BODY COMPOSITION

Body composition is used to describe the percentagês of fat, bone, water, and muscle in human bodies. Two people of same sex and body weight may look completely different from each other because they have a different body composition. Both the body composition and growth are key components of health in both individuals and populations. In specific, body composition is a method of describing what the body is made of. It includes fat, protein, minerals and body water. It also describes weight more accurately than BMI. Body composition analysis can accurately show changes in fat mass, muscle mass, and body fat percentage.

Body composition has been used for almost hundred years by nutritionists and physiologists for the purpose of studying nutrition, physical growth, and physical performance (Forbes, 1999). Human body composition measurements are also objective methods of nutritional assessment and are of interest to nutritionists, health professionals and sports scientists. With the increasing prevalence of obesity and lifestyle diseases, there is increased need for body composition methods with greater sensitivity and precision. The assessment of body composition provides insights into both nutritional status and functional capacity of the human body and is useful in nutrition for describing growth and development from birth through to adulthood and for understanding the developmental origins of health and disease, in designing nutritional strategies, and in monitoring of therapeutic interventions.

Methods of Body Composition

Field Methods

Anthropometry: Anthropometric measurements are non-invasive and help in assessing the nutritional status, identifying individuals at risk, monitoring the efficacy of a nutrition intervention and providing information about the body's stores of fat and muscle. Since these are relatively simple to measure, inexpensive and do not require high level of technical skill, anthropometric measurements are used widely in clinical situations and large epidemiological studies.

(1) **BMI:** The body mass index (BMI) is widely used to estimate body fat as it is simple and inexpensive. The WHO classification is commonly used to categorize BMI. The percentage body fat (%BF) for a given BMI changes with age, and the rate of this change varies depending on sex, ethnicity and individual differences. In addition, BMI is not sensitive to the actual distribution of body fat and metabolic risk. Indians, both within and outside Asia, are more adipose for a given BMI than other ethnic groups. This is important since total body fat and the location of body fat are strongly associated with insulin sensitivity in Indians. Due to the evidence of the increased adiposity in Indians, it was suggested that the BMI cut-off should be reduced to 23 kg/m^2 for non-communicable diseases. The WHO Expert Committee however, set a BMI of 23 kg/m^2 as public health action point rather than a cut-off. Recently, the Indian Consensus Group established guidelines and classified a BMI of ≥23kg/m^2 and ≥25kg/m^2 as overweight and obese, for Asian Indians residing in India.

(2) **Waist Circumference:** Waist circumference is used in children and adults as an indicator of intra-abdominal fat. Waist circumference is measured with a non-stretchable tape to the nearest 0.1 cm, in a standing position during end-tidal expiration at the midpoint of the lowest rib cage and the iliac crest. The indicators of risk based on waist circumference are given ≥102 cm in men and ≥88 cm in women. Several waist circumference cut-off points have been evaluated in relation to BMI cut-off points and cardiovascular diseases in individuals residing in north India and the proposed action level for adult Asian Indians was set as: action level 1: men, ≥78 cm, women, ≥72 cm; and action level 2: men, ≥90 cm, women, ≥80 cm.

(3) **Waist-Hip Ratio:** The waist-hip ratio (WHR) is used as a surrogate measure of lower and upper body fat distribution and measures where the body fat is stored. Android or excess upper body fat is seen more typically in men, while gynoid or excess lower body fat is seen more in women. A

high WHR suggests increased risk of obesity-related health problems. The accuracy of WHR in assessing visceral fat decreases with increasing levels of fatness. WHR is calculated by dividing the waist circumference by the hip circumference and the indicators of risk are ≥1.0 for men and ≥0.85 for women[14].

(4) **Skinfold (SKF) Measurements:** The skinfold (SKF) technique is a measure of subcutaneous fat, by estimating Db to derive per cent BF. The commonly used callipers are Holtain, Lange and Harpenden, which measure to the nearest 0.2 mm. Measurements are made at sites such as biceps, triceps, subscapular and suprailiac, which are used in age- and gender-specific equations, to arrive at values of body density. Body fat is obtained from Db using a population specific conversion formula. The estimates of per cent BF and FFM from skinfold method were found to be accurate in Indian adults when hydrodensitometry (HD) was used as reference. However, when body FM estimates from SKF techniques were compared with the 4C method, the mean error was found to be 6.6 kg in a group of south Indian adults. The possible sources of error in this method are technician skill, type of callipers and the prediction equation used. This technique should be used with caution in older individuals and obese individuals.

