

EATING DISORDERS AND OSTEOPOROSIS

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Introduction

This resource is for anyone in the health care field. This includes those in mental health, social workers, nurses, physicians, physician assistants, dentists, and anyone else that may be part of a health care establishment.

This article examines: the guidelines for achieving optimal health with diet, exercise, and body composition; osteopenia and osteoporosis; how to maintain bone health; the characterization and statistics of anorexia nervosa, bulimia nervosa, binge-eating disorder, night-eating syndrome, and eating disorders not otherwise specified; the female athlete triad; making the connection on how eating disorders lead to osteoporosis; the recommended treatment for osteoporosis when it is related to eating disorders; and maintaining bone health. In addition, this article will provide further eating disorder and bone health resources.

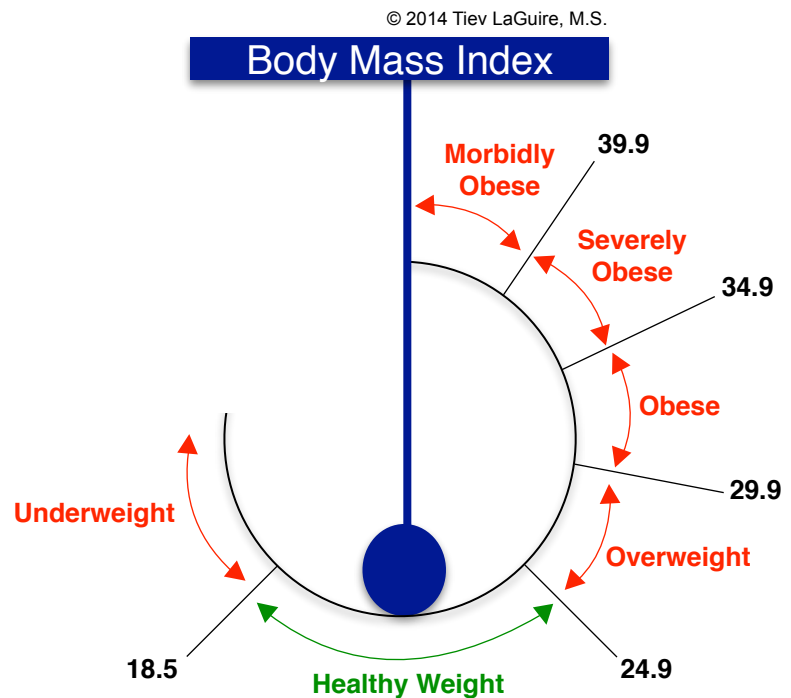
Model of Health

There are many aspects to take into account when striving for a healthy lifestyle. A person's height to weight ratio, otherwise known as their body mass index (BMI), is one such aspect. The BMI can be calculated with the following formulas, depending on the preferred units of measure:

$$\text{BMI} = \frac{\text{weight in pounds} \times 703}{\text{height in inches}^2}$$

$$\text{BMI} = \frac{\text{weight in kilograms}}{\text{height in meters}^2}$$

The healthy weight range of the BMI pendulum lies between the BMIs of 18.5 and 24.9. A BMI lower than 18.5 is considered underweight and poses many health risks for morbidity and mortality, as does a BMI higher than 24.9. One must be careful when interpreting a large BMI, since a person may have a BMI in the overweight or any of the obese categories for actually having a substantial amount of adipose (fat), but also may be placed in one of these categories for having a substantial amount of muscle, such as a body builder. For this reason, body composition, that is, a person's percentage of adipose vs. lean muscle mass, is an important measure of health. The underweight category does not carry the same problem with interpretation. That is to say, if a person has a BMI lower than 18.5, the only explanation for this is that they do not have enough mass of any type (adipose, muscle, bone, etc.) for their height.

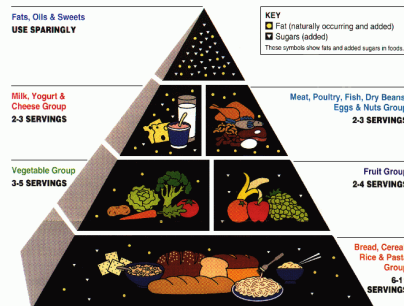


Having a BMI within the healthy weight range doesn't necessarily mean that a person is healthy. They may have a larger or smaller than optimal percentage of adipose and still be classified as having a healthy BMI. Taking a closer look at body composition reveals that, although there are differences for men and women, there is a certain optimal percentage of body fat. This optimal range is 21% - 35% for women and 8% to 24% for men, depending on age.¹ There is plenty of scientific evidence that having a body fat percentage above the optimal range leads to significant and detrimental health consequences such as type 2 diabetes, heart disease, high cholesterol, liver disease, and the list seems endless. Less focus is given to the health consequences that come from having a body fat percentage *less* than the optimal range. There is, however, a *minimal* level of adipose that is required to maintain health for each sex. This minimal level, known as "essential

fat, is 10% - 13% for women and 2% - 5% for men. Women require a higher body fat percentage in order to maintain menstruation and the ability to have children.”² This minimal level should not be the goal of the average person. Instead, this minimum is the absolute lowest level that someone could achieve before losing the most crucial adipose found within the body.

Not all fat is equal. There are different types of fat and many locations where it is found within the body. “Subcutaneous fat is found directly under the skin. It’s the fat that’s measured using skin-fold calipers to estimate total body fat. Visceral or ‘deep’ fat wraps around the inner organs.”³ The minimal body fat percentage helps with temperature regulation, is required for cushion and trauma protection for parts of the body such as the internal organs, helps to hold the eyeball, nerves, blood vessels, and muscles in place within the eye socket, is an important element of cellular membranes, is a major component of the myelin sheath that surrounds neurons (brain cells), allows for storage of fat soluble molecules such as the vitamins D, E, A, and K, and produces the hormone leptin, which plays a role in appetite and metabolic regulations. Dropping below the essential fat percent can lead to problems with staying warm, trauma and damage to organs, tearing of the delicate portions of the eye, weakened cell function or death of cells, decreased function of the nervous system, nutrient deficiencies, and a decrease in metabolic activity.

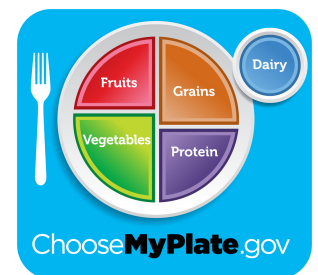
Diet is extremely important for good health as everything that is consumed or inhaled has an effect, positive or negative, on the body. What the USDA once used to represent the food guidance system, the commonly known pyramid, has now, after two decades, been replaced with MyPlate. The



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Food_guide_pyramid#mediaviewer/
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MyPlate guidance system uses amounts, such as cups, whereas the pyramid used serving recommendations (e.g: 2-4 servings of fruit). Since the size of a serving is not typically known by the general public, putting the recommendations in amounts will hopefully make following a healthy diet easier for everyone. Although the recommendations are slightly different for men vs. women, and do also depend on age and physical activity level, the following are general daily guidelines for a healthy diet:⁴

