

Certifications and patents obtained by Biospace



## BIOSPACE

Biospace Co., Ltd.

TEL : +82-2-501-3939

FAX : +82-2-501-3978

Homepage : <http://www.biospace.co.kr>

E-mail : [biospace@biospace.co.kr](mailto:biospace@biospace.co.kr)

Biospace, Inc.

TEL : +1-310-358-0360

FAX : +1-310-358-0370

Homepage : <http://www.biospaceamerica.com>

E-mail : [USA@biospaceamerica.com](mailto:USA@biospaceamerica.com)

Biospace Japan, Inc.

TEL : +81-3-5298-7667

FAX : +81-3-5298-7668

Homepage : <http://www.biospace.co.jp>

E-mail : [biospace@biospace.co.jp](mailto:biospace@biospace.co.jp)

DanilSMC Co., Ltd. [Asia]

TEL : +82-2-3462-5400

FAX : +82-2-3462-5105

E-mail : [danilsmc@danilsmc.com](mailto:danilsmc@danilsmc.com)



# What is Body Composition Analysis



---

## INTRODUCTION

This is to be used for the trainers of gyms and medical practitioners of hospitals and clinics to understand the technical terms related to Biospace products and technologies. Glossaries that have the definition you need and basic concepts of Body Composition Analysis for employing the strategy key concepts of Biospace's Commitment to Quality Glossary Body Composition to approach the best understanding.

---

## ABOUT THE TECHNOLOGY OF BIA...

- What is the principle of BIA?
- What are the advantages and the drawbacks of BIA?
- How does InBody720 measure your body fat?
- What does 'empirical estimation' mean?
- What are the problems with empirical estimation?
- Why do other analyzers use empirical estimation?
- Do you have any comparing examples using empirical estimation?
- How can you measure ECW and ICW separately?
- What does the segmental measurement mean?
- Are there any differences in the segmental measurement among analyzers?
- Isn't the current used harmful to the body?
- Are there any published papers on the measuring principle of InBody and its validity?



### What is the principle of BIA?

Bioelectrical Impedance Analysis is a method of quantifying body composition by introducing an electrical current throughout the body. Impedance can be calculated by measuring current and voltage, based on Ohm's Law ( $R=V/I$ ). Since water is considered as the only component in the body with electrical conductivity, when the electrical current passes through the body, the impedance of its water can be measured. With this impedance value, the volume of body water is calculated.

The volume  $V$  of the solution in a tube can be measured by multiplying area  $A$  and the length  $L$  of the tube. Since the height is already given, the area of the tube needs to be calculated to get the volume of the solution in the tube.

$$V = A \times L \dots\dots\dots ①$$

The impedance is proportional to the length or the height and inversely proportional to the area. By applying the constant of the proportion  $q$  (specific resistivity), the impedance can then be calculated as follows:

$$R = q \times L/A \dots\dots\dots ②$$

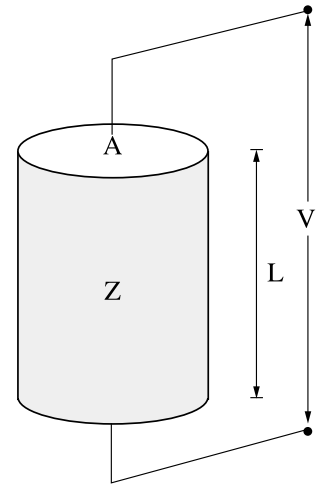
Using Formula ②, a formula to calculate the area of the tube can be produced

$$A = q \times L/R \dots\dots\dots ③$$

When substituting Formula ③ for Formula ①, the volume of the solution can be calculated from its impedance and the height of the tube as follows

$$V = q \times L/R \times L = q \times L^2/R$$

Therefore, the volume of the solution in the tube can be calculated using the height of the tube and its impedance. The value calculated from  $L^2/R$  represents the impedance index.  $L$  can be applied to the height of the examinee, and  $R$  to the measured impedance of the examinee. As such, the volume of body water, which mainly composed of the salt solution, can be calculated by measuring the impedance and the height of the examinee. From the volume of body water, LBM and Fat Mass can be calculated.



