



CLINICAL EXERCISE SPECIALIST MANUAL

A Fitness Professional's Guide
to Training People with
CHRONIC DISEASE

J. DANIEL MIKESKA DHSc

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**A FITNESS PROFESSIONAL'S GUIDE TO
EXERCISE AND CHRONIC DISEASE**

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CHAPTER 24

OSTEOPOROSIS

By the end of this chapter you will understand:

- Statistics
- Mechanics of bone formation
- Factors that affect bone density
- The female triad
- Diagnostic criteria/presentation
- Treatment options
 - Nutrition
 - Pharmacological
 - Exercise
- Preventive measures
- Exercise guidelines—FITT
- Contraindicated movements

Background

Osteoporosis is the most common bone disease in humans and is considered a major public health problem (Sozen, Ozisik, & Basaran, 2017). Osteoporosis is characterized by low bone mass, structural deterioration of the bone architecture in trabecular bone, and porous and thin cortical bone, resulting in decreased bone strength (Fletcher, 2013; Witzke, 2015). Although there are numerous methods to

measure bone density, dual-energy X-ray absorptiometry (DEXA or DXA) is considered the gold-standard due to accuracy, ease of use, and low radiation exposure. However, DXA does not differentiate between trabecular bone and cortical bone, and it cannot determine bone architecture or material properties (Witzke, 2015). Bone mass is considered abnormal when bone mass density (BMD) is equal to, or greater than, 2.5 standard deviations below the T-score, or the young normal adult score (American College of Sports medicine [ACSM], 2018; Sharp, 2018). Osteopenia is also characterized by low BMD, but not the extent of osteoporosis, and is defined as BMD between 1.0 and 2.5 deviations below the T-score. Although genetics can account for up to 75% of a person's bone mineral density, osteoporosis, in many cases, can be prevented or treated (ACSM, 2018; National Institutes of Health, 2018).

Statistics

Osteoporosis affects over 10 million adults in the United States and almost 44 million have osteopenia. It is estimated by 2030 the combined number will increase to more than 71 million for adults over age 50 (National Osteoporosis Foundation, 2014). Females are at a higher risk than males, with 50% of females over age 50 afflicted, and 20% of males. Worldwide, there is a fracture associated with osteoporosis every 3 seconds, with the most frequent fractures in the hip, vertebrae, and wrist/forearm (International Osteoporosis Foundation, 2017; Witzke, 2015). Unfortunately, 25% of older adults who experience an osteoporotic fracture die within 5 years (ACSM, 2018). The associated annual cost of medical treatment and loss of productivity in the United States is estimated to be around \$20 billion and is expected to increase to over \$25 billion in the coming years (ACSM, 2018; Dempster, 2011).

Formation of Bone

Similar to other tissue, bone is in a constant state of remodeling, or breaking down and rebuilding. Osteoclasts breakdown bone matrix, while osteoblasts are responsible for repairing bone matrix. Osteoporosis results when the process of breaking down, or resorption, happens at a faster rate than reformation. Peak bone velocity and growth takes place in puberty, and peak bone mass occurs in early adulthood. It is shortly after peak bone mass, in the mid-twenties to early thirties that bone density starts to diminish in males, and early to mid-forties for females (ACSM, 2018; Sozen et al., 2017). Loss of bone mass stays at a steady rate for males but accelerates in females at the onset of menopause. Because peak bone velocity occurs during puberty, maximizing bone growth during this period will have positive health benefits in later years.

Factors That Effect Bone Mass Density

Factors that affect BMD are activity and exercise, nutrition, genetics, lifestyle, and disease (Gray, 2014; Mitchell, Cooper, Dawson-Hughes, Gordon, & Rizzoli, 2015; Sozen et al., 2017). Risk factors are classified into modifiable and non-modifiable. Non-modifiable factors cannot be changed and are usually genetic. Since the initial findings of the Human Genome Project in 2001, it is thought there are 20,500 human genes (National Human Genome Research Institute, 2018). Human genes are the coding of inheritable instructions for the next generation. Genome-wide association studies, and twin and family linkage studies have determined a genetic component associated with low BMD. Even though it is estimated up to 80% of risk for osteoporosis is genetic, the precise location of only a few genes has been found (Chesi et al, 2019; Marini, Masi, Marcucci, Cianferotti, & Brandi, 2018). Modifiable factors include, environment, diet, and activity level. Osteoporosis is classified as primary or secondary.