- ▶ 1½ - 2 cups of fruit
(fresh, canned, frozen, dried, or 100% juice)
- ▶ 2½ - 3 cups of vegetables
(fresh, cooked, canned, frozen, dried, or 100% juice)
- ▶ 3 cups of dairy
(milk and milk products that retain their calcium content)
- ▶ 5 - 6½ ounces of protein
(meat, poultry, seafood, beans, peas, eggs, soy products, nuts, and seeds)
- ▶ 6 - 8 ounces of grains with at least half being whole grains
(wheat, rice, oats, cornmeal, barley, or other cereal grains, and anything made from these)
- ▶ Limit added fats and refined sugars



© choosemyplate.gov/about.html

It is important to make sure that the diet is well rounded in the macronutrients. “Adults should get 45% - 65% of their calories from carbohydrates, 20% - 35% from fat, and 10% - 35% from protein.”⁵ Eliminating or severely reducing an entire calorie source can be very detrimental to a person’s health. For instance:

- ▶ “The primary role of carbohydrates is to provide energy to cells in the body, particularly the brain, which is the only carbohydrate-dependent organ in the body. The Recommended Dietary Allowance (RDA) for carbohydrates is set at 130 grams per day for adults and children based on the average minimum amount of glucose utilized by the brain.”⁵
- ▶ The RDA for protein is set at 0.8 grams of protein per kilogram of body weight (0.8g/kg). Not only is the skeletal muscle made largely of protein and requires a constant supply for maintenance and repair, protein plays a huge role in the immune system, is important for cellular function, and makes up the body’s enzymes and many of its hormones.⁵ Nine amino acids (the building blocks of protein) are classified as ‘essential,’ meaning they must be consumed in the diet because the body either cannot make them or cannot make them in the amounts required.
- ▶ Although low fat diets are beneficial to one’s health, dropping too low can be problematic. “Fat aids in the absorption of fat-soluble vitamins and other food components such as carotenoids.”⁵ Therefore, not consuming enough fat in the diet can lead to deficiencies in these other nutrients. The type of fat in the diet does matter however, as “saturated fat, monounsaturated fat, and cholesterol are synthesized by the body and thus are not required in the diet.”⁵ The polyunsaturated fats alpha-linolenic acid (omega-3) and linoleic acid (omega-6) on the other hand are very important to the health of the skin, nerve tissue, and the retina of the eye and are classified as essential, meaning they must be consumed in the diet. The adequate intake (AI) for linoleic acid has been set at 12 grams per day for most adult women (ages 19-50) and 17 grams per day for most adult men (ages 19-50). The AI for alpha-linolenic acid for adults 19 years and older is 1.1 grams per day for women and 1.6 grams per day for men.⁵



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Having a well-rounded diet doesn’t necessarily mean that a person is consuming the proper number of calories. Just as important as not consuming too many daily calories, is not consuming too few daily calories.

The metabolic rate at rest is the primary component of daily energy expenditure. Resting metabolic rate [RMR] is modulated by the amount of calories consumed in the diet relative to energy expenditure. Excessive consumption of [calories increases] resting metabolic rate while fasting and very low calorie dieting causes resting metabolic rate to decrease.⁶

Therefore, eating too few calories in an attempt to lose weight can actually cause the body to slow the person’s metabolic rate, making it even more difficult to lose weight. There is a fine balance of calories in vs. calories out that must be achieved in order to succeed at the desired goal, be it weight gain, weight loss, or weight maintenance. Even if one is actively trying to lose weight, there is still

a minimum number of calories that the body requires to prevent entering into starvation mode and causing the metabolic rate to decrease. This minimum is shown to be 1,200 calories per day for women and 1,500 calories per day for men.⁷ This minimum is just that . . . *the minimum*. As one adds in daily activities, such as exercise, or even reading, cleaning house, driving, or desk work, the minimum daily required caloric intake increases.

Four prediction equations [have been] identified as the most commonly used [equations] in clinical practice (Harris-Benedict, Mifflin-St Jeor, Owen, and World Health Organization/Food and Agriculture Organization/United Nations University (WHO/FAO/UNU)). Of these equations, the Mifflin-St Jeor equation was the most reliable, predicting RMR within 10% of measured in more non-obese and obese individuals than any other equation, and it also had the narrowest error range.⁸

Below are the Mifflin-St Jeor equations⁹ for each sex to *estimate* the daily caloric needs of a person trying to maintain their current weight. These equations can only be used for estimation. Exact caloric expenditure would need to be determined through either direct calorimetry (measuring the amount of heat produced over a period of time) or indirect calorimetry (measuring the amount of carbon dioxide produced and oxygen consumed over a period of time). For each equation, weight must be in kilograms, height in centimeters, and age in years. The activity factor (AF) refers to how active a person is, and ranges from sedentary (AF = 1.2) to extra active (AF = 1.9). For patients under medical care there is also an injury factor (IF) that would be multiplied in addition to the activity factor.

Women: $((10 \times \text{weight}) + (6.25 \times \text{height}) - (5 \times \text{age}) - 161) \times \text{Activity Factor}$

Men: $((10 \times \text{weight}) + (6.25 \times \text{height}) - (5 \times \text{age}) + 5) \times \text{Activity Factor}$

In addition to a decrease in the metabolic rate when caloric intake drops too low, vitamin and mineral intake will also tend to be deficient as a consequence. The vitamins and minerals, known as the micronutrients, serve numerous different roles, such as acting as co-enzymes and antioxidants, required in energy metabolism, as well as having a vital role in the growth, development, and maintenance of every part of the body.

Exercise is just as important for proper health and maintenance as diet. “Adults should do the equivalent of 2½ hours of moderate-intensity aerobic activity each week.”¹⁰ Just like most everything else in life, one can over do it on exercise as well.

Thirty minutes a day of moderate physical activity is enough to help prevent things like diabetes, high cholesterol, and high blood pressure. Too much exercise can lead to injuries, exhaustion, depression, and suicide. It can also cause lasting physical harm. [The] adrenal glands, pumping out hormones [during exercise], can only produce so much cortisol at a time. [One] can distinguish healthy enthusiasts from exercise addicts by the following trait, ‘Healthy exercisers organize their exercise around their lives, whereas dependents organize their lives around their exercise.’ Excessive exercise, like extreme diets, attracts people who feel an extreme need for control in their lives. Treatment for exercise addiction often includes encouraging patients to take up more social forms of exercise such as yoga and cycling instead of the solitary pursuits of running or going to the gym, which can be breeding grounds for perfectionist pathology.¹¹

The following six-statement exercise addiction inventory (EAI) is used, rated based on the level of agreement with each statement, to check addictive exercise behavior:¹²

- 1) *Exercise is the most important thing in my life.*
- 2) *Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do.*
- 3) *I use exercise as a way of changing my mood.*
- 4) *Over time I have increased the amount of exercise I do in a day.*
- 5) *If I have to miss an exercise session I feel moody and irritable.*
- 6) *If I cut down the amount of exercise I do, and then start again, I always end up exercising as often as I did before.*

Eating Disorders

There are three main categories of eating disorders. The last category includes two subcategories:¹³

- ▶ Anorexia Nervosa (AN)
- ▶ Bulimia Nervosa (BN)
- ▶ Eating Disorders Not Otherwise Specified (ED-NOS)
 - ▶ Binge-Eating Disorders (BED)
 - ▶ Night-Eating Syndrome (NES)

