BODY COMPOSITION ANALYSIS • BCA

Frequently Asked Questions

1. Is DXA the gold standard test for body composition? How does it compare to other techniques available for determination of body composition such as hydrometrics, volumetric analysis, caliper readings, electric impedance analysis etc?

Body composition (particularly body fat percentage) can be measured in several ways. These include:

- **ANTHROPOMETRY** (skin fold test or pinch test) Anthropometry refers to measurements made of various parameters of the human body, such as circumferences of various body parts or thicknesses of skin folds. In the skin fold or pinch test, a pinch of skin is precisely measured by calipers at several standardized points on the body to determine the subcutaneous fat layer thickness. These measurements are converted to an estimated body fat percentage based on multiple statistical models. Some formulas require as few as three measurements, others as many as seven. Skin fold-based body fat estimation is sensitive to the type of caliper used, and technique. This method also only measures one type of fat: subcutaneous adipose tissue (fat under the skin). Two individuals might have nearly identical measurements at all of the skin fold sites, yet differ greatly in their body fat levels due to differences in other body fat deposits such as visceral adipose tissue: fat in the abdominal cavity. Because most anthropometric formulas actually estimate body density, not body fat percentage, the body fat percentage is obtained by applying a second formula. Consequently, the body fat percentage calculated from skin folds or other anthropometric methods carries the cumulative error from the application of two separate statistical models. These methods are therefore inferior to a direct measurement of body density and the application of just one formula to estimate body fat percentage. One way to regard these methods is that they trade accuracy for convenience.

- **UNDERWATER WEIGHTING** Hydrostatic weighting estimates a person’s average body density. With a well engineered weighing system, body density can be determined with great accuracy by completely submerging a person in water and calculating the volume of the displaced water from the weight of the displaced water. A correction is made for the buoyancy of air in the lungs and other gases in the body spaces. If there were no error whatsoever in measuring body density, the uncertainty in fat estimation would be about ± 3.8% of the body weight, primarily because of normal variability in body constituents. Estimation of body fat percentage from underwater weighting has long been considered to be the best method available, especially in consideration of the cost and simplicity of the equipment. Underwater weighing gives an actual measurement of body density rather than a prediction. Hydrostatic weighting is not readily available to the general population at large, however.

- **AIR DISPLACEMENT PLETHYSMOGRAPHY** (ADP) In ADP, subjects enter a sealed chamber that measures their body volume through the displacement of air in the chamber. Body volume is combined with body weight (mass) in order to determine body density. The technique then estimates the percentage of body fat and lean body mass (LBM) through known equations (for the density of fat and fat free mass). ADP is also not readily available to the general population at large.
**-BIOELECTRICAL IMPEDANCE ANALYSIS (BIA)**  In BIA, two or more conductors are attached to a person's body and a small electric current is sent through the body. The resistance between the conductors will provide a measure of body fat between the pair of electrodes, since the resistance to electricity varies between adipose, muscular and skeletal tissue. Fat-free mass (muscle) is a good conductor as it contains a large amount of water (approximately 73%) and electrolytes, while fat is anhydrous and a poor conductor of electric current. Factors that affect the accuracy and precision of this method include instrumentation, subject factors, technician skill, and the prediction equation formulated to estimate the fat-free mass. BIA method is a lower-cost but less accurate way to estimate body fat percentage.

**-CROSS SECTIONAL ANATOMIC IMAGING (MRI, CT, US)**  MRI and CT give precise body composition measures, but are not readily available to the population at large for this purpose. CT also exposes the patient to ionizing radiation. Ultrasound has also been used to measure subcutaneous fat thickness, and by using multiple points a measurement of body composition can be made. Ultrasound can also directly measure muscle thickness and quantify intramuscular fat. Ultrasound, CT, and MRI equipment is expensive, however, and not cost-effective solely for body fat measurement.

**-DXA (DUAL ENERGY X-RAY ABSORPTIOmetry)**  DXA was originally designed to measure bone mass and has been shown to be both accurate and precise when used for this purpose. Body composition measurement by Dual Energy X-ray Absorptiometry (DXA) is now used increasingly for a variety of clinical and research applications. X-rays of two different energies are used to scan the body, one of which is absorbed more strongly by fat than the other. A computer can subtract one image from the other, and the difference indicates the amount of fat relative to other tissues at each point. A sum over the entire image enables calculation of the overall body composition. Total body or estimated total body scans using DEXA give accurate and precise measurements of BMD and body composition, including bone mineral content (BMC), bone mineral density (BMD), lean tissue mass, fat tissue mass, and fractional contribution of fat. These measurements are extremely reproducible, making them excellent for monitoring pharmaceutical therapy, nutritional or exercise intervention, sports training &/or other body composition altering programs. They are also fast, simple, non-invasive, and expose the subject to a level of x-rays less than that of a cross-country flight. DEXA exams provide both total body and up to 14 regional (trunk, individual arms & legs, android, gynoid, etc.) results. BC assessments by DXA are readily available, less expensive, and less invasive compared with other diagnostic imaging techniques. DXA is now one of the most frequently used techniques for BC measurement as a result of the increasing worldwide availability of these scanners. For these reasons, it is considered to be superior to many other methods.