Primary osteoporosis, the most common, is age related and is the consequences of cumulative bone loss, and is non-modifiable. Secondary osteoporosis is the result of lifestyle or disease state, many of which are modifiable. Table 24.1 details risk factors, and some primary and secondary causes for osteoporosis.

Table 24.1

Osteoporosis risk factors, primary and secondary causes

Non-modifiable	Modifiable/Lifestyle	Disease Category
Female	Inactivity	Genetic • Cystic fibrosis • Marfan syndrome • Hemochromatosis
Age	Poor nutrition	Endocrine: • Central obesity • Diabetes • Athletic amenorrhea
Family history	Low calcium level	Gastrointestinal • Celiac disease • Gastric bypass/surgery • Pancreatic disease
Ethnicity (White, Asian)	Low Vitamin D level	Hematological • Leukemia • Hemophilia • Sickle Cell disease
Kyphosis	Excessive Vitamin A	Neurological • Epilepsy • Stroke • Parkinson's disease
Small body frame	Smoking	Musculoskeletal • Muscular dystrophy • Spinal cord injury • Proximal myopathy
Menopause prior to age 45	Excessive alcohol consumption	Autoimmune • Rheumatoid arthritis • HIV • Lupus
Previous fracture	Excessive soda	COPD
	Excessive caffeine	Depression
	Immobilization	Renal disease
	Low body weight	

Fall risk

- Impaired hearing
- Impaired vision
- Ill-fitting footwear and clothing
- Poor ambulatory environment
- Poor ambulatory environment

Chesi et al., 2019; Sharp, 2018; Sozen et al., 2017

The Female Triad

A discussion of osteoporosis must include the female triad. The female triad is a syndrome characterized by low energy, amenorrhea, and osteoporosis (Barrack, Ackerman, & Gibbs, 2013). Even though all components may not be present, it is estimated 50-60% of female adolescent athletes have at least two components. Athletes involved in sports where a lean physique is preferred, such as figure skating and running, are the most vulnerable. Early detection and intervention are critical to avoid lifelong health concerns. The following risk factors should be assessed (Bush, 2018):

- Menstrual irregularities or amenorrhea
- History of stress fracture
- A history of critical comments regarding food
- Depression
- Self-restricted food consumption
- Obsessiveness or perfectionism
- Weight fluctuations
- Overtraining
- Recurrent injuries
- Sleep disorders

Bone loss related to the female athlete triad is not fully understood. However, the most recent evidence suggests a combination of low estrogen levels and a chronic lack of proper nutrition leads to poor bone health and development (Witzke, 2015). Although further studies need to be conducted to clarify relationships, it is surmised low energy levels can result in weakening tissue such as muscles, tendons, and ligaments, leading to excessive musculoskeletal injuries (Barrack et al., 2013). In addition to musculoskeletal injuries, another consequence of the female athlete triad is endothelial dysfunction that can lead to cardiovascular irregularities. Due to low estrogen levels brought about by amenorrhea, nitric oxide (NO) is not properly stimulated, hindering vasodilation. Additionally, anti-atherosclerotic properties normally facilitated by NO can be inhibited, leading to higher levels of triglycerides and high-density lipoproteins (Barrack et al., 2013).

Pharmacology

Pharmacological therapy for osteoporosis is mostly comprised of antiresorptives, and is designed to increase or stabilize BMD, or reduce bone loss. Antiresorptives include hormone replacement therapies, selective estrogen receptor modulators, bisphosphonates, and some antibodies. Anabolic drugs to stimulate osteoblastic bone formation are fairly new but offer a promising path to increase BMD. A list of common drugs and the side effects are in Table 24.2.