The above eating disorders are characterized by:¹³

- ▶ *Aberrant or restricted eating*
- ▶ *Purging behaviors*
- ▶ *Excessive exercise*
- ▶ *Preoccupation with food, weight, and body image*



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Key Points for Optimal Health

- **BMI Range:** 18.5 - 24.9
- **Body Fat:**
 - Women: 21 - 35 %
 - Men: 8 - 24 %
- **MyPlate recommendations:**
 - 1½ - 2 cups fruit
 - 2½ - 3 cups vegetables
 - 3 cups dairy
 - 5 - 6½ ounces protein
 - 6 - 8 ounces grains with at least half being whole grains
 - Limit added fats and refined sugars
- **Macronutrient RDAs:**
 - Carbohydrates:
 - 45 - 65 % of daily calories
 - 130 grams per day minimum
 - Protein:
 - 10 - 35 % of daily calories
 - 0.8 grams per kilogram body weight per day minimum
 - Fat:
 - 20 - 35 % of daily calories
 - Low saturated fat and cholesterol consumption
 - Get enough omega-3 and omega-6 fats in the diet
- **Minimum Daily Calories:**
 - Women: 1,200
 - Men: 1,500
- **Physical Activity:**
 - 30 minutes a day

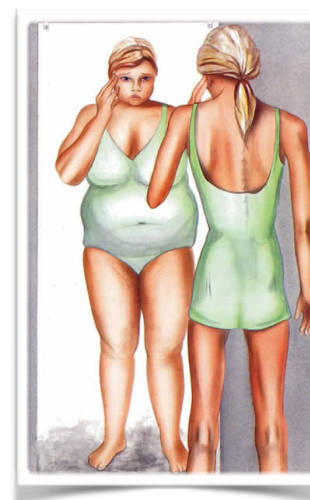
Eating Disorder Facts:

- ▶ “Eating disorders such as AN and BN are 10 - 15 times more common in women than in men.”¹³
- ▶ “Most patients with eating disorders are women between 12 and 25 years old. Young women are particularly vulnerable to eating disorders because of their desire to have an ideal body image, and they are more likely to go on strict diets by restricting food intake compared with men.”¹³
- ▶ “Eating disorders have one of the highest death rates of all psychiatric diagnoses. Many with eating disorders may look and feel deceptively well and may have normal electrograms but are still at high risk for cardiac arrhythmias and sudden death.”¹⁴
- ▶ “In total, 86% of patients are diagnosed with eating disorders before the age of 20. For this reason, the Society for Adolescent Medicine issued this statement: ‘Because of the potentially irreversible effects of an eating disorder on physical and emotional growth and development in adolescents, because of the risk of death, and because of the evidence suggesting improved outcome with early treatment, the threshold for intervention in adolescents should be lower than in adults.’ Irreversible risks are growth retardation, pubertal delay or arrest, impaired acquisition of peak bone mass, and increased risk of osteoporosis.”¹⁴
- ▶ “Depression is a major risk factor for both substance use disorder and [eating disorders] and explains to a greater degree the association between [the two] disorders. Neuroimaging studies with computerized tomography (CT) have demonstrated structural brain abnormalities in both anorexics and bulimics.”¹⁴
- ▶ “Borderline personality disorder is also common in patients with eating disorders.”¹⁴
- ▶ “Eating disorder patients who restrict intake of food have been found to have deficiencies in calcium, iron, riboflavin, folic acid, vitamins A and C, vitamin B₆ and essential fatty acids. Other studies have shown deficiencies in eating disorder patients for vitamins D and E, as well as micronutrients such as copper and zinc.”¹⁴

Anorexia Nervosa

“Anorexia nervosa is an eating disorder characterized by an irrational fear of weight gain. People with anorexia nervosa believe that they are overweight even when they are extremely thin.”¹⁵

“Low body weight in females cause the body to stop producing estrogen, resulting in a condition known as amenorrhea, or absent menstrual periods. In addition, individuals with anorexia often produce excessive amounts of the adrenal hormone cortisol.”¹⁵ It has been shown that the rate of bone mineral density loss is increased in the lumbar spine of men and in the femoral neck of women with elevated cortisol levels.¹⁶ “Weight loss, restricted dietary intake, and testosterone deficiency may be responsible for the low bone density found in males with the disorder.”¹⁵



© medicallywiseinfo.com/2010/1004/anorexia-nervosa.html

AN Facts:

- ▶ “Up to 3.7% of females will be diagnosed with anorexia nervosa.”¹⁴
- ▶ “0.2% - 1% of all adolescent girls and 1% - 4% of college-age women have [anorexia nervosa]. Because many cases go undiagnosed, the true prevalence of anorexia nervosa is likely higher.”¹⁷
- ▶ “The prevalence of variants of [anorexia nervosa] is estimated at twice the reported prevalence of anorexia nervosa as diagnosed by DSM IV criteria.”¹⁷
- ▶ Anorexia nervosa “typically emerges between ages 14 and 16.”¹³
- ▶ “About 50% of individuals with AN will later develop bulimic symptoms.”¹³
- ▶ 90% - 95% of anorexics are female.¹⁴
- ▶ “The number of deaths in anorexics is 11.6 times what would be expected in others of their same age and sex [and a] 56.9 times increased number of observed versus expected deaths in anorexics from suicide.”¹⁴ If alcohol is abused, the death rates are higher.¹⁴
- ▶ “Depression is reported in 36% of adolescent girls with AN.”¹⁸
- ▶ It has been shown that “anorexic adolescent girls with depression [have] greater deficits in [bone mineral density (BMD)] than those without depression. Girls with depression and primary amenorrhoea [have] an additional reduction in BMD compared with those who [are menstruating].”¹⁸
- ▶ It has been estimated that there is “a fracture rate of 7 times normal in women and men with AN [and] a 57% cumulative risk of fracture at 40 [years] after diagnosis.”¹⁹
- ▶ Amenorrhea is “often an early indicator of the illness, seen before significant weight loss in about 20% of patients.”²⁰

Bulimia Nervosa

“Bulimia nervosa is associated with chaotic eating behaviors. Binge eating is followed by purging, fasting, and/or intensive exercise in an attempt to compensate for the excessive calories ingested. Large quantities of food, frequently high in carbohydrate or sugar, are consumed (approximately 3400 - 4800 calories per episode). Intake usually occurs rapidly and in secrecy, until extreme fullness. Although [vomiting is] commonly used in an attempt to purge all calories from the body following a binge, approximately 1200 calories are retained after bingeing and vomiting, regardless of the amount eaten. Individuals with bulimia nervosa may be overweight, slightly underweight, or of normal weight, and often experience rapid weight fluctuations.”²¹



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BN Facts:

- ▶ Bulimia nervosa “usually occurs around age 19 or 20.”¹³
- ▶ “80% of bulimics are female.”¹⁴
- ▶ “19% of college-aged females are bulimic.”¹⁴
- ▶ Approximately “25% of individuals with BN have a history of AN.”¹³
- ▶ “An estimated 4.2% [of females] will [be diagnosed with] bulimia nervosa.”¹⁴
- ▶ The number of deaths in bulimics is 1.3 times what would be expected in others of their same age and sex. If alcohol is abused, the death rate is higher.¹⁴
- ▶ “Despite normal weight, bulimics may be severely malnourished.”¹⁴
- ▶ “Bulimia is associated with electrolyte, fluid, and mineral imbalance; increased cardiac risk; gastrointestinal bleeding; dental enamel erosion; peripheral muscle weakness; cardiomyopathy; and hypometabolism.”¹⁴
- ▶ “Depression, anxiety disorders, substance abuse, self-mutilation, and/or extreme body dissatisfaction frequently precede the onset of bulimia nervosa.”²¹

