# Body Composition

Objectives:

* What is body composition?
* How does body composition affect a person’s health?
* What are the health risks and costs associated with overweight and obesity?
* What is the significance of body fat distribution?
* What is Body Mass Index (BMI) and why is it important?

**Body Weight versus Body Composition**

According to surveys, the top reason American females exercise is for weight control. For males, the top reason is to improve muscle tone while weight control ranks as the fourth most important reason.1 Levels of attractiveness based on weight and visible musculature are significant points of emphasis in American culture. As such, individuals with well-toned muscles and low body weight are marketed as *superior* within the context of attractiveness, financial success, and multiple other traits. Unfortunately, this emphasis, as seen in mainstream media, can result in unrealistic ideals and potentially harmful behaviors, such as eating disorders.

Unlike the mainstream outlets, which focus on the association between fat levels and physical attractiveness, this chapter focuses on the health-related consequences related to good and bad body composition. **Body composition** is defined as the body’s relative amount of fat-free mass (FFM) and fat mass (FM) and is generally expressed as a percentage of total body weight. FFM includes bones, muscles, ligaments, body fluids and other organs, while FM is limited to fat tissue.

**The Importance of Measuring Body Composition Rather Than Just Tracking Body Weight**

Tracking weight can be helpful, but body composition measurements help separate a person’s actual weight from the weight that could be unhealthy.

For example, an individual who weighs 200 pounds and has 8% body fat, such as an athlete, only carries around 16 pounds of FM. However, a 200-pound person who has a sedentary lifestyle and a body composition of 20%, carries 40 pounds of FM. Weight alone, in this case, does not distinguish between FFM and FM and would suggest both individuals have similar health. As body fat percentage increases, the potential for various diseases also increases significantly.

## Diseases Associated with Excessive Body Fat

According to the National Institute of Health (NIH), a wide array of diseases can be linked to excessive body fat. Some of them are:

* Type II Diabetes Mellitus
* Hypertension
* Cancer
* Cerebrovascular Disease (Stroke)
* Cardiovascular Disease
* Metabolic Syndrome
* Lung Disorders
  + Sleep Apnea
  + Asthma
* Musculoskeletal Diseases
  + Osteoarthritis
  + Gout
* Gallbladder Disease
* Pancreatitis
* Non-Alcohol Fatty Liver Disease
* Dementia
* Psychological Problems and Quality of Life
* Kidney Disease
* Pregnancy Problems

## How Much Fat is Needed?

Fat is a necessary component of daily nutrition. It is needed for healthy cellular function, energy, cushioning for vital organs, insulation, and for food flavor.

Fat storage in the body consists of two types of fat: essential and nonessential fat. **Essential fat** is the minimal amount of fat necessary for normal physiological function. For males and females, essential fat values are typically considered to be 3% and 12%, respectively. Fat above the minimal amount is referred to as **nonessential fat**. It is generally accepted that an overall range of 10-22 percent for men and 20-32 percent for women is considered satisfactory for good health. A body composition within the recommended range suggests a person has less risk of developing obesity-related diseases, such as diabetes, high blood pressure, and even some cancers.

A woman’s essential fat range is naturally greater than a man’s because of fat deposits in breasts, uterus and sex-specific sites. In both males and females, non-essential fat reserves can be healthy, especially in providing substantial amounts of energy.

Excessive body fat is categorized by the terms overweight and obesity. These terms do not implicate social status or physical attractiveness, but rather indicate health risks. **Overweight** is defined as the accumulation of non-essential body fat to the point that it adversely affects health. According to the American College of Sports Medicine (ACSM), the threshold for being characterized as overweight is having a body composition of FM greater than 32% and 19% for females and males, aged 20-39, respectively.2

**Obesity** is characterized by excessive accumulation of body fat and can be defined as a more serious degree of being overweight. Classifications of obesity begin at body composition of FM greater than 39% and 25% in females and males ages 20-39, respectively. 3

## Other Health Risks

Diseases are not the only concern with an unhealthy body fat percentage. Several others are listed below.

