
- Balance exercises help prevent falls, a major cause of disability in older adults.
- Stretching helps keep the body limber and flexible.

It is important to emphasize that there is little overlap between the four types of exercise in that an intense focus on one area generally cannot compensate for the lack of training in another area. Therefore, a program including all four types of exercise will produce the best results. Although endurance activities have routinely been emphasized for the reduction of risk factors related to several diseases (eg., heart disease, diabetes and obesity), strength training, balance and flexibility should play equally important roles, especially for the osteopenic or osteoporotic patient.

A considerable body of evidence exists supporting the health benefits of strength training, especially in older populations. There is a strong link between muscle weakness and the inability to perform activities of daily living. Strength training can increase muscular strength, muscle mass, postural stability and BMD, but also provides many people with positive psychological benefits, including increased confidence and feelings of well-being. When combined with balance training, strength training can play an important role in the prevention of falls.

The overload principle. Assuming that traditional principles of exercise programming apply to bone, a continual increase in training intensity will be required to achieve further increases in BMD. This is the overload principle, which states that adaptation will occur only when exercise intensities are greater than what is normally encountered; this applies to the development of all components of fitness. Given that many people adopt a routine program and do not adjust their routine to provide an increase in intensity (especially when working individually and without regular instruction), it is unclear whether a meaningful increase in BMD will occur. Clearly, the maintenance of such a program generally will not result in negative consequences, and many other health benefits will typically be realized. For increases in BMD, however, progressive increases in intensity and exercise variety may be particularly important.

Exercise guidelines. Specific guidelines for the prescription of exercise have been published by the American College of Sports Medicine.[21] Generally, guidelines for older populations[22] are not appreciably different from those for young adults. Also, the mere presence of disease, including osteoporosis, does not automatically preclude participation in exercise. Of course, the approach to the exercise program design in these individuals should be conservative at first and then augmented as tolerated. For the best results, an exercise professional with a degree in exercise physiology should be consulted to ensure proper form and technique for the exercises prescribed.

For the prevention of bone loss and falls that could lead to the loss of function, strength and balance training should be a major focus. For the development of strength, eight to 10 exercis-

es targeting the major muscle groups should be performed on two to three nonconsecutive days per week. Exercise intensity or the weight lifted should gradually be increased to an amount that can be lifted eight to 12 times (repetitions). For those who are more frail, 10 to 15 repetitions at a lighter weight can be used. For the greatest benefit, and after an appropriate period of introduction to strength training, the repetitions performed should be "repetitions to fatigue" (a weight that can be lifted only eight to 12 times before exhaustion). In a dose-response fashion, the overall amount of weight lifted will determine the degree of adaptation achieved up to a person's genetic limits. Therefore, especially for the improvement of BMD, multiple sets of the eight to 10 exercises should be performed, especially for exercises targeting the larger muscle groups. This can be done using a curcuit approach, in which each exercise is performed once in a specific order and is then repeated one or two more times. Another option is to perform each exercise twice in succession, separated by a 1-minute rest. Increases in intensity and/or the number of repetitions should be individualized, determined by the overall health of the patient and how well the exercise is tolerated.

A typical set of strength exercises is presented in Table 1. These can be perfomed using exercise machines or using free weights (dumbbells and barbells). Training with free weights requires more careful instruction and can be more challenging for a beginner; however, in addition to enhancing strength, modest improvements in balance may occur.

The two exercises from the BEST study that were associated with the greatest amount of change in bone were the squat and the military press.[18] For a well-rounded, overall strength program, the six exercises indicated in Table 1 should be performed along with the chest or bench press and abdominal crunches. For a program of 10 exercises, bicep and tricep exercises can be added. For the development of leg strength, leg extension and leg curl exercises can be performed in place of the squat or leg press. Also, because the squat is an exercise that is technically advanced, the leg press may be more appropriate for a beginner. For variety, exercises can be interchanged (as long as the three major areas of the body identified in Table 1 are included) and the intensity of workouts can be alternated with heavy, moderate and light days.

