

**Vol 2, 2008 CEC ARTICLE: Special Medical Conditions Part 1**  
**(Osteoporosis) and Exercise**  
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This article is designed to give you the basic understanding for participants that may have special medical conditions. In the first of this series we will examine exercises and research for osteoporosis.

**OSTEOPOROSIS:**

A condition where the bones have low mass and strength. The deterioration of the integrity of the structure of the bone results in weak bones with a higher risk for fracture. Although it affects more women than men, men can have osteoporosis as well. There are 2 kinds of osteoporosis:

**Primary:** This occurs in the bone itself where the bone remodeling is disrupted. This usually occurs in women after menopause and men in their 60's and 70's.

**Secondary:** This results from the effects of other diseases, conditions, or medications like thyroid disease, hypogonadism, and the use of glucocorticoids.

Osteoporosis usually has no signs or symptoms. Over 34 million Americans have osteopenia, which can develop into osteoporosis. 8 million women and 2 million men have osteoporosis. 33% of the men over 75 years of age have osteoporosis. Over ½ the women and ¼ of the men in the US will have an osteoporosis-based fracture in their lives.

Bones act as a reservoir for calcium and make the frame of the body. It is continually adapting and changing based on its environment. The body has 2 main types of bone – cortical and trabecular. The cortical bone is the dense outer shell and the trabecular is the honeycomb interior that makes the bone strong and light and is where the bone marrow produces blood elements. The most common fractures are in the trabecular bone in the vertebrae, the forearm and hip. The bones break because the bone mass, bone mineral density and bone architecture are reduced.

The highest possible bone density can be obtained during growth because of the high levels of bone density. Bone mass and bone mineral density increase from infancy through adolescence into young adulthood. In the late 20's to early 30's a peak is reached and bone loss begins to occur. Peak bone density can be achieved by consuming adequate calcium, vitamin D, getting adequate physical exercise, not smoking and not consuming too much alcohol. If an inadequate amount of calcium is supplied during childhood the bones develop less bone tissue with thin trabeculae. With adequate vitamin D, a growing bone can have inadequate mineralization. Adequate intake of dietary calcium reduces bone loss in pre and postmenopausal women. Medical therapy is supplemented with calcium, vitamin D and physical activity.

Bone remodeling consists of 6 phases 1) inactive, 2) activation, 3) resorption, 4) reversal, 5) formation, and 6) mineralization. There are 2 types of bone cells involved: the osteoblasts (bone-forming) and osteoclasts (bone-removing) cells.

In phase 1 (INACTIVE), a thin layer of lining cells covers the surface of the bone. In this layer are osteocytes (osteoblasts that have stopped laying down new bone. The osteocytes monitor the amount of strain (bending) on the bone.

In phase 2 (ACTIVATION), the bone-remodeling unit activates and signals certain white blood cells to become osteoclasts. The lining and osteocytes move apart and allow the osteoclasts to come in and remove old bone.

In phase 3 (RESORPTION), the osteoclasts remove old and damaged bone tissue, which creates pits and divots in the bone. This phase can last 2-3 weeks in healthy adults. The old and damaged bone is dissolved and carried away by the blood to be used in other bone-forming sites or to adjust mineral levels in the blood.

In phase 4 (REVERSAL), the osteoclasts leave the pits and macrophage cells clean out the debris. They also deposit a high mineral-containing bone tissue as a cement to prevent more bone erosion. Osteoblasts then gather to begin bone formation.

In phase 5 (FORMATION), the osteoblasts deposit osteoid (a substance to form bones) in the pits. This process takes 2-3 months.

In phase 6 (MINERALIZATION), minerals are added to the osteoid. The osteoid are mineralized with hydroxyapatite crystals (made up of calcium and phosphorous) and make new bone. New layers of bone form until the pits are filled. Then the osteoblasts flatten into a lining and the bone becomes inactive.

The entire cycle takes about 3 months. About 40% of the trabecular and 10% of cortical bone is remodeled annually.

#### STATISTICS:

In postmenopause, the ovaries decrease the production of estrogen (a bone regulating hormone). There is usually a 2-5% loss in bone mineral density over a 10-year period after menopause. Bone loss rate is the highest 3-6 years after menopause. A woman may lose up to 20% of her peak bone mass density 5-7 years after menopause. Then the loss rates usually return to premenopausal levels. Factors that contribute to the loss are certain medications, smoking, heavy alcohol consumption and inactivity.