### Performance of physical activity

An important component of a healthy lifestyle and weight management is regular physical activity and exercise. To the contrary, those who live a sedentary lifestyle will find it more difficult to maintain a healthy body weight or develop adequate musculature, endurance, and flexibility. Unfortunately, additional body weight makes it more difficult to be active because it requires more energy and places a higher demand on weak muscles and the cardiovascular system. The result is a self-perpetuating cycle of inactivity leading to more body weight, which leads to more inactivity.

### Emotional wellness

Studies indicate obesity is associated with a 25% increase in anxiety and mood disorders, regardless of age or gender. Other studies suggest increases in BMI significantly increase the incidence of personality disorders and anxiety and mood disorders. Additional studies have been able to associate a higher incidence of psychological disorders and suicidal tendencies in obese females compared with obese males.4

### Pre-mature death

The association between obesity and diseases, such as cancer, CVD, and diabetes, suggests that people with more body fat generally have shorter lifespans. The Center for Disease Control (CDC) estimates up to 365,000 deaths each year can be linked with obesity, representing nearly 15% of all deaths. Other studies have tied the Years of Life Lost to body mass index measurements, estimating anywhere from 2 to 20 years can be lost, depending on ethnicity, age at time of obese classification, and gender.5

### Economic impact

The physical harm caused by obesity and overweight is mirrored by its economic impact on the health care system. The CDC has estimated the medical costs to be about $147 billion in 2008, which includes preventative, diagnostic, and treatments. Overweight and obesity also contribute to loss of productivity at work through absenteeism and *presenteeism*, defined as being less productive while working. The annual nationwide productive costs fall within the range of from $3.38 to $6.38 billion.6

## Body Fat Distribution

Body composition measurements can help determine health risks and assist in creating an exercise and nutrition plan to maintain a healthy weight. However, the presence of unwanted body fat is not the only concern associated with an unhealthy weight. Where the fat is stored, or fat distribution, also affects overall health risks.

Non-essential fat is primarily stored in **adipose tissue**, or fat cells, located on the surface of the body and surrounding the body’s organs. Surface fat, located just below the skin, is called **subcutaneous fat**. Fat that lies deeper in the body surrounding the body’s organs is called **visceral fat**. Unlike subcutaneous fat, visceral fat is more often associated with abdominal fat. Researchers have found that excessive belly fat decreases insulin sensitivity, making it easier to develop Type II diabetes. It may also negatively impact blood lipid metabolism, contributing to more cases of cardiovascular disease and stroke in patients with excessive belly fat.7

Body fat distribution can easily be determined by simply looking in the mirror. The outline of the body, or body shape, would indicate the location of where body fat is stored. Abdominal fat storage patterns are generally compared to the shape of an apple, called the **android shape**. This shape is more commonly found in males and post-menopausal females. In terms of disease risk, this implies males and post-menopausal females are at greater risk of developing health issues associated with excessive visceral fat. Individuals who experience chronic stress tend to store fat in the abdominal region.

A pear-shaped body fat distribution pattern, or **gynoid shape**, is more commonly found in pre-menopausal females. Gynoid shape is characterized by fat storage in the lower body such as the hips and buttocks. This shape may be connected to females’ child-bearing abilities as enzymes associated with fat-storage and mobilization are activated during certain times of pregnancy and post-partum.

Besides looking in the mirror to determine body shape, people can use an inexpensive tape measure to measure the diameter of their hips and waist. Many leading organizations and experts currently believe a waist circumference of 40 or greater for males and 35 or greater for females significantly increases risk of disease.8

In addition to measuring waist circumference, measuring the waist and the hips and using a waist-to-hip ratio (waist circumference divided by the hip circumference) is equally effective at predicting body fat-related health outcomes. According to the National Heart, Lung, and Blood Institute, a ratio of greater than 0.82 for females and 0.94 for males is associated with a higher risk of developing heart disease, diabetes, and hypertension. 9

## Body Mass Index

In addition to body composition and waist/hip circumferences, measuring body mass has also been used as an effective method to assess health risks. **Body mass index (BMI)** is a measurement of

height (m2) and weight (kg) suggesting that a person’s body’s weight should be proportional to his or her height. For example, based on the BMI scale, a female with a height of 5’6” should not weigh more than 155 lbs. If her weight exceeded 155 lbs., she would be categorized as “overweight.”