### What are the advantages and the drawbacks of BIA?

**Over the past decade**, a technique has been developed which analyzes body composition based on the electrical properties of biological tissues. Bioelectrical Impedance Analysis (BIA) has many advantages over other methods in that it is safe, rapid, easy to perform, and requires minimal operator training. Thus, the technique has become widely used in hospitals, health and fitness centers and in field studies.

**Nevertheless**, the clinical usefulness of conventional BIA to detect acute or chronic changes in body composition has been limited due to localized fluid accumulation or loss, and inability to accurately assess the distribution between ICW and ECW. Because of the limits, BIA has had difficulties applying to patients, the elderly, children, and athletes. However, they are the very people who really need to analyze their body composition.

**BIOSPACE has overcome the limited capacity of BIA and proved the technology through several clinical studies and research papers.** Because the body is not an isotropic conductor with a uniform cross-sectional area, we assume the body as five cylindrical rods; four limbs and one trunk. We measure the amount of body water segmentally. Also, we use multi-frequency so that we can measure ICW and ECW separately. Thus, we do not have to use empirical estimation to compensate inaccuracy, which makes the measurement insensitive to slight compositional changes.

### *Accurate measurement of the total body water, the key to Body Composition*

#### How does InBody720 measure your body fat?

Body Composition Analyzer InBody720 of Biospace uses BIA (Bioelectrical Impedance Analysis). Impedance is an opposing force against the flow of electric current. Body fat, compared to body water such as blood, has much weaker conductivity and on that account, has relatively high impedance. Therefore, between two people with the same weight, a person with the greater portion of body fat will show higher impedance. In particular, InBody720, using the segmental BIA method, can measure impedance of each limb and the trunk separately.

#### Then, how is it possible to measure body fat in your body?

All the Body Composition Analyzers using BIA including InBody720 measure the volume of the total body water. As it is inversely proportional to impedance, it is feasible to get the volume of the total body water from obtained impedance. Moreover, FFM (Fat Free Mass) in a healthy body always consists of 73.3% water, which is constant for any race or gender. Therefore, with the volume of the total body water known, the amount of FFM can be calculated and by subtracting the calculated amount of FFM from weight, we get the amount of body fat as well.

---

1. Measure the volume of the total body water using impedance
2. From TBW, calculate FFM.  
$$\text{FFM} = \text{TBW} / 0.73$$
3. Calculate Fat Mass.  
$$\text{Fat Mass} = \text{Weight} - \text{FFM}$$

As it can be assumed from the above, InBody720 is very sensitive to detect even a slight change in the total body water. Therefore, for the accurate analysis, the total body water has to be stabilized when measured.

#### What does 'empirical estimation' mean?

Empirical estimation refers to the application of the variables estimated from the personal information input, such as gender, age and body type as in athletes or average people. For example, when body composition analysis of a female examinee is conducted, her Body Fat Mass can be estimated based on the empirical fact that women usually have more Body Fat Mass than men. Her Body Fat Mass has to be higher than that of a male examinee with the same weight. Thus, an empirical estimation, in order to revise inaccurate estimations, refers to those variables that may affect the results of a body composition analysis.

#### What are the problems with empirical estimation?

**Analytic error** For example, those analyses overestimate the percentage of body fat in physically trained women and underestimate it in small-framed men with high-level of body fat. If statistical analysis governs the outputs but the subject does not belong to an average group, then empirical estimation produces errors.

**Insensitive to compositional changes** When doctors treat obese patients, they perform body composition analysis repeatedly to monitor the effect of treatment. In this case, a machine using empirical estimations can not reflect the exact compositional changes of the patients.

**Inadequate for a research apparatus** With an analyzer which is already programmed to consider the differences of gender and age, if a comparison study is to do on percent body fat between male and female individuals in their 50's, the results would be already set data rather than actual measurement displaying differences. Therefore, such machine with empirical estimation is not adequate for differentiating body composition between groups.



### Why do other analyzers use empirical estimation?

Conventional body composition analyzers need empirical data to overcome the poor accuracy and reproducibility. This might help the measurement to compensate the inaccuracy in case of an average person, but rather it brings about insensitive measuring so that there is a difficulty in detecting changes of body composition. Concerning clinical use of the body composition analyzer, sensitivity is one of the most important issues. However, with a conventional impedance body fat analyzer, patient's input data such as gender and age affect the outputs directly. In other words, changing these input data produces different results with the same person. In this case, the data is obtained not by actual measurement but by estimation. Thus, empirical estimation will produce errors in any body shape altered from standard one. Because of this, conventional body composition analyzers have considerable error rates in those individuals with extreme obesity or illness, children and elderly people.