Table 24.2

Common drugs used for the treatment and prevention of osteoporosis

Antiresorptive	Preventive or Treatment	Effect	Side effects
Bisphosphonates	Prevention and treatment	Decrease bone resorption via osteoclast inhibition	GI disturbance Heartburn Headache
Receptor activator of nuclear factor kappa-B ligand (RANKL antibodies)	Treatment	Suppresses bone resorption via osteoclast inactivation	Increased risk for infection UTI
SERMS	Prevention and treatment	Interaction with bone's estrogen receptors Increase trabecular bone mass	Hot flashes Cramps Increased risk for blood clots
Calcitonin	Treatment	Increase osteoblast activity Inhibits osteoclast activity Reduces vertebral fracture risk	GI disturbance Headaches Flushing Allergic response
HRT	Prevention	Preserves BMD via a reduction in bone resorption Decreases fracture risk	Cancer Increased cardiovascular risk Stroke Blood clots
Anabolic agents	Treatment	Regulates blood calcium levels Osteoblast activation	Headache Nausea

Pavone et al., 2017; Sharp, 2018; Witzke, 2015

Nutrition

Nutrition is a vital for bone maintenance across the lifespan. Optimization can be achieved during childhood, adults can strive to maintain healthy bone, and seniors can prevent or treat osteoporosis (Mitchell et al., 2015). Calcium and Vitamin D are central to any nutrition plan for the prevention and treatment of osteoporosis (ACSM, 2018; Witzke, 2015). The dietary reference intake (DRI) for calcium is 200 mg/day for infants, an upper limit of 3000 mg/day for adolescents and pregnant women, and 1200 mg/day for females over age 50. Vitamin D is needed for calcium absorption and has a DRI of 400mg/day for infants, and an upper limit of 4000 mg/day for adolescents and pregnant women (ACSM, 2018).

Conversely, caffeine and alcohol may reduce bone strength by inhibiting calcium absorption, and Vitamin A can increase the risk of fractures from bone loss. Other important nutrients are in Table 24.3.

Table 24.3

Nutrients useful for the prevention and treatment of osteoporosis

Nutrient	Reasons/Benefits	Recommended amount	Source
Calcium	Comprises 50% of bone mass	Infants: 200-1000 mg/day Toddlers: 500-2500 mg/day Adolescents: 1100-3000 mg/day 50-70 years: 800-2500 mg/day > 70 years: 800-2000mg/day	Dairy Some varieties of fish Green, leafy vegetables
Vitamin D	Facilitates calcium absorption	Infants: 400-1000 mg/day Toddlers: 400-2500 mg/day Adolescents: 400-4000 mg/day 50-70 years: 400-4000 mg/day > 70 years: 400-4000/day	Sunshine Some fatty fish
Vitamin K	Activates some proteins May decrease risk of certain fractures	<18 years: 30-75 mcg/day > 18 years: 90-120 mcg/day	Dark green vegetables
Vitamin C	Helps the production of collagen	Adults: 75-90 mg/day	Citrus fruits Some berries Some peppers
Potassium	Helps with bone strength	Adults: 4.7 g/day	Fruits Vegetables Dairy Meat Nuts
Magnesium	Helps reduce calcium loss	Adults: 310-420 mg/day	Fruits Vegetables Nuts
Omega 3 fatty acids	Reduces systemic inflammation	Adults: 1-1.6 g/day	Fatty fish Nuts and seeds Some vegetables
Protein	Builds strong bones, particularly during childhood and adolescents	1-1.5 g/day per kg of bodyweight	Meat Dairy Eggs Beans

ACSM, 2018; Mitchell et al., 2015; Witzke, 2015

Exercise and Activity

Because bone formation occurs when people are young, it is important to optimize BMD during childhood and adolescence through loading activities. Weight bearing activities should be performed daily and moderate-to-vigorous activity has been shown to improve hip strength and bone structure (Fletcher, 2013). General bone-loading, even non-targeted activities including plyometrics, basketball, soccer, volleyball, gymnastics, and weight training can produce benefits, such as an increase in BMD into adulthood (Fletcher, 2013; Witzke, 2015).