Weight (kg)

BMI =

Height (m2)

Among several criticisms, the BMI method has been faulted for not distinguishing between FM and FFM, since only the overall weight is taken into account. For athletes, who may be more massive as a result of larger muscles, this criticism holds true. For example, a professional football player who weighs 215 pounds and stands at 6’3” would have the exact same BMI as a relatively sedentary arm-chair quarterback who also weighs 215 pounds with the same height. This discrepancy also exists when applying BMI to the senior population. As age increases, muscle mass declines. Seniors who have experienced years of muscle mass decline but increased body fat may maintain a constant weight despite having a very different body composition.

Other criticisms of using BMI as a health risk assessment tool include its failure to take age or gender into account. As discussed previously, females naturally have more body fat yet are classified in the same context as males. Because this measurement is so widely used by physicians, patients continue to express concerns about the validity of BMI as an indication of fatness.

Regardless of the criticisms, BMI as used for the general population, has been shown to be a reasonable predictor of health outcomes. At its core, it is not intended to be an estimate of body composition, i.e., measure FM and FFM. Instead, it is intended to be used as an estimate of healthy/unhealthy levels of body fat. When used as a means of tracking weight changes over time it can be a valuable tool in predicting health and for recommending lifestyle modifications.10

## How to Measure Body Composition

Multiple methods exist to estimate body composition. Remember, body composition is the ration of FM and FFM used to help determine health risks. Of the other methods already mentioned (waist, waist-to-hip ratio, and BMI), none provide estimates of body composition but do provide measurements of other weight-related health markers, such as abdominal fat. Experts have designed several methods to estimate body composition. While they are not flawless, they do provide a fairly accurate representation of body composition. The most common are:

### Hydrostatic Weighing (Underwater Weighing)

At one time, hydrostatic weighing (also and maybe more accurately called **hydrodensitometry**) was considered the criterion for measuring body composition. Many other methods are founded on this model, in one form or another. This method attempts to measure the density of the body by applying Archimedes’ principle:

density = mass/volume. The mass and volume components are measured by using dry weight and then weight while being submerged in a water tank. Since fat is less dense than muscle tissue, a person with more body fat will weigh less in the water than a similar person with more lean mass. Using the measurements, the density can be determined and converted into body fat percentage. With a small margin of error (around 1-2%) this method is very accurate. Unfortunately, the expense and practicality of building and maintaining a water tank limits access for most. Also, for those with a fear of water, this would obviously not be the preferred method.

### Dual Energy X-Ray Absorptiometry (DEXA)

Replacing underwater weighing as the new “gold standard,” is DEXA. While underwater weighing accurately compartmentalizes FM and FFM, DEXA adds a third compartment by using low-radiation X-rays to distinguish bone mineral. This addition slightly increases the accuracy of DEXA by eliminating some of the guess work associated with individual differences, such as total body water and bone mineral density.

Originally, DEXA scanners were designed to determine and help diagnose bone density diseases. As a result, they can be found in many physicians’ offices. However, a full body scan, which takes only a few minutes, is all that is needed to also determine body fat percentage.

Major disadvantages to this method are its high cost and the need for a well-trained professional to operate the equipment and analyze the results.

### Air Displacement (Plethysmography)

A good alternative to more expensive methods, air displacement determines body density using the same principle as underwater weighing, by measuring mass and volume. Clearly, the main difference is that mass and volume are being determined by air displacement rather than water displacement. Using a commercial device (the Bod Pod is most commonly referenced), a person sits in a chamber that varies the air pressure allowing for body volume to be assessed. Air displacement provides a viable alternative for those with a fear of water.

Like many other methods, the expense, availability, and training of personnel Air Displacement requires limit accessibility. Additionally, its accuracy is slightly less than underwater weighing.

### Bio-electrical Impedance Analysis (BIA)

BIA takes a slightly different approach to measuring FFM. The premise behind BIA is that FFM will be proportional to the electrical conductivity of the body. Fat-tissue contains little water, making it a poor conductor of electricity; whereas, lean tissue contains mostly water and electrolytes, making it an excellent conductor. BIA devices emit a low-level electrical current through the body and measure the amount of resistance the current encounters. Based on the level of impedance, a pre-programed equation is used to estimate body fat percentage.