2. **Is whole body DXA for body composition suitable for the evaluation and management of childhood obesity?**

In select circumstances, DXA has been employed in the assessment of body fat in overweight and obese children. Newer scanning techniques in particular have significantly shortened scanning times, which have allowed for its application in pediatric studies. There are widely acknowledged limitations and disadvantages with whole body DXA in children, however. Whole body DXA for childhood obesity should not be performed outside specialist centers, and should only be ordered by a pediatric specialist who is familiar with its role in the evaluation of BC. DXA in children should only be considered as part of a medically guided program under the supervision of a pediatric specialist, who can interpret the body composition results and use them to guide medically necessary therapy.
3. **Is whole body DXA for body composition safe in pregnancy?**
   **What if I might be in early pregnancy, and not yet know it?**

Women should always inform their physician or x-ray technologist if there is any possibility that they are pregnant. While the vast majority of medical x-rays do not pose a critical risk to a developing child, there may be a small likelihood of causing a serious illness or other complication. The actual risk depends on how far along the pregnancy is and on the type of x-ray. In general, the radiation exposure from whole body DXA is relatively low, but it is not zero. As a precaution, therefore, we recommend that whole body DXA for body composition in women of childbearing age be scheduled in the first 7-10 days following onset of the menstrual period, before conception can occur.

4. **What is the radiation exposure from whole body DXA?**
   **How does it compare to other imaging tests, and what are the risks involved?**

Whole body DXA does involve low level radiation. Low level radiation is a natural part of life, however. Exposure from cosmic rays and naturally occurring isotopes in the environment at sea level is 2,000 microSieverts per year at sea level. In Calgary it is 3,000 microSieverts per year because of the higher altitude and reduced protective effect of the atmosphere from cosmic rays. At more than 30,000 feet there is an additional exposure of the 3 to 5 microSieverts per hour. The largest source of background radiation comes from radon gas in our homes, however, which can be up to 2000 microSieverts per year.

A DXA whole body scan results in less than 5 microSieverts exposure. In other words the exposure for a DXA whole body scan is equivalent to taking a commercial airline flight of approximately one hour duration, such as from Calgary to Vancouver. Considering the annual dose equivalent from natural background radiation (2400 uSv per annum) and from other imaging procedures such as dental bitewing (60 uSv), Chest X-ray (50 uSv), and thoracic and lumbar lateral spine X-ray (820 uSv), the radiation exposure from whole body DXA is relatively low.

The additional lifetime risk of fatal cancer from a whole body DXA exam is negligible, less than one in a million. This is a negligible addition to the 1 in 5 lifetime chance that we all have of dying from cancer.

5. **How long does the test take? Is there any special preparation required?**

The scan takes approximately 15 minutes. No injection of dye or other tracer is required. Wear loose fitting clothing. Shoes and any objects with metal or dense buttons or zippers must be removed. Do not eat a large meal before the test. It will be measured as part of the body. Large implanted metal objects such as joint replacements may interfere with the test.
6. What is the cost?

Body composition measurement by DXA is not covered by the Alberta Health Care Insurance Plan unless it is requested by a medical doctor as part of treatment of a medical condition. If you have additional insurance, you should check with your plan administrator if you are eligible for reimbursement.

Single DXA: $75.00

7. How accurate and precise is whole body DXA scanning for BCA?

The ability to monitor change in BC in an individual depends on the precision error of the measurement. DXA is now one of the most frequently used techniques for BC measurement as a result of the increasing worldwide availability of these scanners. The precision of a particular DXA device for assessing whole BC is generally good, with coefficients of variation of about 1% for BMC and 2-3% for total body fat. For this reason, DXA has been used to determine both long term change in BC with aging and short-term change in BC as a result of intervention. DXA devices are proven to have long-term stability and provide high precision in BMD scans of 1-2% and in BC scans of 2-6%.

8. What is the minimal detectable difference (MDD) in body fat loss that can be readily discerned by serial whole body DXA scans? That is, how much weight in fat do I have to lose before this test can tell the difference?

MDD refers to the Minimal Detectable Difference – the magnitude of change that a pair of measurements must exceed in order to be considered statistically significant (for example, say a 95% statistical likelihood that a real change has occurred). Although this is different than the difference between two group means, MDD results do indicate the order of magnitude of a significant change in body fat mass for an individual, as measured by DXA.

In some study populations, relative and absolute MDD values ranged from 11% or 160 grams for arm fat, to 4.3% or 628 grams for total fat.

9. How should I use the results?

Calculation of Desired Body Weight based on % Fat:

The calculation will be based on your actual Lean Body and Bone Mineral Mass rather than of some average person.