After menopause, estrogen levels remain low and an increase in bone remodeling occurs, but the pits are deeper and not completely filled which leads to the decrease in bone density and mass.

In the US adults over 50 experience more than 2 million osteoporosis fracture per year. 330,000 of those fractures are in the spine, 300,000 in the hip, and 400,000 in the wrist and 810,000 in other sites. The hip is the most common for women in there 70s and 80s.

The vertebrae in the spine compress over time and are more likely to fracture. Kyphosis/Dowager's hump can lead to acute and chronic pain and reduce activity and the ability to move.

A hip fracture can lead to disability, depression, loss of independence, loss of mobility and sometimes death. Only 33% of hip fracture patients regain normal independent living. Almost 30% are moved to nursing homes within a year of the fracture. 1 in 5 dies within a year of the fracture.

#### PREVENTION AND RISKS:

To prevent osteoporosis, a person needs to attain the highest possible level of peak bone mass by young adulthood. Diet, exercise and lifestyle (like not smoking and consuming too much alcohol) are key though young adulthood. To slow the deterioration of bone nutrition, participation in exercise, not smoking, not consuming alcohol excessively and appropriate medical therapies.

Bone density screening is useful for post menopausal women, premenopausal women who do not have a regular menstrual cycle, women with eating disorders, or women who are treated with steroids or anticonvulsants.

Other indications for bone density testing include:

- Maternal history of fracture
- Prolonged immobilization
- Renal failure
- Liver disease
- Excess thyroid hormone production or administration
- Malabsorption syndromes
- Height loss greater than 4 cm
- Weight loss greater than 5 kg
- Rheumatoid arthritis
- Osteopenia
- After organ transplants
- Glucocorticoid therapy or Cushing's syndrome
- Primary hyperthyroidism
- Premature menopause
- Amenorrhea

Other risk factors include:

- Small skeletal frame
- Caucasian or Asian
- Family history especially if the relative with osteoporosis was your mother
- Naturally or surgically postmenopausal without hormone replacement drugs

Taking high doses of cortisone-like drugs for more than 6 months  
History of low calcium intake  
Lack of weight bearing activities like jogging or weight lifting  
Smoking  
Drinking more than 3 alcoholic beverages per day  
Low body weight for height

#### EFFECTIVE EXERCISE STRATEGIES:

Lack of activity is a primary risk factor for bone loss and osteoporosis. Skeletal loading through muscle contraction and ground retraction forces create skeletal strain/deformation. Bones respond to strain with changes to the architecture, mass and density of the bone. Excessive strain leads to damage and fracture, while strains somewhat above what is normal lead to strengthening the bone. When strains are higher than normal for a period of time the bone density increases, if it remains the same bone density remain constant, and if it is lower than normal for a period of time bone density is lost. From observations we know the bone density comparisons of the following:

Active persons are higher than inactive  
Athletes are higher than non-athletes  
Weight lifters are higher than swimmers

The following is an interesting comparison of impact and load associated with different athletes and bone density.

Swimmers	Weight Supported	Low impact/low load
Runners	Weight Bearing	Moderate impact/low load
Basketball	Weight Bearing Impact	High impact/moderate load
Rowers	Weight supported	Low impact/High load
Power lifters/gymnasts	Impact greater than body	High impact/high load

Experimental training studies were performed to test the direct effect of physical activity on bone density and to assess how much and which type is necessary and safe for the majority of the population.

A study by Kerr was done on postmenopausal women comparing low rep (6-8) high load exercises with high rep (20) low load exercises. Each participant trained only one side of her body to use the control as the other side of her own body. The high load low rep exercises were effective at increasing the bone density, where the low load high rep was not.