Eating Disorders Not Otherwise Specified

Eating Disorders Not Otherwise Specified “includes both BED and NES and is the most common eating disorder diagnosed in epidemiological studies.”¹³ This category includes “those who have not yet lost 15% of expected weight for height and age, those who purge but do not binge-eat, and those who have been amenorrheic for less than 3 months.”²¹

ED-NOS Facts:

- ▶ “Reported in almost 3% to 5% of women between the ages of 15 and 30 years in Western countries.”¹³

Binge-Eating Disorders

“Binge-eating episodes are associated with: eating much more rapidly than normal; eating until feeling uncomfortably full; eating large amounts of food when not feeling physically hungry; eating alone because of being embarrassed by the amount that one is eating; feeling disgusted with oneself, depressed, or very guilty after overeating.”²¹

BED Facts:

- ▶ “About 0.6% of women and 2% of men have sub-threshold BED, and 5% of women and 4% of men have BED.”¹³
- ▶ A range of “1% to 5% of the population falls into the category of binge eating disorder.”¹⁴
- ▶ “60% of BEDs are female.”¹⁴
- ▶ Despite normal weight, binge-eaters may be severely malnourished.¹⁴

Night-Eating Syndrome

“Night-eating syndrome is characterized by morning anorexia; awakenings accompanied by nocturnal food intake; and hyperphagia, defined as consuming 25% or more of daily calories intake after the evening meal at least two times/week for 3 months.”¹³

NES Facts:

- ▶ “Prevalence rates for NES have been reported as 1.5% to 5.7% in the general population, and rates of 6% to 16% among individuals in [the] overweight and obese weight-loss populations. Nighttime eating has been reported in 9% of candidates for bariatric surgery, 3.8% of older adults with type 2 diabetes, and 12% of psychiatric outpatients. Up to 50% of obese individuals report that nighttime eating preceded their obesity.”¹³
- ▶ “Many night eaters report being more depressed in the evening, and many have a history of mood disorders.”¹³

The Female Athlete Triad

The female athlete triad is not an eating disorder, but is commonly seen among those *with* eating disorders. The triad consists of three parts: “amenorrhea (absence of menstrual cycles), eating disorders, and the resultant osteoporosis.”²²

*Anyone may be affected, but women and girls participating in activities which emphasize leanness are at especially high risk. These activities can include:*²³

- ▶ *Gymnastics*
- ▶ *Ballet*
- ▶ *Diving*
- ▶ *Figure skating*
- ▶ *Aerobics*
- ▶ *Fashion models*²²
- ▶ *Marathon runners*²²

*Weight class sports associated with disordered eating in athletes, including males, are:*²³

- ▶ *Wrestling*
- ▶ *Rowing*
- ▶ *Martial arts*

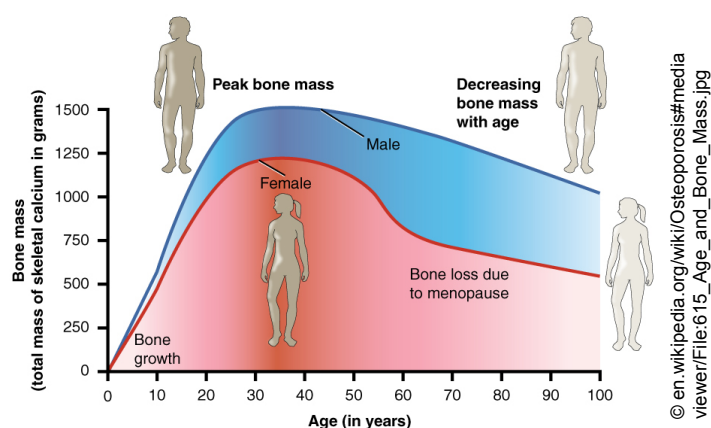
“An unbalanced diet, inadequate caloric intake relative to exercise level and excessive training may predispose females to menstrual abnormalities. Any female who hasn’t started menstruating by age 16, misses three consecutive periods, or has periods that occur at intervals of greater than 35 days should be evaluated by a physician.”²³ “Prolonged amenorrhea is associated with an increased risk of osteopenia and rate of fractures.”¹⁴

Osteoporosis

“Bone density correlates strongly with sensitive nutrition indices, such as body mass index, lean body mass, fat mass, [insulin-like growth factor-1] and leptin levels, and caloric intake. Short-term fasting over a four-day period [has been shown to lead] to a 50% reduction in rates of bone formation in healthy volunteers, demonstrating the profound effects of nutrition status on bone metabolism.”¹⁷

All through life the bones are constantly turning over, meaning that the osteoblast cells are continually depositing new bone and the osteoclast cells are continually degrading the bone, a process known as remodeling. The purpose of this turnover is to maintain blood calcium homeostasis, since bones are used for calcium storage when dietary calcium intake is high, and as a calcium reserve when dietary calcium intake is low.

From birth until about age 20, the bones are in a phase of active growth. This stage is characterized by an increase in bone length and bone width. Between the ages of 12 and 30, the rapid phase of bone dimensional growth tapers off and consolidation occurs with the attainment of peak bone mass.²⁴



On that account, the most crucial years for reaching optimal bone size and maximum bone density are birth to 30 years of age, with the teens and the twenties being most important for reaching peak bone mass. Once this window of opportunity has passed, the body enters into a phase where bone degradation (resorption) occurs faster than bone formation, taking place at a loss of approximately 1% of bone mass per year.²⁵

Although this happens for both men and women, bone resorption takes place at a faster rate for women. This rate difference is attributed to estrogen having a protective effect on the bones, and for this reason, once a woman's estrogen level drops due to menopause, the bone resorption rate increases. “Estrogen produces its beneficial effects primarily by preventing bone loss by suppressing the secretion of cytokines such as IL-1, IL-6, TNF- α , and PGE2, which activate osteoclasts, and by increasing secretion of TGF- β and osteoprotegerin, which inhibit osteoclast differentiation and activation.”¹⁷ Thus, given that “the incidence of hip fractures increases with age, doubling for each decade after age 50,”²⁶ not reaching maximum bone mass in the early years leads to a lower reserve to draw from as one ages, allowing for osteoporosis to occur at a much younger age than it otherwise would have, thereby leading to the very serious consequences of bone fractures such as the hip and spine. In fact, “about 20% of people who have a hip fracture die within a year of their injury [and] it is estimated that only 1 in 4 persons have a total recovery from a hip fracture.”²⁶