Bioelectrical Impedance Analysis (BIA): Bioelectrical impedance analysis technique is used to predict body composition based, on the electrical conductive properties of the body and involves measuring the impedance (Z) to the flow of a low-electrical current (800 µA), at a fixed frequency (50 kHz). The BIA device can be single frequency, when it operates at a frequency of 50 kHz or multifrequency, when a wide range of frequencies are used. The principle of BIA is that Lean Tissue (LT), consisting of water and electrolytes, is a good electrical conductor, while fat, which does not have water, is a poor conductor. Hydration factor of 73 per cent is used to predict FFM from TBW. The possible sources of error in BIA are differences in limb length, physical activity, nutrition status, hydration level, blood chemistry, ovulation and placement of electrodes.

Laboratory Methods

(1) **Hydrodensitometry [underwater weighing (UWW)]:** The method measures the water displaced by the body, when it is fully submerged and in combination with residual lung volume measurements can provide accurate measure of body volume (BV), from which Db can be estimated. An individual with a higher percentage of FFM will weigh more in water and have a low %BF, since bone and muscle are denser than water, while fat will float. A large amount of FM will make the body lighter in the water and that individual will have a high %BF. The underwater weight of the individual is used to calculate the weight loss. The UWW technique though accurate has disadvantages such as being time-consuming and causing discomfort to the individual.

(2) **Air displacement plethysmography (ADP):** The ADP which is similar in principle to UWW measures the Db and hence total body fat and LT. ADP uses the association between pressure and volume to derive BV for an individual seated inside the chamber. BV is estimated as the volume of air in an empty chamber minus the volume of air in the chamber after the person sat in it. The individual is seated in an enclosed chamber, and by altering the volume of the chamber, the volume of the displaced air can be determined from the air pressure change. The measurement time is about 5-8 min/individual.

(3) **Isotope dilution method (hydrometry):** Hydrometry is based on the dilution principle, where the amount of TBW (solvent) can be estimated if the concentration and amount of the tracer (isotope) are known. The TBW comprises 40-60 per cent of the human body weight and mainly present in the FFM. Estimates of FFM can be obtained from TBW. While the method is accurate, the cost of the isotopes and the technical expertise needed in analysing the results limit the wide use.

(4) **Dual-energy X-ray absorptiometry (DEXA):** The DEXA method measures body fat, muscle and total body bone mineral (TBBM) using two X-ray energies. The principle of the DEXA is that the attenuation of X-rays with high and low photon energies is measureable and depends on the properties of the underlying tissue. The variations in the attenuation of X-ray through the tissues

are caused by differences in the density and chemical composition of fat, LT and bone. The DEXA is quick, has low radiation exposure and needs little technical skill and preparation by the individual. The images can be split into the components of bone and soft tissue using two different energy levels. While DEXA is the gold standard for bone mineral density measurements, it is also used to estimate total and regional body fat and LTM.

(5) Computed tomography (CT) and computed tomography body composition (CTBC): A high-resolution, three-dimensional volume image of parts of the body can be obtained from CT, using X-ray projections from different angles of the body. The attenuation differences between X-rays of lean soft tissue and adipose tissue (AT) are used to separate these tissues. The fat in the skeletal muscle tissue and in the liver can be accurately determined using CT, although it is significantly less accurate for liver fat <5 per cent. Direct volumetric measurements of organs and different AT depots can be obtained using CT. However, body composition measurement using CT is often measured using a two-dimensional analysis of specific axial slices of the body. This is done mainly to minimize the radiation dose and also due to the difficulties in the manual segmentation of different compartments in the images.