There is no universally accepted standard for ideal % Body Fat. Essential fat is the minimum required for normal physiologic function and is backed by scientific evidence. The percentage is higher for women during reproductive years because of the role of body fat in storing essential hormones. The definition for obesity is more arbitrary but is also supported by considerable scientific evidence. Between the extremes, what is considered ideal depends on heredity, ethnic background, culture and many other factors. The appropriate level is an individual decision based on many factors including

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information and the advice of health care professionals. The following is a commonly accepted guideline:

<table>
<thead>
<tr>
<th>Guidelines for % Body Fat</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential Fat:</td>
<td>10 – 13</td>
<td>2 – 5</td>
</tr>
<tr>
<td>Athletes:</td>
<td>14 – 20</td>
<td>6 – 13</td>
</tr>
<tr>
<td>Fitness:</td>
<td>21 – 25</td>
<td>14 – 17</td>
</tr>
<tr>
<td>Healthy:</td>
<td>25 – 31</td>
<td>18 – 24</td>
</tr>
<tr>
<td>Obese:</td>
<td>32 +</td>
<td>25 +</td>
</tr>
</tbody>
</table>

The following steps are required:

a) Determine the desired % Body Fat (%DF):

b) Calculate the corresponding desired fat mass (FM) based on your own Lean Body and Bone Mineral Mass (LBBMM):

\[
\frac{FM}{FM + LBBMM} = \frac{%DF}{100}
\]

Or,

\[
FM = \frac{%DF}{100} \times \frac{LBBMM}{(1 - \frac{%DF}{100})}
\]

c) Calculate the desired weight by adding the calculated FM to the determined LBBMM

\[
\text{Desired Weight} = FM + LBBMM
\]

Where:

- FM = Fat Mass
- LBBMM = Lean Body and Bone Mineral Mass
- %DF = % Desired Fat

In the case of the subject in the example:

a) Let us assume that the desired % fat is a healthy level of 30%:

b) Fat Mass (Kg) = \( \frac{30}{100} \times 48.1 \text{ Kg} / (1 - \frac{30}{100}) \)

\[
= 20.6 \text{ Kg}
\]

c) Desired Weight = 48.1 + 20.6 = 68.7 Kg

The desired weight may change if the target % Fat Mass is changed or if LBBMM changes over time as a result of a fitness program or other factors (repeat measurement will be required). In the interim, simple measurements such as weight, body circumference and skin fold thickness can be used to monitor progress.

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10. How often should follow-up DXA exams be considered?

The ability to monitor change in BC in an individual depends on the precision error of the measurement. The precision of a particular DXA device for assessing whole BC is generally good, with coefficients of variation of about 1% for BMC and 2-3% for total body fat. For this reason, DXA has been used to determine both long term change in BC with aging and short-term change in BC as a result of intervention. As a general rule, we do not recommend repeating DXA measurements before 3 to 6 months.

11. What are the minimum acceptable levels of body fat? Is it harmful to have too low body fat?

Essential levels of body fat are required to maintain normal organ function. Essential body fat levels are approximately 5% for men and 8% for women. Minimum acceptable levels of body fat are 5% for men and 10-14% for women. In athletes, body fat ranges from 5-13% for men and 12-22% for women.

For women, having too little body fat can disrupt the menstrual cycle and lead to infertility, and also increases the risk of osteoporosis. For men, testosterone levels may decrease, which may decrease sperm production and libido. For athletes, after roughly 20 minutes of exercise, the body can no longer draw energy from ingested carbohydrates, so normally turns to body fat stores. Low body fat levels, however, can lead to incomplete recoveries after workouts, depleted glycogen stores, and nutritional deficiencies that may lead to further problems.

12. What is the problem with having too high a body fat?

High body fat is one of the most serious public health problems of the 21st century, as it is a leading PREVENTABLE cause of death worldwide, and as it shows increasing, not decreasing, prevalence in adults and children.

High body fat increases the likelihood of various diseases, particularly heart disease, type 2 diabetes, obstructive sleep apnea, certain types of cancer, osteoarthritis, and asthma. A particularly notable association is “metabolic syndrome”, a combination of medical disorders which includes diabetes mellitus type 2, high blood pressure, high blood cholesterol, and high triglyceride levels.

Health consequences from high body fat fall into two broad categories: those attributable to the effects of increased body fat (such as osteoarthritis, obstructive sleep apnea) and those due to the increased number of fat cells (diabetes, cancer, cardiovascular disease, fatty liver disease, etc). High body fat has been found to reduce life expectancy. A body mass index (BMI, calculated by dividing the subject’s weight in kilograms divided by the square of his or her height in meters) above 32 has been associated with a doubled mortality rate among women over a 16 year period. 1 million (7.7%) of deaths in Europe are attributed to excess body fat / weight. On average, excess body fat reduced life expectancy by 6-7 years. A BMI of 30-35 reduces life expectancy by 2-4 hours, while severe obesity (BMI > 40) reduces life expectancy by 10 years.