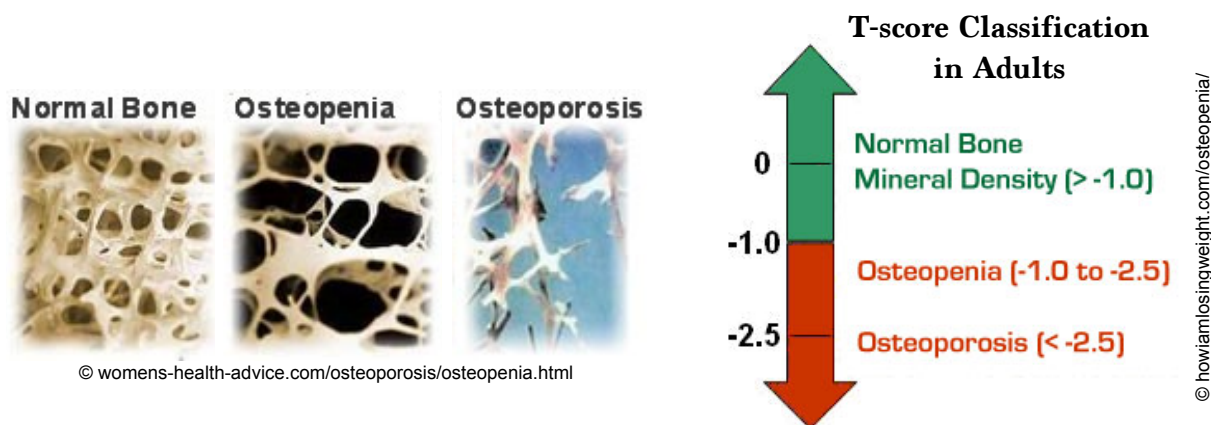
Further, “up to one-third of individuals with osteoporosis who suffer a hip fracture, become totally dependent for assistance with basic activities of daily living.”²⁷

*Other complications of fractures:*²⁶

- Blood clots, which may break off, blocking blood vessels and can be fatal
- Pneumonia
- Muscle atrophy (wasting of muscle tissue)
- Postoperative infection
- Nonunion or improper union of the bone
- Mental deterioration following surgery in older patients
- Bedsores from lying in the same position with minimal movement

During osteoporosis, “the bones are weakened by loss of bone tissue, making a person much more susceptible to fractures.”²⁵ Before the bone loss is severe enough to be classified as osteoporosis, however, it is referred to as osteopenia.

*Osteopenia and osteoporosis are commonly defined with the use of t-scores and z-scores. T-score measures a person’s bone density in terms of standard deviations above or below the peak bone density for gender, whereas z-score measures bone density in terms of standard deviations above or below the mean bone density for age and gender. Because it is more important to compare current bone density to peak bone density to estimate the extent of bone loss in adults, t-score is used to report bone density in adults. However, t-score is not an accurate measure of bone density in adolescents, who are still in the process of accumulating bone mass; therefore, z-score is used in this population. Osteopenia is defined as a bone mineral density t-score between -1 and -2.5 in adult women, or z-score between -1 and -2 in children and adolescents. Osteoporosis is defined as a t-score of less than -2.5 in adult women, or a z-score of less than -2 in children and adolescents.*¹⁷



“Fracture risk doubles with each decrease of one standard deviation in bone density. Bone loss occurs at all skeletal sites and involves both cortical and trabecular bone, which increases risk for fractures at both the spine and hip.”¹⁷ The most common sites of osteoporotic fracture are hip fractures, and fractures of vertebrae, ribs, and pelvis.²⁸

To determine how one compares to the normal bone mineral density for their age and sex, “a bone mineral density (BMD) test [is used to measure] bone density in various parts of the body. This safe and painless test can detect osteoporosis before a fracture occurs and can predict one’s chances of fracturing in the future.”¹⁵ Dual-Energy X-ray Absorptiometry (DEXA or DXA) “is the most effective tool for assessing and monitoring bone density. Bone density measurements reported by DEXA are expressed as bone mineral content (BMC) in grams per cross-sectional area of bone (g/cm^2). DEXA thus measures areal rather than volumetric bone density and is susceptible to variations in size of bone. Therefore, DEXA may underestimate BMC in small children and overestimate it in large children.”¹⁷

There are also biochemical markers that can be used to determine if someone is undergoing bone loss and at risk of osteoporosis. “Osteocalcin and N-telopeptide (NTX) are established biochemical markers of bone formation and resorption, respectively, and may be used as reliable measures of bone metabolism.”¹⁹ “Osteocalcin influences bone mineralization, in part through its ability to bind to the mineral component of bone, hydroxyapatite. In addition, osteocalcin functions in cell signaling and the recruitment of osteoclasts and osteoblasts.”²⁹ “NTX molecules are mobilized from bone by osteoclasts and subsequently excreted in the urine. Elevated levels of NTX indicate increased bone resorption.”³⁰

Growth hormone (GH) and insulin-like growth factor-1 (IGF-1) are both anabolic to bone.

*IGF-1 functions as a bone-tropic hormone, which positively affects bone growth and bone turnover by stimulating osteoblasts, collagen synthesis, and longitudinal bone growth. Increasing levels of GH directly stimulate the proliferation of osteoblast precursors and then activate osteoblast differentiation (both directly and through IGF-1), thereby leading to increased bone formation. Levels of GH and IGF-1 rise through the early pubertal years to peak at mid-puberty, about a year after peak height velocity is achieved, and then decrease to plateau at adult levels.*¹⁷

“Osteoporosis occurs less frequently in men due to several factors including greater accumulation of skeletal bone mass during youth, greater bone size, the absence of a distinct equivalent of menopause, and a shorter average lifespan. [However,] testosterone plays an essential role in the maintenance of bone mass, and a low testosterone level is generally associated with osteoporosis in men.”²⁷

*Risk factors for developing osteoporosis:*¹⁵

- ▶ Thinness or small frame
- ▶ Family history of the disease
- ▶ Being postmenopausal and particularly having had early menopause
- ▶ Abnormal absence of menstrual periods (amenorrhea)
- ▶ Prolonged use of certain medications, such as those used to treat lupus, asthma, thyroid deficiencies, and seizures
- ▶ Low calcium intake
- ▶ Lack of physical activity
- ▶ Smoking
- ▶ Excessive alcohol intake

Making the Connection

Eating disorders are directly related to the health of one's bones, with actions early in life having harmful consequences felt years later. "Studies of healthy women show a depression of bone formation indexes with as little as 5 [days] of nutritional deprivation. Rapid increases in indexes of bone resorption are also seen with more severe nutritional restriction."¹⁹ "Poor nutrition, chronic caloric restrictions, low body weight, and hypogonadism frequently lead to deficits in bone mineral density in [eating disorders] due to both reduced accrual of peak bone mass and premature bone loss. Deficits in bone mass or bone size in patients with [eating disorders] may not be entirely reversible and increase fracture risk."¹⁸ "The improvement of bone density with weight recovery even before resumption of menses is an indication of the critical role played by nutrition factors (independent of gonadal function) in the osteopenia of [those with eating disorders]."¹⁷

Eating disorder patients, particularly anorexics, have an elevated risk of osteoporosis due to having: a decrease in food consumption, a BMI below the healthy range, and amenorrhea. Amenorrhea in those with eating disorders is brought on by the presence of low estrogen levels.¹⁴ There is a direct correlation between bone density and amenorrhea, since estrogen has a protective effect on bone, the longer the duration of amenorrhea, the further decrease in bone density.¹⁷