The Bone Estrogen Strength Training (BEST) used 320 postmenopausal women some with and some without hormone therapy. These women exercised 3 times a week with aerobic, weight bearing, and weightlifting for a year. The women who lifted the most weight generally increased the most in bone density. Indications were that most participants who would continue their exercise would not lose the 1% of bone density per year that is typical in postmenopausal women. ½ of the group continued on the program for 4 more years and ½ stopped the program. Those that continued to lift maintained or

increased their bones density, while those that did not lost bone density. Again those that were lifting more weight saw better gains. With those that were exercising some took the recommended 800mg/day and those who took more than 800mg/day with their exercise. Calcium should not be consumed more than 500mg at a time. It is better to spread it out through the day. Again the group taking the higher doses of calcium with the weight lifting did better at increasing bone density than those that only took the recommended 800mg/day. Also those on hormone therapy did better than those that did not.

The challenge is to design an exercise program for osteoporosis prevention that is safe, enjoyable, and effective (strain magnitude, rate, and distribution). Therefore, we must look at specificity, overload, reversibility, initial values and diminishing returns.

### Specificity

The exercises must target the bone sites of interest because loading is a localized effect. Muscular contraction affects bone primarily in the area where the tendons attach. The force dissipates as it moves through the skeleton, so they are less effective at remote sites. (A leg press will not help shoulder and neck bone density)

### Overload

The load must be more than regular daily habitual activity creates. Small, progressive increases in load (strain magnitude, rate and distribution) must be greater than daily activities but not so great they cause injury.

### Reversibility

If the training stops the bone density increases will be lost. 2-3 times a week is required to stimulate bone development.

### Initial Values

Those with the lowest bone density have the greatest potential for gain from exercise.

### Diminishing Returns

Each person has a biological limit on how much training can help his or her bone density. Genetics, nutrition, lifestyle and history are also important and exercise cannot make up for these other factors.

Other program design consideration include how much bone loss has occurred, age, menopausal status, risk factors, curvatures of the spine and function of daily activities. If a person has lordosis (swayback) the gluteus maximus, hamstrings, lower abdominals and bilateral piriformis (part of deep 6 rotators) need to be strengthened and the hip flexors and low back stretched. If then have a flat back the quadriceps, hip adductors, hip flexors, and low back should be strengthened and the hamstrings and piriformis stretched. These protocols will help return the spine to its natural curve and help prevent injuries. We need to promote muscle balance. In a forward head posture the upper and lower trapezius and serratus, muscles need to be strengthened and the pectoralis minor needs to be stretched. The spine being out of alignment puts the person at a greater risk for spinal fractures.

Precautions for people with osteoporosis in the spine

Avoid exercises that flex the spine bending forward at the waist. (Crunches and curls  
Avoid pulling the neck forward  
Avoid exercises that have excessive lumbar hyperextension (dead lifts, roman chair, and low back machines.  
Avoid movements that put the person at risk of falling (step aerobics, quick directional changes)  
Avoid high-impact, jarring, jumping, or jogging activities.

#### THE “BEST” Program

The weight lifting exercises used were the Military press, seated leg press, lat-pull down, seated row, back extension, rotary torso, and weight march. The goal was to increase weightloads by 20% every 2 months for a year.

The workout consisted of a 3-5 min cardio warm-up, strength training 20 min. cardio weight bearing 15 min; small muscle exercises 5 min. and a cool down 2-5 min. The original workout was 1.5 hours, but 45 min routines have been shown to be as effective. There must be at least 2 sets of each of the exercises. The workout should be done 3 times per week on non-consecutive days. The aerobic exercise should be done at 60-80% of estimated maximal heart rate. 2 sets of 4-8 repetitions for each exercise. The load should be 70-80% of the 1 rep max. If a client can perform more reps in good form than the desired number of reps the weight needs to be increased. The small muscle group exercises can be performed at home. Alternate moderate/hard/moderate for the days during the week. Moderate days are 6-8 reps at 70% of 1 rep max, and heavy days 4-6 reps at 80% of 1 rep max. (Exception is the military press, which is done at a 4-rep max on heavy days). A 45-60 sec rest interval is used between sets since this is a high load lifting protocol.

**Note: The biggest problem was getting the women to push themselves to do what they were capable of not what they felt or thought they could do.**

The cardio activities included in the BEST program were:

- Walking with a weighted vest (except on heavy lifting days)
- Stepping up and off a step or box or stair climbing with a weighted vest (except on heavy lifting days)
- Uphill walking
- Walking on a treadmill with a weight vest and increased the weight at specific time intervals
- Walk/Jog Circuit for specific time intervals. The jog time starts at 1 min and walk 1 min. The jog increase by one minute every interval, but the walk stays at 1 min.