When performing each exercise, it is important to use slow and controlled movements and breathes throughout the entire motion (exhale when lifting, inhale when lowering). Also, most exercises are performed in an erect and stable position, while concentrating on the muscle group being worked. If two-thirds of the repetitions for the set cannot be performed, the weight is too heavy. If muscle soreness is severe or persists for more than 48 hours, the intensity should also be decreased.

Table 1.
Typical Set of Strength Exercises

Lower Body	Upper Body	Trunk
Leg Press*	Military Press*	Lat Pulldown*
Squat*	Chest or Bench Press	Back Extension*
Leg Extension	Bicep Curl	Abdominal Crunches
Leg Curl	Tricep Extension	Seated Row*

** The six BEST strength training exercises for the development of bone, as identified from the BEST Study.*[18]

Table 2.
Individualizing Treatment to Promote Compliance

Nutrition: Provide information regarding appropriate calcium and vitamin D supplements. Refer to a nutritionists to evaluate the diet for milk and milk products. Provide information about other good sources of these nutrients (eg., almonds, brazil nuts, carob, pistachio nuts and sesame seeds).[23]

Exercise: Ensure that proper exercise guidelines are followed and refer to a fitness professional. Provide information to help motivate patients to begin and stay on an exercise program. Such information is available from a variety of sources, including the National Institutes of Health,[24] The National Osteoporosis Foundation,[25] the American College of Sports Medicine,[21,22] and The BEST Book.[19]

Pharmacologic Therapy: There are no conclusive comparative studies of various classes of antiresorptive medications. Thus, individual preference, clinical experience, side effect profile or other considerations (such as formulary availability) may guide the choice of initial pharmacologic therapy. However, it is helpful that multiple drug classes are available, especially for the patient who may not respond to a single drug.

- Teriparatide is a unique new drug that should be prescribed as part of a broad treatment program. Since its use is limited to 24 months of treatment, it is likely that teriparatide will be restricted to patients whose BMD does not respond to antiresorptive therapy. Also, patients should be continued on antiresorptive therapy when the 24-month treatment period has been completed.

Balance training is another important component of fall prevention. While strength training aids in the ability to perform activities of daily living, a program comprised only of strengthening exercises will generally not improve balance sufficiently to prevent falls. In addition, fall prevention should also include an inspection of the home environment. The lack of handrails or nonslip strips (in the bathtub), the presence of unsecured rugs or other obstacles, and floors that are highly waxed or uneven all contribute to the risk of falling.

Promoting Compliance

A major challenge for doctors and patients is choosing an exercise program that will stand the test of time. Patients are more likely to stay with an exercise program if:

- they think they will benefit from it
- it includes activities they enjoy
- they feel they can do the activities correctly and safely
- they feel knowledgeable in adjusting their program to respond to the unique and changing demands of their lives
- they have regular access to the activities
- they can fit the activities into their regular daily schedule
- they feel that the activities don't impose financial or social costs they aren't willing to take on
- there are few negative consequences (such as injury, lost time or negative peer pressure)
- the advice of a qualified fitness professional is sought before an exercise program is begun.

Individualizing treatment is the key to compliance (Table 2) and compliance is often the key to success in any clinical endeavor.

Motivation tips. The benefits of an exercise program—as well as other healthy lifestyle interventions—can be reaped only if the individual adheres to the program and follows through with recommendations. The question is how to motivate patients to do what is best for them. Here are a few suggestions:

- Individualize treatment and follow-up programs.
- Assist patients in locating peer groups to create enthusiasm about participation in diet and exercse programs.
- Develop relationships with qualified fitness professionals (exercise physiologists and nutritionists) to whom you can refer your patients.
- Provide patient-directed materials, including a list of reliable internet sites.
- Serial BMD testing may be helpful in demonstrating individual progress for patients who are not following their treatment programs. ■

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(continued on page 28)