(6) Magnetic resonance imaging (MRI): Images of soft tissue in the body can be produced by MRI, which uses the different magnetic properties of the nuclei of elements in the cell, usually hydrogen in water and fat. Several methods based on MRI have been developed for quantification of AT and muscles. Diffuse fat infiltration in organs and precise regional measurements of AT and LT are estimated using 'quantitative fat water imaging', which is based on Dixon imaging. In this technique, the separation of the signals into water and fat image is made using the magnetic resonance frequencies of protons in fat and water. Since the MRI does not use ionizing radiation, it can be used for three-dimensional volumetric imaging even in neonate and infants. However, due to the limited availability of efficient tools for analyzing three-dimensional image segmentation, body composition using MRI is restricted to one- or two-dimensional slices. Poor prediction of visceral and subcutaneous AT changes during weight loss has been observed using single slice MRI.

(7) Whole-body potassium counter (WBKC): The cellular 4C model partitions the body into fat, body cell mass (BCM), ECF, and extra cellular solids (ECSs). The BCM is the metabolically active tissue and contains more than 98 per cent of the body's potassium content. The WBKC is the gold standard to accurately measure the BCM. Besides BCM, the total body potassium (TBK) method can provide estimates of body fat using estimates of weight, BCM and TBW. The method can also be used as a non-invasive method of estimating body protein and skeletal muscle mass. The measurement of BCM is particularly useful in conditions of changing hydration status, such as in pregnant women, infancy and severe acute malnutrition where the hydration status is affected by oedema. The TBK method is the reference measurement to define the protein requirements of pregnancy as it is independent of a changing hydration status during pregnancy and free of radiation exposure from imaging techniques.

Factors Affecting Body Composition

Body composition can also be influenced by factors likely:

- **Age:** People lose muscle mass as they age if they don't maintain it with sufficient weight training. This results in a slower metabolism.
- **Sex:** Women have more body fat than men as nature's way of preparing for pregnancy and nursing.
- **Genes:** These play a role in whether you are naturally lean or have a tendency to retain fat, including where you store it.
- **Hormones:** These can influence water retention and body composition.

Different Physique of Weight Distribution:

People who have undergone an amputation can have a different physique. It is often hard to assess how this affects a person's body weight. According to Brunnstom (1992) the contribution of the individual body parts on the total body weight is as follows:

- Head: 7%
- Trunk: 43%
- Whole arm: 6.5%
- Upper arm : 3,5%
- Forearm : 2,3%
- Hand: 0,8%
- Whole leg: 18,5%
- Femur: 11,6%
- Lower leg: 5,3%
- Foot: 1,8%

BONE MASS:

Bone content is the percentage of bone mineral as compared to total body weight. The average bone content for adults is 3-5%. A measure of the amount of minerals (mostly calcium and phosphorous) contained in a certain volume of bone. Bone mass measurements are used to diagnose osteoporosis (a condition marked by decreased bone mass), to see how well osteoporosis treatments are working, and to predict how likely the bones are to break. Low bone mass can occur in patients treated for cancer. Also called BMD, bone density, and bone mineral density.

This measurement is good to keep track over a long period of time as bone mass can decline slowly with age.

Factors that can increase risk for bone loss:

– Low calcium
– Women post menopause
– Smoking
– Alcohol
– Inactive lifestyle
– Gender (women are more likely to develop osteoporosis than men)
– Age (bone loss increases with age)

BODY MASS:

Body mass can be divided into two major components: **body fat** (energy stores) and **lean mass** (including muscle, organs, and bone), each of which has distinct biological significance and was likely subject to different selective pressures during human evolution. Humans have a high proportion of body fat compared to other primates, and to mammals more widely. In contrast, skeletal muscle mass (a major constituent of lean mass) is low compared with our closest relatives *Pan*, other primates. Within our species, fat and lean masses vary in relation to selective pressures such as climate and disease load. The ability to estimate fat and lean mass from skeletal characteristics would offer novel potential to investigate past human adaptation, health and evolution, as well as to understand the origins of contemporary variation in body composition.