The balance and stretching exercises were incorporated for the low back, internal and external rotators of the shoulders, hip flexors, quads, hamstrings, IT band, piriformis, gastrocnemius, soleus, upper traps, scalenes of the neck, shoulder, biceps, pecs, upper back, sides and spine. Balancing on one foot and moving the other leg or bending the upper body at the waist was incorporated.

Small muscle group strengthening was done with a band and was mostly posture muscle. Straight-arm rotator pull out from chest high, arm lift up and out, bent elbow external rotator. With small dumbbells exercises for rear delt and low back, low and mid trap were added.

For the abdominals, all exercises were done on the floor with the head down on the ground and knees bent. Pelvic tilts, heel lifts with toes down, alternating low foot lifts, alternating high foot lifts, knees up reverse crunch, foot tap down with knees up, bicycles, and toe taps leaving knees up. This was to avoid pulling on the neck and compromising the spine.

#### APPLICATIONS TO WATER AEROBICS:

For the small muscle groups, aerobics, stretching and balance the translation is simple. We already have vertical Pilates exercises, stretching, small muscle group posture exercises, and balance work that satisfy what the protocol requires. For the aerobics sections shallow water with rebounding, water step, water running with or without equipment, and working against the current of a lazy river or current pool will meet the requirement. Deep-water aerobics is more difficult; they must travel with force and muscle activation, propulsion jacks and cross countries, and switching the direction of travel. Remember that athletic rowers had good bone density because of the force they exerted with the whole body in the row. They must push/pull and use the properties of the water to get the results for which they are looking. The strength-training component is the difficult component for water because of the type of equipment we have and getting participants to understand how hard they must push. Modified pull-ups on a starting block or diving board can help, but we can't regulate the weight. Doubling up 2 buoys in one hand for the 6-8 reps can help, but we will be limited by what they can hold comfortable in their hands. Military presses are impossible in the water, but rows can be done with bands on the railing around the pool. Leg presses can be done in hip deep water with huge propulsion jumps up. Although properly designed water aerobics can help maintain bone density and create overloads beyond daily activities additional equipment needs to be brought to the pool or a strength training regime suggested in order to see significant gains in bone density. However, for people with osteoporosis already the water is a safer place for them to perform many of the activities and not risk a fracture.

The BEST Exercise Program for Osteoporosis, 2 ed, Lohman et al. 2004

The osteoporosis handbook, 3ed., Bonnick, S. 2000.

Incidence and economic burden of osteoporosis-related fractures in the US, 2005-2025, J. Bone Miner Res 22(3):465-475, 2007.

National Osteoporosis Foundation. Report Vol 18 NO 1, 2002

A physician guide to prevention and treatment September 2007

Prevention: How can I prevent osteoporosis September 2007



8. T/F The prevention of osteoporosis is a lifelong goal that can be helped by nutrition, having a small skeleton, exercise and not smoking.

9. Peak bone density is reached by what approximate age?

10. Post menopausal bone density decreases how much over 10 years?

11. Name a nonmodifiable risk for osteoporosis.

12.T/F Osteopenia and osteoporosis are the same thing.

13. Which of the following risk factors can lead to osteoporosis in premenopausal women.

A eating disorders

B overexposure to sunlight

C having been on hormone replacement therapy for 10 years

D. running 3 times a week

14. General findings from exercise training studies suggest the protocol for osteoporosis should include.

A. Low load high reps

B. High load high reps

C. High load low reps

D. Low Load Low reps

15.Muscular contraction affects bone primarily

A. due to the amount of strain applied

B. in the region where the tendon attaches

C. in the region adjacent to where the tendon attaches

D. near the joints

16. List the six BEST strength-training exercises in the study

17. Describe the stretching and strengthening protocol for sway back.

18. Describe the stretching and strengthening protocol for flat back.

19. Describe the stretching and strengthening protocol for head forward.

20. List the abdominal exercises and say why they are performed the way they are.

21. List the muscles stretched in the stretching protocol.

22. List the small muscles worked at home for posture.

23. What is the biggest problem with women in the strength training and adaptive water training protocol?

24. How much calcium can be consumed at one time.