The most accurate BIA devices use electrodes on the feet and hands to administer the point-to-point electrical current. The margin of error for these devices falls in the range of 3–5%. Portable or handheld BIA devices that only measure lower or upper body conductivity have a higher margin of error (4–8%).

Because BIA devices primarily measure hydration, circumstances that may influence hydration status at the time of measurement must be taken into account. Recent exercise, bladder content, hydration habits, and meal timing can cause wide measurement variations and influence accuracy. However, this method is generally inexpensive, often portable, and requires limited training to use, making it a very practical option.

### Skinfold Analysis

Skinfold analysis is a widely used method of assessing body composition because of its simplicity, portability, and affordability. It is also fairly accurate when administered properly. Margins of error are about 4–7%, depending on the quality of the skinfold calipers and skill of the administrator/technician. The assumption of skinfold measurement is that the amount of subcutaneous fat is proportionate to overall body fat. As such, a technician pinches the skin at various sites and uses calipers to measure and record the diameter of the skin folds. These numbers can then be plugged into an equation to generate an estimate of body fat percentage.

The proportionality of subcutaneous fat and overall body fat depends on age, gender, ethnicity, and activity rates. As such, technicians should use the skinfold technique specific to the equation that accounts for those variables to improve accuracy.

## Weighing in on the U.S.

Despite the well-known health concerns implicated in overweight and obesity and the availability of multiple methods for assessment and tools to improve body composition, current trends in the United States and around the world are moving in the wrong direction. The unprecedented number of obese Americans has led experts to label it an epidemic, much like they would a disease in a developing country. According to the CDC, the number of American adults (>20 years) that fall into the overweight classification based on BMI are 70.7%. Of those, 37.9% fall within the obese classification. In 1962, the overweight and obesity rates for adults in the U.S. were 32% and 13%, respectively. In other words, overweight trends have more than doubled and obesity rates have almost tripled over the past 50+ years.11

Of more concern are the increasing number of obese children ages 6-11 and adolescents ages 12-19, amounting to 17.4% and 20.6%, respectively.12 While those numbers have stabilized over the past decade, this has led to a dramatic increase in insulin resistance, a form of diabetes formerly known as adult onset diabetes.

With such a diverse population in the U.S. and with an understanding of how BMI is calculated, it is only natural to question the high number of overweight and obese citizens based on BMI alone. However, it is generally believed this is an accurate portrayal of weight status. In a study attempting to compare BMI measurements to actual body fat percentage, it was determined that the total number of obese citizens may be underestimated, and its current prevalence may be worse than is currently being reported.

## What Can Be Done?

With the available tools to identify health risks associated with body fat, anyone concerned about their health should gather as much data about body composition and body fat distribution as possible. Compiling multiple measurements and analyzing them provides a better idea of a person’s current health status and will help determine the next course of action. For example, BMI alone can be beneficial. But when combined with waist circumference, a greater understanding of risk can be achieved. Likewise, when combining BMI and waist circumference with body fat percentage, an ideal conclusion of health status can be made.

In the lab accompanying this chapter, you will be guided through the process of assessing your BMI, waist circumference, waist-to-hip ratio, and body fat percentage.

The next course of action is to set goals and formulate a plan to get to a healthy range of weight and body fat percentage. Where weight loss is needed, the plan should include a balance of calorie restriction and physical activity/exercise. This might also include tracking your current eating and activity habits. More specific information on weight management strategies will be discussed in a later chapter.

## Low Body Composition

Because more people experience excess body fat, the focus up to this point has been on health concerns related to overweight and obesity. However, fat is an essential component to a healthy body, and in rare cases, individuals have insufficient fat reserves, which can also be a health concern. The range of essential body fat for males is 3-5% and 8-12% for females. Attempting to, or intentionally staying in those ranges, through excessive exercise or calorie restriction is not recommended. Unfortunately, low body fat is often associated with individuals struggling with eating disorders, the majority of whom are females.