Even though it is known anaerobic and aerobic exercise increase BMD and/or slow the progression of bone loss, there are no specific exercise guidelines for osteoporotic adults as recommendations should be based on the individual needs of each client (Chaconas, Olivencia, & Russ, 2013; Witzke, 2013). Because the skeletal response to activity is greatest at the site of maximum stress, exercises should target loading to at-risk bones. Exercise should be pain free, with a focus on weight bearing exercises and fall prevention (ACSM, 2018). Clients should be able to perform each movement with proper form, tissue health (bone, ligament, tendon, and muscle) needs to be considered during exercise selection, as does joint range of motion. Keep in mind any client who presents with osteoporosis needs a medical clearance to exercise and non-osteoporotic adults should follow the ACSM FITT guidelines for their specific situations.

Table 24.4 combines the exercise recommendations from numerous organizations and literature. Table 24.5 lists movements contraindicated for clients with osteoporosis.

Table 24.4

FITT recommendations for clients with osteopenia or osteoporosis

Exercise	Frequency	Intensity	Time	Type	Avoid
At-risk clients/osteopenia					
Aerobic	3-5 days/week	Light to moderate 40-70% HRR	30-60 minutes combined aerobic and resistance	Weight bearing • Walking • Running • Biking • Tennis • Stair stepper	• Any movement that causes pain • Explosive movements • Dynamic abdominal movements
Resistance Begin with 5-10 minutes of mild warm-up	2-3 days/week	60-80% 1RM 80-90% 1 RM	8-12 reps 5-6 reps 2-3 sets Rest as needed	• Modality based on assessment • Functional standing movements	• Unsupported forward flexion • Excessive twisting, bending, or compression
Neuromuscular	Daily			• Balance progression • Gait training	
Flexibility	5-7 days/week	Mild discomfort	3 stretches for each muscle group Hold for 15-30 seconds		
Clients with osteoporosis					
Aerobic	3-5 days/week	Light to moderate 40-60% HRR	30-60 minutes combined aerobic and resistance	No or low impact • Walking • Swimming • Stair climbing	
Resistance Begin with 5-10 minutes of mild warm-up	2-3 days/week	60-80% 1RM	8-12 reps	• Modality based on assessment • Bone loading movements • Functional standing movements	
Neuromuscular	Daily			• Balance progression • Gait training	
Flexibility	5-7 days/week	Mild discomfort	3 stretches for each muscle group Hold for 15-30 seconds		
ACSM, 2013; Sharp, 2018; Witzke, 2015					

Table 24.5

Contraindicated movements for clients with osteoporosis

Exercise	Intention	Reason for concern
Yoga plough	Stretch low back	Compresses cervical spine
Neck circles/hyperextension	Relieves tension Stretches neck, traps, and shoulders	Compresses cervical nerve roots and arteries
Neck bridging	Strengthens neck	Compresses cervical discs
Straight-leg sit-up & Double leg lifts	Strengthens abdominals	Excessively stresses hips and low back
Standing toe touch	Stretches posterior chain	Forward flexion places stress on the low-back increasing risk for disc compression
Back hyperextension	Strengthens low back and hips	Increases risk for disc tissue damage
Hip twists	Stretch torso/strengthen abdominals	Increases risk for disc tissue damage, and hip capsular damage
Hurdler stretch Yoga lotus position	Stretch hamstring on the straight leg and quadriceps on the flexed leg	Places stress on the medial ligament of the flexed knee
Full squat	Strengthens lower body and core	Stresses ligaments and meniscus of the knee

ACSM, 2013; Sharp, 2018; Witzke, 2015

Discussion and application

1. Discuss the benefits of exercise and the guidelines for someone experiencing osteoporosis and/or osteopenia.
2. Discuss the female triad and how it can effect BMD in males and females.

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