Other problems, such as a decrease in the production of growth hormone and other growth factors, low body weight (apart from the estrogen loss it causes), calcium deficiency, and malnutrition, contribute to bone loss in girls and women with [eating disorders]. Weight loss, restricted dietary intake, and testosterone deficiency may be responsible for the low bone density found in males with [eating disorders].¹⁵

Heightened bone resorption has been measured using the biomarker N-telopeptide (NTX), with elevated NTX levels indicating increased bone loss in adults. Osteocalcin on the other hand, used for evidence of diminished bone formation, shows decreasing levels in adults and adolescents with AN. In addition, osteocalcin levels have a strong correlation with indicators "of nutrition status, such as BMI and percent body fat, levels of insulin-like growth factor-1 (IGF-1), and bone density."¹⁷ "A significant increase [can be] observed in serum osteocalcin concentrations in patients with AN from low weight to 90% [ideal body weight]."¹⁹ These biomarkers have given proof that in adults there is "increased bone resorption in the setting of decreased bone formation. This state of bone metabolism likely contributes to the severity of bone loss seen in [eating disorder] patients compared with that of other estrogen-deficient populations. In contrast, bone metabolism in adolescents with anorexia nervosa differs in that the subjects demonstrate decreased bone formation without any change in bone resorption."¹⁷

In addition to NTX and osteocalcin being used as biomarkers to check bone remodeling, GH and IGF-1 are also looked at for bone status. "In states of GH deficiency, bone density and markers of bone formation are significantly reduced." Furthermore, there has been shown to be "normal levels of basal GH but low levels of IGF-1 in adolescents with anorexia nervosa, demonstrating a state of GH resistance."¹⁷ Low levels of serum IGF-1 result from undernutrition and correlate with low BMI in patients with [eating disorders]. Studies of adolescents with anorexia nervosa have noted

decreased adult height and low serum levels of IGF-1. Studies of adults have demonstrated that serum IGF-1 levels decrease with weight loss, increase with weight recovery, and predict bone loss.”¹⁷

Eating Disorders and Osteoporosis Facts:

- ▶ “Bone density is reduced at either the spine or hip by more than 2.5 SD (osteoporosis) in almost 40% of patients and by more than one standard deviation (osteopenia) in 92% of women with anorexia nervosa.”²⁷
- ▶ “About 85% of partially recovered anorexia nervosa patients have bone mineral deficiencies, even if they have regained [menstruation] and are within 10% of ideal body weight.”²⁵ “Despite recovery from AN, osteopenia persists.”¹⁹
- ▶ “Bone loss is more severe when anorexia nervosa begins in adolescence than when it starts in adult life.”¹⁷
- ▶ “The severity of bone deficiency in males is even greater than females with the same eating disorder, especially for those with anorexia nervosa and in those with a very low BMI and longer duration of illness.”²⁷
- ▶ “Severe bone loss can occur in patients who have had anorexia nervosa for less than a year.”¹⁷
- ▶ “The longer the duration of the disorder, the greater the bone loss and the less likely it is that bone mineral density will ever return to normal.”¹⁵

Treating Eating Disorder Related Osteoporosis

Although “research studies have now documented that the bone loss associated with [eating disorders] may not return to normal despite improved eating habits and that the long-term damage to the bones often results in osteoporosis-related fractures,”²² it is still of great importance to prevent further bone loss from occurring and replenish degraded bone to whatever extent possible. “Normalized present weight is the best predictor of BMD in patients with eating disorders.”²⁷ Therefore, “the primary goal of medical therapy for individuals with [eating disorders] is weight gain and, in females, the return of normal menstrual periods.”¹⁵ “A prolonged period of sustained weight recovery may be necessary before a definite increase in bone density is observed.”¹⁷ Moreover, “studies have shown increases in BMD from 6% to 20% with return of menses following weight restoration.”²⁰

*The mainstays of current treatment are:*²⁵

- ▶ *Weight restoration*
- ▶ *Patient education about the impact the eating behavior or the energy imbalance is having on reproductive and bone health*²⁰
- ▶ *Normalizing body composition (particularly fat content)*
- ▶ *Calcium and Vitamin D supplementation*

Medical Intervention

“Estrogen supplementation (without weight gain) does not stop further bone loss or correct low bone mineral density,”²⁵ in fact, hormone therapy or oral contraceptives, once thought to be an effective treatment for bone loss reversal, is no longer supported.²⁰ “Experts agree that estrogen should not be a substitute for nutritional support.”¹⁵ “Nutritional rehabilitation of women with AN confirms the fact that recovery of bone formation occurs first, and that it is followed by suppression of resorption. This chronology suggests that therapy with anti-resorptives such as estrogen may not be effective without appropriate nutritional therapy.”¹⁹ Furthermore, it has been shown that there is “no improvement of bone mineral density with estrogen administration in adult women with anorexia nervosa [and] persistent loss of bone mass was demonstrable despite estrogen therapy.”¹⁷

Menses will usually resume with proper nutrition and weight gain. “With reversal of amenorrhea, studies have shown a 6% - 25% increase in bone density. This is in contrast to studies that have shown a 4.1% - 4.9% increase in BMD with bisphosphonates.”¹⁹ “Bisphosphonates have been prescribed by providers to women with osteopenia or osteoporosis, but the long-term impact on future childbearing and fetal health is unknown and such treatment should be discouraged.”²⁰ “Bisphosphonates inhibit bone resorption by decreasing osteoclast function.”¹⁷ This class of drug is “directly taken up into bone and can remain present for many years after stopping. Risendronate is excreted more rapidly than Alendronate and therefore is the drug of choice, [however,] reliable contraception must be used for the duration of treatment and continued for at least six months after stopping before planned pregnancy.”³¹

Nutritional Intervention

Considering that depression is a major risk factor for eating disorders, is commonly seen among those with anorexia nervosa, and even often precedes the onset of bulimia nervosa, preventing and treating depression is of great importance for restoring bone mass loss due to an eating disorder.

*Omega-3 fatty acids are important in brain cell communication, therefore having significant effects on brain function and mood. Many studies have shown a benefit of omega-3 fatty acid to treat depression. [In addition to omega-3 fatty acids,] the B vitamins are [also] implicated in the mood disorders seen in eating disorder patients. B₁₂ and folic acid have significant mood-enhancing benefits when used alone and in combination with antidepressants. Both low B₁₂ and low folic acid have been noted in patients with depression. As well, in population studies, an association has been found between depression and low levels of these two vitamins. Low levels of folate have been implicated in poor response rates to standard antidepressant therapy. B vitamins also [aid in the conversion of] glucose into energy in the brain cells and assist in the manufacturing of neurotransmitters. B₁₂ is essential for nerve health.*¹⁴

Weight restoration is key to preventing further bone loss. “Niacin supplementation has been shown in several case reports to improve appetite. Zinc supplementation (100 mg of zinc gluconate) has been shown to help with weight gain in anorexics, increasing their body mass index twice as fast as placebo. Zinc also lowers the severity and duration of diarrhea associated with malnutrition. [Further,] zinc is vital in the regulation of gene expression, immune function, wound healing,

reproduction, growth and development, behavior and learning, blood clotting, thyroid hormone function, and insulin action.”¹⁴

Lifestyle Intervention

“Although walking and other types of regular exercise can help prevent bone loss and provide many other health benefits, these potential benefits need to be weighed against the risk of fracture, delayed weight gain, and exercise-induced amenorrhea in people with anorexia and those recovering from the disorder.”¹⁵ “Regular weight-bearing exercise should be encouraged [only] in those with a BMI >16, [however] excessive exercise [is] to be avoided in those with osteoporosis.”³¹

After Intervention

Most all of beneficial outcomes appear after weight gain and/or the return of menses.