### Do you have any comparing examples using empirical estimation?

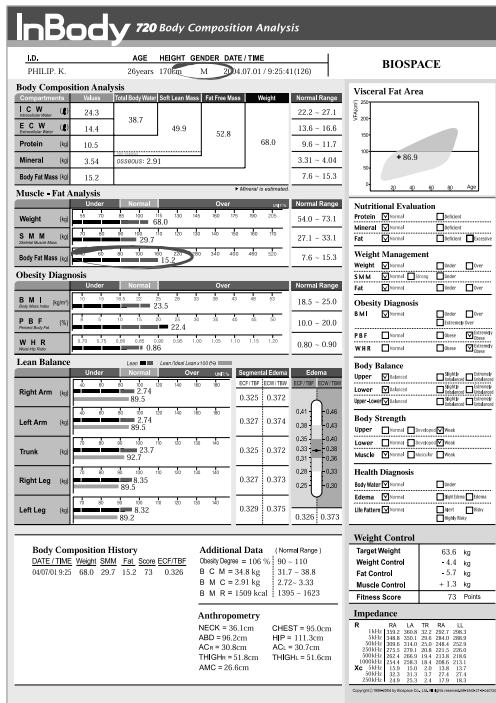
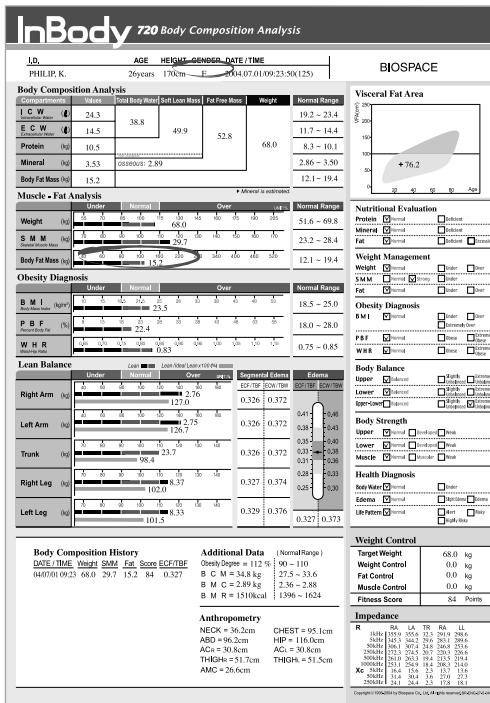
With the conventional body fat analyzers, body fat is increased by 7% by changing the gender input from male to female. This indicates that a significant portion of the output value was determined partly by input data besides the measurement values.

1 <sup>st</sup>		2 <sup>nd</sup>	
Body Composition Analyzer		Body Composition Analyzer	
BODY TYPE	Standard	BODY TYPE	Standard
SEX	male	SEX	female
AGE	26	AGE	26
HEIGHT	170cm	HEIGHT	170cm
WEIGHT	68.0kg	WEIGHT	68.0kg
BMI	23.5	BMI	23.5
FAT%	24.6%	FAT%	31.1%
FAT MASS	16.7kg	FAT MASS	21.1kg
FFM	51.3kg	FFM	46.9kg

#### <Comparison between two measurements>

	1 <sup>st</sup>	2 <sup>nd</sup>	Change
Weight(kg)	68.0	68.0	0.0
Fat percent(%)	24.6	31.1	+ 6.5

The same test with InBody showed the constant results in fat mass and lean body mass. This indicates that InBody does not use such empirical estimation.