The main concern of low body fat relates to the number and quality of calories being consumed. Foods not only provide energy but also provide the necessary nutrients to facilitate vital body functions. For example, low amounts of iron from a poor diet can result in anemia. Potassium deficiencies can cause hypokalemia leading to cardiovascular irregularities. If adequate calcium is not being obtained from foods, bone deficiencies will result. Clearly, having low body fat, depending on the cause, can be equally as detrimental to health as having too much.

The health concerns most often linked to low body fat are:

* Reproductive disorders
  + Infrequent or missing menstrual cycles
* Respiratory disorders
* Immune System disorders
* Circulatory disorders
* Premature death

In some cases, despite attempts to gain weight, individuals are unable to gain the pounds needed to maintain a healthy weight. In these cases, as in the case of excess fat, a holistic approach should be taken to determine if the low levels of body fat are adversely affecting health. These individuals should monitor their eating habits to assure they are getting adequate nutrition for their daily activity needs. Additionally, other lifestyle habits should be monitored or avoided, such as smoking, which may suppress hunger.

Additional reading on low body fat and its impact can be found on the Livestrong.com website, on this page: [At what body fat percent do you start losing your period?](http://www.livestrong.com/article/385269-at-what-body-fat-percent-do-you-start-losing-your-period/).

**Terminology Checklist**

**Body Composition:** The measurement of the body’s proportion of fat mass to fat free mass.

**Fat Mass:** The amount of fat tissue in the body often expressed as a percentage of total body mass.

**Fat Free Mass (FFM):** not fat tissue in the body such as bones, muscles, ligaments, and blood.

**Essential Fat:** the amount of fat needed for vital body functions.

**Non-essential fat:** the amount of fat that exceeds the necessary fat needed for vital body functions. This fat is considered energy storage.

**Overweight:** the accumulation of non-essential body fat to the point that it adversely affects health.

**Obesity:** is characterized by excessive accumulation of body fat and can be defined as a more serious degree of being overweight.

**Adipose Tissue:** another term for fat. More specifically it is loose connective tissue composed of adipocytes.

**Subcutaneous fat:** fat tissue stored below the skin’s surface.

**Visceral Fat:** fat tissue stored around central organs.

**Android shape**: a body shape used to help characterize body fat distribution in which fat is stored in the abdominal region. The android shape is also called the “apple” shape.

**Gynoid shape**: a body shape used to help characterize body fat distribution in which fat is stored in the hips, buttocks, and thighs. It is also called the pear shape.

**Body Mass Index (BMI):** an index based on concept that weight and height should be proportionate. It is calculated by dividing weight by the height squared (weight/height2).

**Hydrodensitometry**: This method attempts to measure the density of the body by using water displacement.

**Dual Energy X-ray Absorbtiometry (DEXA):** A method of measuring body composition that uses low energy x-rays that also measure bone density.

**Air Displacement Plethysmography**: A method of measuring body composition that measures the density of the body by using air displacement.

**Bio-electrical impedance analysis (BIA):** A method of measuring body composition by emitting a small electrical current through the body and using the amount of resistance encountered by this current to predict body fat content.

**Skinfold Analysis**: A method of measuring body composition by measuring the diameter of pinched skin at various sites on the body.

**Test Your Knowledge**

1. The key to healthy body composition is to:
   1. Emphasize short-term weight loss
   2. Focus on lifestyle changes
   3. Emphasize diet only
   4. Set unrealistic goals
2. The people who tend to gain weight in the hip area have a higher incidence of coronary heart disease than those people who gain weight in the abdominal area.
   1. True
   2. False
3. The “Bod Pod” estimates percent body fat by using:
   1. Low energy x rays
   2. Water displacement
   3. Air displacement
   4. Electrical current
4. Essential body fat is best described as:
   1. Fat essential to look good
   2. Fat essential for body functioning
   3. Fat used as energy storage
   4. Fat used to cushion organs
5. Which of the following methods for measuring body composition would be considered most accurate?
   1. DEXA
   2. Skin folds
   3. BIA
   4. Plethysmography

Answer Key

1. B
2. B
3. C
4. B
5. A

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