MUSCLE MASS

Muscle mass is the percentage of muscle in the body as compared to total body weight. Muscle mass includes the weight of the muscles in your body in kilograms or pounds. While the body fat percentage measures the amount of fat your body holds. Burning body fat can be a result of the accumulated muscles. Muscles are like engines when it comes to consuming energy. Our muscle mass plays a crucial role when it comes to fitness. When your body builds muscles, it burns energy and fat all the time. As your muscle mass increases, the faster your body is able to burn calories/energy. This leads to an increase of your basal metabolic rate (BMR), which helps in losing weight.

Muscle mass includes smooth muscles, skeletal muscles and water contained in the muscles. Where the skeletal muscles are the most visible when there is no fat layer. Muscles consist of water and protein. This is why it's important to include protein in your adjusted eating schedule.

Although there are indeed different types of muscle, from a biological point of view, there is no such thing as "lean muscle". The word "lean" is usually meant to suggest the absence of body fat. But here's the truth: all muscle is "lean muscle".

Lean Body Mass (also sometimes known as simply "lean mass," likely the source of the word "lean muscle") is the total weight of your body minus all the weight due to your fat mass.

Lean Body Mass (LBM) = Total Weight – Fat Mass

LBM includes the weight of:

- Organs
- Skin
- Bones
- Body Water
- Muscle Mass

Unlike lean muscle, Lean Body Mass correctly uses the word "lean" as it describes the entire weight of your body minus fat. This is why it is also known as "Fat-Free Mass."

Because your Lean Body Mass comprises so many parts, any change in the weight of these areas can be recorded as changes in LBM. Keep in mind, the weight of your organs will not change much. Bone density will decrease over time, but it won't significantly affect the weight of your LBM.

PERCENTAGE OF BODY FAT

Body fat percent is a measurement of body composition telling how much of the weight of your body is fat. The percentage of your body that is not fat is fat-free mass. There are normal ranges for body fat, which differ for men and women.

Weighing yourself on a regular bathroom scale does not assess your body composition. A regular scale cannot tell how much of your total weight is comprised of water, fat, or muscle. To know whether your body composition is healthy, you should get an estimate of your body fat percentage. You can do so by taking simple measurements and entering them into a body fat percentage calculator.

Healthy Body Composition

The American Council on Exercise (ACE) gives the following ranges of values for different populations.

ACE Body Fat Percent Norms for Men and Women		
Description	Women	Men
Essential Fat	10% to 13%	2% to 5%
Athletes	14% to 20%	6% to 13%
Fitness	21% to 24%	14% to 17%
Acceptable	25% to 31%	18% to 24%
Obese	Over 32%	Over 25%

Athletes tend to have lower body fat, which may be beneficial for performance in sports such as running and cycling. But having an extremely low body fat percent is a health problem. For example, the female athlete triad increases the risk of injury and health issues. It includes eating disorders, amenorrhea, and decreased bone mass with an increased risk of stress fractures and osteoporosis.

If you are overweight or obese, you have an excessive amount of body fat and a high body fat percentage. If your body fat percentage is too high, you can improve your body composition by gaining lean body mass through building muscle and bones and by losing excess body fat.

SEGMENTAL FAT

Body composition analysis is a method of describing what your body is made of, including fat, muscle, protein, minerals, and body water. We all know that each body part has different volumes or in segmented way. Segmental Analysis provides body composition data in segments in addition to the usual full body analysis.

For example, ~~the In~~Body technology divides the body into five segments or "cylinders": the two arms, two legs, and the trunk (the area between the neck and legs.)

Anyone can theoretically be underdeveloped/overdeveloped (depending on your body goals) for certain body segments. The good news is that segmental analysis allows you to identify and compare these segments.

In the InBody result sheet, the top bar shows Lean Body Mass (in pounds) is in a given segment. The top bar of the Segmental Lean Analysis compares the pounds of Lean Body Mass in proportion to your height and gender. This top bar can also be used for comparison between segments. An uneven weight distribution between the right and left legs may be a sign of overtraining or injury. Later on, you will see how strength and conditioning coaches use segmental analysis to train their athletes.

The number shown at the bottom bar is the percentage relating the lean mass in the segment that is analyzed to the overall body weight. This shows whether the amount of Lean Body Mass you have in a segment **in proportion to your total body weight is sufficient.** The 100% = sufficient.

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