1<sup>st</sup>2<sup>nd</sup>

### <Comparison between two measurement>

	1 <sup>st</sup>	2 <sup>nd</sup>	Change
Weight(kg)	68.0	68.0	0.0
Skeletal Muscle Mass(kg)	29.7	29.7	0.0
Body Fat mass(kg)	15.2	15.2	0.0
Pecent Body Fat(%)	22.4	22.4	0.0

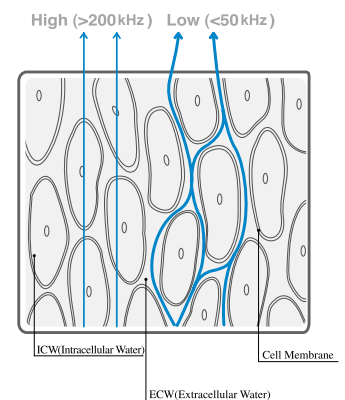
Because accuracy and precision of InBody have been improved by Biospace's own technologies, we don't have to use empirical estimation to compensate for incorrect data. The data from InBody are not affected by gender, age, and race, and it can measure people with extreme obesity or illness, children, and elderly people correctly.

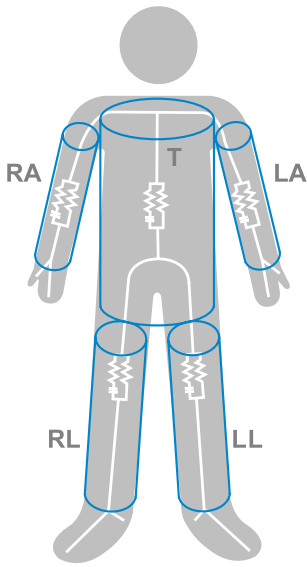
How can you measure ECW and ICW separately?

Why is the multifrequency so important?

*Accurate measurement of the total body water, the key to Body Composition Analysis using BIA!*

The problem of the conventional BIA with a single low frequency is that it has to estimate the amount of intracellular water from extracellular because low frequency cannot pass through plasma membrane and into intracellular water. The bilayered cellular membrane divides the body cell into intracellular and extracellular water. The intra and extracellular waters are proportionate to one another in a healthy body; however, an imbalanced body fluid distribution occurs in those who are elderly and suffer from obesity, or geriatric diseases, and they are the very people who need to analyze their body composition. Extracellular water is measured by low frequency currents(lower than 50kHz), and intracellular water is measured by high frequency currents(higher than 200kHz). **InBody720 sends the electric current at the frequencies of 5, 50, 250, 500 and 1000kHz to detect even the smallest change in body fluid, providing useful information on edema, malnutrition and geriatric diseases.**





What does the segmental measurement mean?

*For the most accuracy,*

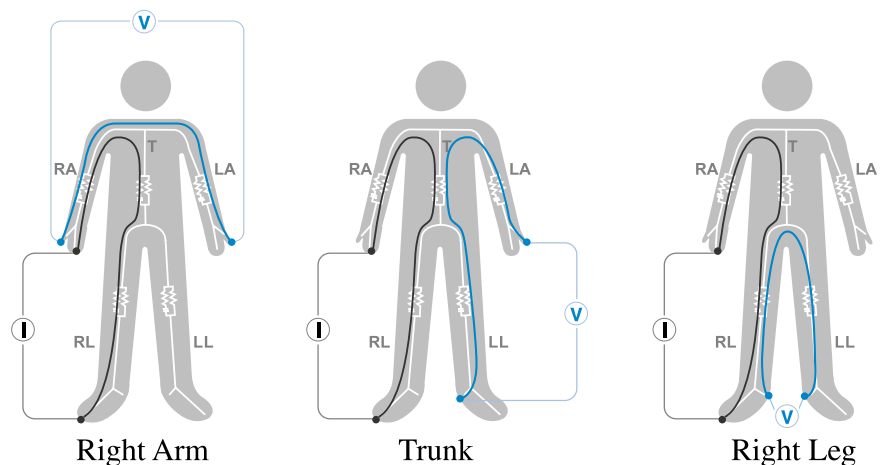
*BIA body composition analyzers should measure our body segmentally.*

**The segmental measurement** is the technology that assumes the body as five cylinders -four limbs and one trunk - and measures impedance of these parts separately. Segmental body composition analysis provides segmental measurement of body water and fat free mass. Furthermore, the analysis is highly accurate because the measured value of a certain part does not affect the measurements of other segments. It is because the conventional body composition analyzers lack accuracy in measuring body fat and cannot figure out the patient's exact body shape. It needs empirical references to correct inaccurate measured values. **For the purpose of clinical research, InBody720, with the technology of segmental analysis, can detect differences by gender, aging, disease and ethnic without any empirical estimation and examine a patient's segmental development.**

Are there any differences in the segmental measurement among analyzers?

