Body Composition Measurement

Learn more

Body Composition in Children and Adults

Body composition, or fat vs. fat-free (lean) mass, reflects the results of a person's physical activity and nutritional practices. Monitoring body weight alone can be very misleading, because a scale can’t tell the difference between a pound of fat and a pound of muscle. Sedentary people sometimes gain fat and lose muscle without any noticeable change in their weight. Or, while on an exercise/weight training program a person may not experience a significant change in weight, yet their muscle mass is most likely increasing, while they are also probably losing body fat. A body composition analysis would reveal these important shifts in body composition that a scale cannot. And even though a certain amount of body fat is needed to insure good health, excess body fat has been found to dramatically increase the risk of diseases such as cancer, diabetes, and heart disease, just to name a few. In fact, the Centers for Disease Control and Prevention (CDC) have now declared obesity an epidemic, with 66% of adult Americans either overweight or obese (having excess body fat). Even more alarming is the dramatic increase of obesity in children and adolescents, with 30% of young Americans under the age of 18 now classified as either overweight or obese.

Only by accurately assessing body composition will one know exactly what makes up their weight, enabling sensible decisions regarding nutrition and exercise programs to be made. It’s the single best way for a person to get the “whole picture” of what’s really going on in their body.

Body composition measurement techniques can vary greatly, with many methods being too difficult, invasive, or inaccurate. For example, Skinfold Calipers and Bioelectric Impedance have error factors of up to +/-8%. This means that a skinfold or bioelectric impedance measurement of 22% body fat could actually be as low as 14% or as high as 30%. Inaccurate information like this can be downright dangerous if used for developing diet and/or training programs, so it’s important to use an accurate method when assessing body composition.

Body Composition in Infants

It is now widely recognized that the accurate assessment and tracking of body composition in the critical period immediately following birth can provide key information in both clinical and research settings. Body composition information can be used to help monitor and evaluate infant growth patterns, optimize nutritional interventions, obtain important feedback during drug treatments, and optimize release criteria. The collection of body composition data can also be used in establishing normative infant body fat ranges. Looking beyond infancy, recent studies have shown that an infant’s body composition may indicate a propensity for diseases later in life related to obesity, hypertension, cardiovascular, and diabetes.

Previously, obtaining reliable infant body composition data has been difficult, with available methods limited by problems with accuracy, practicality, invasiveness, and safety. The PEA POD has solved all of these issues by offering accurate and precise measurements of infant body fat and fat-free mass quickly, safely, and comfortably using its patented and proven Air Displacement Plethysmography.

Air Displacement Plethysmography (ADP)

The patented Air Displacement Plethysmography used by the BOD POD and PEA POD is similar in principle to hydrostatic (or “underwater”) weighing. The obvious difference is that air is more convenient and comfortable than water, so that ADP provides a much easier and safer testing environment, better reliability, and

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COSMED Body Composition page
http://www.cosmed.com/bodycomposition

COSMED BOD POD GS page
http://www.cosmed.com/bodpods

COSMED BOD POD EX page
http://www.cosmed.com/bodpodex

COSMED PEA POD page
http://www.cosmed.com/peapod
significantly improved repeatability and accuracy.

The basic operating principles of ADP include Densitometry, Mass Measurement, Volume Measurement, Thoracic Gas Volume, and Surface Area Artifact.

Densitometry

With Air Displacement Plethysmography, body composition is derived from body density, or Densitometry. In densitometry, the more dense a body is, the lower the percentage of body fat; the less dense a body is, the higher the percentage of body fat (Density = Mass/Volume).

Densitometry is based on modeling the body into two compartments: a fat compartment and a fat-free mass compartment. The fat-free mass compartment consists of protein, water, mineral, and glycogen.

From the subject’s body density, relative proportions of body fat and lean body mass are calculated based on the density of fat and lean tissue. Because lean tissue is more dense than fat tissue, a higher density reflects a higher proportion of lean tissue. A commonly used equation which translates whole body density to percent body fat is the Siri equation: Percent Fat = \[\frac{495}{\text{Density}} - 450\]

Once the percent body fat is calculated, the percent lean body mass can also be determined as follows: Percent Lean Body Mass = 100 - Percent Fat

Mass Measurement

Mass (weight) is measured using a very precise, integrated electronic scale.

Volume Measurement

Volume is determined by ADP, which occurs when the subject is inside the BOD POD or PEA POD chamber. Because ADP relies on the relationship between pressure and volume, it allows for the derivation of an unknown volume by directly measuring pressure.

During the volume measurement, small changes in volume occur inside the chamber, and the pressure response to these small volume changes is measured. This is done by measuring the interior volume of the empty chamber, then measuring it again when the subject is inside. By subtraction, the subject’s body volume is obtained. For example, the interior air volume of the empty chamber is 450 liters; so if the volume of the chamber is reduced to 350 liters with the subject inside, the body volume of the subject would be 100 liters.

Thoracic Gas Volume

Because any air trapped in the subject’s thoracic cavity, either free or trapped, is not part of their body volume, the air in the lungs must be accounted for. Depending upon the capabilities of the device being used, thoracic gas volume may be directly measured, retrieved from a previous test, predicted (using a standard prediction equation), or entered manually.