*Bone density analysis [show] that, on treatment, patients [gain] a significant increase in spine BMD and hip BMD after weight gain from low weight to 90% [ideal body weight] in just 2.2 months. Despite the large increases, the bone density of the patients with AN [does] not reach the values of control subjects and [is] still significantly different at 90% [ideal body weight]. Rapid increases in bone density [can be] seen in those who [regain] menses and those who [remain] amenorrheic. Data suggest that the group that [remains] amenorrheic [has] greater suppression of ovarian function, even at baseline, than the group that [regain] menses, as evidenced by significantly lower [luteinizing hormone (LH)] concentrations at baseline and a lack of estradiol rise into the normal range. LH suppression [is] expected to compromise ovarian stimulation and, in turn, estradiol secretion. Because estradiol decreases bone resorption, its suppression would favor an increase in NTX. Osteocalcin concentrations rise with weight gain in both patients that resume menses and those that remain amenorrheic, whereas elevated NTX concentrations fall into normal range only with resumption of menses. [This] suggests that the recovery of bone metabolism is biphasic, involving a primary nutritional mechanism that stimulates bone formation and a hormonal mechanism that decreases bone resorption.*¹⁹

Maintaining Bone Health

“An NIH consensus conference on osteoporosis concluded that bone mass attained early in life is the most important determinant for lifelong bone health.”²⁰

Calcium

The body cannot make calcium, therefore, it must be obtained from the diet. Although calcium is necessary for blood clotting and the contraction of muscle, among other roles, the main functions of calcium are to develop and maintain bones. Calcium is stored in the bones as the compound hydroxyapatite, a crystal that forms a lattice-like structure around the collagen matrix of bones. This hydroxyapatite is the key to strong bones and prevents bones from breaking under impact.

Males and females ages 9 to 18 years should consume 1300 mg of calcium per day. This amount is crucial for proper bone development and density during these years of rapid growth. For ages 19

through 50, the required amount decreases to 1000 mg per day before again increasing to 1200 mg for females above age 50 and males above age 70. “Females with irregular or absent menses require 1500 mg of calcium per day.”²³ More is not always better, and calcium does have a tolerable upper intake level (UL) set at 3000 mg for males and females aged 9 to 18 years, 2500 mg for those between the ages of 19 and 70, and 2000 mg for those above 70 years of age. Amounts above the UL are typically not going to be consumed from a normal diet, but instead will be supplied through supplementation.

Key Points for Optimal Health

• Calcium:

Females:

9 - 18 years = 1300 mg

19 - 50 years = 1000 mg

> 50 years = 1200 mg

Irregular or
absent menses = 1500 mg

Males:

9 - 18 years = 1300 mg

19 - 70 years = 1000 mg

> 70 years = 1200 mg

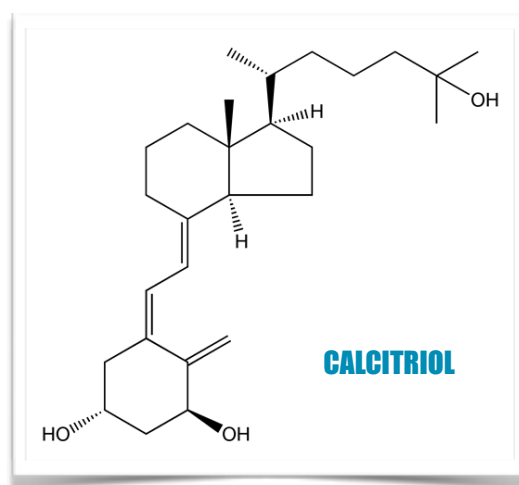
Just as important as the amount of calcium contained in the foods we eat, is the bioavailability of that calcium, or the percentage of calcium that can be absorbed by the body from those foods. For example, as little as 5% of the calcium contained in spinach is absorbed by the body, but as much as 70% of the calcium contained in kale is absorbed.³² The bioavailability for the calcium in dairy products is roughly in the middle, at about 30%.³² Dairy products may not seem as good of a source of calcium due to the 30% absorption rate, however they are the superior source due to the total amount of calcium found within them compared to other foods with higher bioavailability.

Foods rich in calcium:

- ▶ Milk and milk products such as cheeses, yogurt, and ice cream
- ▶ Fortified foods such as orange juice and breakfast cereals
- ▶ Fish that retain their bones such as sardines

Vitamin D

Vitamin D is extremely important to bone health. A vitamin D deficiency during childhood can lead to the disease known as rickets, where the bones are soft and bow out under the weight of the body, and a deficiency during adulthood can lead to osteomalacia, where there is decreased mineralization of the bone. Of the several forms of vitamin D, the molecule known as calcitriol, is the active form. One of calcitriol's many functions is to increase the gene expression for the protein calbindin in intestinal cells. Calbindin goes on to increase the amount of calcium absorbed from the diet.³³ In this way, vitamin D plays a crucial role in calcium's absorption and therefore bone health.



© commons.wikimedia.org/wiki/File:Calcitriol.png

Vitamin D can be made from cholesterol by the body through a series of steps. One of these steps requires the exposure to specific wavelengths of light within the ultraviolet range, which can be obtained from sunlight. Since it is advised to use sunscreen or limit the amount of time in the sun to protect against skin cancer, both of which will hinder the production of vitamin D in the body, one should make sure to consume the recommended amount through the diet, in addition to any time spent in the sun.

As of the updated recommendations in 2010, males and females aged 1 to 70 years need to consume 15 µg (600 IU) of vitamin D per day. Those above the age of 70 need 20 µg (800 IU) per day. Vitamin D does have a UL, which is 100 µg (4000 IU) per day for males and females above the age of 9 year.

Foods rich in Vitamin D:

- ▶ Fatty fish such as salmon, tuna, and eel
- ▶ Fortified foods such as milk
- ▶ Cod liver oil
- ▶ Beef liver

Key Points for Optimal Health

- **Vitamin D:**

1 - 70 years = 15 µg

> 70 years = 20 µg

Exercise

The key to exercising for bone health is doing weight-bearing exercise. The resistance of the weight (even simply the body's own weight), signals to the bones to become stronger to withstand such force. It should be noted that "moderate weight-bearing aerobic exercises, such as walking, can slow bone loss, but very strenuous exercise can [actually] speed bone loss."²⁵

Other Factors

Among the many detrimental outcomes from smoking, "smokers may absorb less calcium from their diets"¹⁵ leading to weaker bones. "Women who smoke also tend to have an earlier menopause than nonsmokers."³⁴ An earlier menopause means a decrease in estrogen levels sooner in life than would otherwise have occurred. As estrogen levels decrease, bone resorption increases.