Surface Area Artifact

Due to isothermal behavior, the volume of air in close proximity of the subject’s surface is overestimated by 40%. This small surface area artifact (an apparent reduction in the subject’s body volume) is automatically calculated by the BOD POD and used to correct subject body volume.

The surface area of clothing and hair can also have a significant impact on volume measurements. It is extremely important that subjects tested using ADP wear minimal, form-fitting clothing and a cap to compress the hair on the head.

BOD POD vs. other Body Composition methods

Over the years a number of methods have been developed to measure body composition. Until the BOD POD, all of these methods had drawbacks, such as being inaccurate, messy, difficult, requiring extensive training, or invasive.

In measuring body composition, it’s not only important what the result is, but also how you arrive at it. For example, let’s say you’re a woman with a skinfold or bioelectric impedance body fat measurement of 22%. At first glance it seems that you fall into a healthy body fat range. The problem is, since the error factor for both of these methods is up to +/-8%, this number could mean your actual body fat might be as low as 14% (risky – low body fat) or as high as 30% (borderline excess fat). Inaccurate information like this is no better than no information at all, and can be downright dangerous if being used to determine an appropriate diet and/or training program.
This is why it's so important to receive an accurate body composition assessment. It's the only way to get the proper information necessary for making sensible decisions regarding nutrition and fitness programs.

**Hydrostatic (Underwater) Weighing**

This technique determines body fat from body density (the ratio of body weight to body volume) or: $D = \frac{\text{Mass}}{\text{Volume}}$. It is based on the whole-body principle of Archimedes, which states an object's loss of weight in water equals the weight of the volume of water it displaces. In this procedure the subject sits strapped in a chair that is submerged into a water tank and weighed. While submerged, the subject must expel all the air from their lungs and hold their breath for 10-15 seconds until the scale can be read. This process is repeated up to 10 times to ensure accuracy.

**Average Test Time:**
30-60 minutes

**Advantages:**
- An established reference method for measuring body density.
- Known to be very accurate when compliance issues can be followed properly.

**Disadvantages:**
- Test time is lengthy, arduous, and very difficult to perform correctly
- Technician must be highly skilled in order to obtain accurate results
- Some populations are impossible to test, including the extremely obese, disabled, elderly, infants and small children, and those with an aversion to water
- Ongoing maintenance issues are high. Water temperature needs to remain constant and the tank should be drained after each measurement, since dirty water can skew results.
- A wide range of equipment, protocols, calibration, and methods for determining residual Residual Volume can contribute to measurement errors
- Hygiene issues

**Dual Energy X-Ray Absorptiometry (DXA)**

This technique was initially developed to measure bone mineral density, not body composition. During testing a subject lies on a table and the body is slowly scanned. Computer software then reconstructs an image of the underlying tissue to determine total fat and lean mass.

**Average Test Time:**
10 minutes

**Advantages:**
- Provides more accurate results than field methods.
- Comfortable

**Disadvantages:**
- Uses x-ray technology, which is invasive
- Special license required for operator
- Equipment is very expensive and availability is mostly exclusive to medical facilities
- Cannot accommodate extremely large/obese people
- Different DXA equipment can produce different results

**Bioelectric Impedance**

Considered a field method, this technique is based on the concept that the lean tissue of the body is more conductive than fat tissue due to its higher water content. Testing involves placement of electrodes on the skin, while a low dose electrical current is passed through the body. The resistance to this current is determined and converted to percent body fat.

**Average Test Time:**
Under 5 minutes
BOD POD vs other Body Composition methods

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*Populations – refers to the ability of the method to assess body composition among a wide range of populations, including the elderly, obese, children, and those with disabilities.

Advantages:
- Quick
- Easy and comfortable

Disadvantages:
- Not as accurate as the BOD POD, hydrostatic weighing, or DXA (error factor of ±8% fat)
- Results are greatly affected by the type of instrument used, hydration level, food intake, and skin temperature
- Can’t be used by those with medical implants such as pacemakers and defibrillators

Skinfold Calipers

Considered a field method, this technique measures subcutaneous fat at several sites on the body by pinching the skin with calipers. The assumption is that subcutaneous fat is proportional to the subject’s total body fat.

Average Test Time: Up to 20 minutes

Advantages:
- Portable and easily performed in the field
- Inexpensive

Disadvantages:
- Not as accurate as the BOD POD, hydrostatic weighing, or DXA (error factor of ±8% fat), since only subcutaneous fat is being measured
- Reliability is highly dependent upon the type of calipers used and the skill level of the technician
- Not a valid method for measuring the extremely obese
- Testing can take a long time, as many sites need to be pinched repeatedly to achieve the most accurate results

Body Mass Index (BMI)

This is a mathematical calculation based on a subject’s height and weight, which is used to make an assumption of the subject’s body fat.

Average Test Time: Less than 5 minutes

Advantages:
- Inexpensive
- Easy to perform

Disadvantages:
- Does not directly measure body fat
- Often misclassifies muscular subjects as being obese
- Same range classifications are used for both men and women
- Does not take into account age, gender, and ethnicity when determining results