Alcohol has also been shown to have a correlation with bone health as "those who drink heavily are more prone to bone loss and fracture, because of both poor nutrition and increased risk of falling."¹⁵

Conclusion

Those with eating disorders are doing great harm to their bones that cannot be seen or felt. It isn't until years later when they have a fracture that the damage is revealed. Unfortunately, most that suffer from eating disorders do so during the most crucial years of bone formation, leading to osteopenia and osteoporosis at a much earlier age than would otherwise be expected. The health of one's bones depends directly on the health of one's body and mind. Those with eating disorders should be put on the road to recovery as soon as possible to avoid any further expense to their

bones. Although weight gain is the first step to rescuing the patient's bones, their mental and emotional state should be the true focus for recovery, as that is the true underlying condition.

Additional Resources

- ▶ To calculate the 10-year probability of a bone fracture: <https://www.sheffield.ac.uk/FRAX/>
- ▶ To see a doctor specializing in osteoporosis: <http://medschool.creighton.edu/medicine/departments/departmentsofmedicine/divisions/endocrinology/osteoporosisresearchcenter/patientservices/index.php>
- ▶ To take part in a clinical trial:

<http://www.creighton.edu/researchcompliance/humanresearchprotectionprogram/researchparticipantinformation/volunteertobearresearchparticipant/osteoporosis/>

<http://clinicaltrials.gov/ct2/results?term=osteoporosis&recr=Open>

<http://clinicaltrials.gov/ct2/results?term=eating+disorders&recr=Open>

- ▶ For further information on osteoporosis: http://niams.nih.gov/Health_Info/Bone/default.asp
- ▶ For further information on eating disorders:

<http://www.nimh.nih.gov/health/topics/eating-disorders/index.shtml>

<http://www.nationaleatingdisorders.org>

<http://iaedp.com>

<http://something-fishy.org>

<http://www.bulimia.com>

References

1. "Your Body Fat Percentage: What Does It Mean?" NYU Langone Medical Center. <<http://www.med.nyu.edu/content?ChunkIID=41373>>
2. "What are the guidelines for percentage of body fat loss?" The American Council on Exercise. <<http://www.acefitness.org/acefit/healthy-living-article/60/112/what-are-the-guidelines-for-percentage-of/>>
3. "The Truth About Fat." WebMD. <<http://www.webmd.com/diet/features/the-truth-about-fat?page=2>>
4. "Food Groups." United States Department of Agriculture. <<http://www.choosemyplate.gov/food-groups/>>

5. "Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids." Institute of Medicine of The National Academies. <<http://www.iom.edu/Reports/2002/Dietary-Reference-Intakes-for-Energy-Carbohydrate-Fiber-Fat-Fatty-Acids-Cholesterol-Protein-and-Amino-Acids.aspx>>
6. "Impact of Energy Intake and Exercise on Resting Metabolic Rate." Sports Med. Aug 1990. 10(2):72-87.
7. "Minimum Amount of Calories Needed Per Day to Survive." Live Strong. <<http://www.livestrong.com/article/310517-minimum-amount-of-calories-needed-per-day-to-survive/>>
8. "Comparison of Predictive Equations for Resting Metabolic Rate in Healthy Non-Obese and Obese Adults: A Systematic Review." J Am Diet Assoc. May 2005. 105(5):775-789.
9. "Losing Weight with Basal Metabolic Rate: The Mifflin-St Jeor Method." The Fitness Corner Blog. <<http://doctorholmes.wordpress.com/2011/01/27/losing-weight-with-basal-metabolic-rate-the-mifflin-st-jeor-method/>>
10. "Weight Management." United States Department of Agriculture. <<http://choosemyplate.gov/weight-management-calories/weight-management/better-choices/increase-physical-activity.html>>
11. "Exercise Addiction in Men." WebMD. <<http://www.webmd.com/men/features/exercise-addiction>>
12. "The Exercise Addiction Inventory: A New Brief Screening Tool." Addiction Research and Theory. Oct 2004. Vol. 12, No. 5.
13. "Eating Disorders." PSAP-VII: Women's and Men's Health. Martha Fankhauser.
14. "The Importance of Nutrition As the Best Medicine for Eating Disorders." Diet and Nutrition. Carolyn Coker Ross. March/April 2007. Vol. 3, No. 2.
15. "What People With Anorexia Nervosa Need to Know About Osteoporosis." National Institutes of Health Osteoporosis and Related Bone Diseases National Resource Center. January 2012.
16. "Cortisol Secretion and Rate of Bone Loss in a Population-Based Cohort of Elderly Men and Women." Calcif Tissue Int. 2005. Sep;77(3):134-138.
17. "Evaluation and Treatment of Low Bone Density in Anorexia Nervosa." Nutrition in Clinical Care. 2002. Vol. 5, No. 6, 298-308.
18. "Depression in Anorexia Nervosa: A Risk Factor for Osteoporosis." The Journal of Clinical Endocrinology & Metabolism. 2005. 90(9):5382-5385.
19. "Treatment of anorexia nervosa is associated with increases in bone mineral density, and recovery is a biphasic process involving both nutrition and return of menses." Am J Clin Nutr. 2007. 86:92-99.

20. "Treatment of Amenorrhea and Osteopenia in the Eating-Disordered Woman." The Female Patient. Catherine Takacs Witkop. Vol. 34. February 2009.
21. "Eating Disorders." Guidelines for Adolescent Nutrition Services. Irene Alton. 2005.
22. "Secondary Causes of Osteoporosis." The Creighton University Osteoporosis Research Center. Partners in Research Biannual Newsletter #23. Spring 2009.
23. "The Female Athlete Triad." American College of Sports Medicine. 2011.
24. "Major Functions of Calcium in the Body." National Dairy Council. <http://www.nationaldairycouncil.org/sitecollectiondocuments/health_wellness/dairy_nutrients/cal2w.pdf>
25. "Osteoporosis and Eating Disorders." Eating Disorders Review. #EDRPH115A.
26. "Hip Fracture." The University of Chicago Medicine. <<http://www.uchospitals.edu/online-library/content=P08957>>
27. "High Risk of Osteoporosis in Male Patients with Eating Disorders." International Journal of Eating Disorders. 2008, 41:7.
28. "U.S. Hospitalizations Involving Osteoporosis and Injury, 2006." Agency for Healthcare Research and Quality. July 2009. <<http://www.hcup-us.ahrq.gov/reports/statbriefs/sb76.pdf>>
29. "Bone Recognition Mechanism of Porcine Osteocalcin from Crystal Structure." Nature. 2003. Oct 30;425(6961):977-980.
30. "Test ID: NTXPR NTX-Telopeptide, 24 Hour, Urine." Mayo Clinic Mayo Medical Laboratories. <<http://www.mayomedicallaboratories.com/test-catalog/Clinical+and+Interpretive/61656>>
31. "Eating Disorders and Osteoporosis." Eating Disorders Network, South East Scotland. June 2009.
32. "Perspectives in Nutrition." McGraw-Hill. Byrd-Bredbenner, Moe, Beshgetoor, and Berning. 9th edition.
33. "Advanced Nutrition and Human Metabolism." Thomson Wadsworth. Gropper, Smith, and Groff. 4th edition.
34. "Smoking and Bone Health." NIH Osteoporosis and Related Bone Diseases National Resource Center. <http://www.niams.nih.gov/Health_Info/Bone/Osteoporosis/Conditions_Behaviors/bone_smoking.asp#b>

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