Even if body composition analyzers can measure our body segmentally, the same measurement accuracy cannot be recorded in all analyzers. Human subjects can be considered to be made up of five tubes: two legs, two arms, and one trunk. There are many factors that can affect impedance in a human subject. While the trunk makes up the biggest part of body, its impedance index is the lowest, at about  $20\ \Omega$ , due to the fact that it has the largest width of all the body parts. In the case of arms, which usually has an impedance of about  $300\ \Omega$ ,  $2\text{--}3\ \Omega$  can be considered a small error. However, in the case of the trunk, the same  $2\text{--}3\ \Omega$  can be considered as a significant error capable of affecting the results of the test on the trunk. Therefore, to assure the accuracy of the impedance on the trunk, it is necessary to develop precise measurement technologies. As such, the accurate measurement of the trunk provided by InBody720 can contribute to heighten the accuracy of the body composition analysis.

(I) = current  
(V) = voltage



### Isn't the current used harmful to the body?

No, it is harmless to the body. InBody uses a small alternating current to measure the impedance. It is invasive and in 1996 by American Journal of Clinical Nutrition, it was proven to be safe when applied to the human body. Having passed IEC 601-1 of the International Safety Standard after safety and validity tests, InBody is a safe apparatus to use. While CT and DEXA cannot be applied to pregnant women because they irradiate, BIA apparatus is safe enough to be used to diagnose pregnant women.

### Ref.

Bioelectrical impedance analysis during pregnancy and neonatal birth weight. Chezzi F. et al. Eur J Obstet Gynecol Reprod Biol 2001 ;98(2) :171-6

Multifrequency bioelectrical impedance analysis in women with a normal and hypertensive pregnancy, Herbert Valensise et al. Am J Clin Nutr 2000 ;72(3) :780-783

Potential use of bioelectrical impedance analysis in the assessment of edema in pregnancy., Morita H et al. Clin Exp Obstet Gynecol 1999 ;26(3-4) :151-4

Assessment of body composition in pregnant women at term. Morais AA. et al., Rev Assoc Med Bras 1997 ;43(2) :109-13

Assessment of degree of edema by means of bioelectrical impedance during pregnancy, Arisawa M, Fukuba K, Seki T, Mochimaru F. Nippon Sanka Fujinka Gakkai Zasshi 1996 ;48(1) :25-31

Bioelectric profiles and nutritional status in pregnancy: protocol of a multicentric project to measure bioimpedance in pregnancy. Mele MC, Castelli A., Minerva Ginecol 1996 ;48(12) :25-33

Fluid changes during pregnancy: use of bioimpedance spectroscopy. Van Loan MD, Kopp IE, King JC, Wong WW, Mayclin PL. J Appl Physiol 1995 Mar ;78(3) :1037-42

Total body water in pregnancy: assessment by using bioelectrical impedance HC Lukaski, WA Siders, EJ Nielsen and CB Hall, Am J Clin Nutr 1994 ;59 :578-585

Effect of fat and fat-free mass deposition during pregnancy on birth weight. Villar J et al. Am J Obstet Gynecol 1992 ;167(5) :1344-52

### Are there any published papers on the measuring principle of InBody and its validity?

Please refer to "Research Thesis based on InBody" as we have at Biospace. It is a collection of abstracts of crucial papers in which studies have been done within and outside the company on InBody, its measuring principle and its validity.

---

## ABOUT BODY COMPOSITION ANALYSIS...

- What is body composition analysis?
- Why is body composition analysis important?



### What is body composition analysis?

The human body is composed of four constituents - total body water, protein, mineral and fat. The ratio among these four in a body is closely associated with health, which differs in gender, age, and individual properties.

### *Body composition analysis; explore your body under your skin.*

Body composition analysis is to diagnose body components quantitatively so that it can provide basic information on the correct body condition. Body composition analysis is very important in preventive medicine since it provides the basis of appropriate physical activity and dietary formulas for improving personal daily routine. It can be also usefully applied to follow-up studies of patients treated for various diseases.

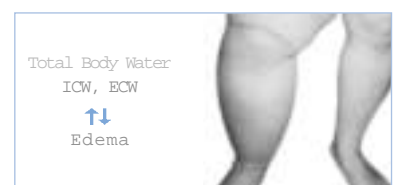
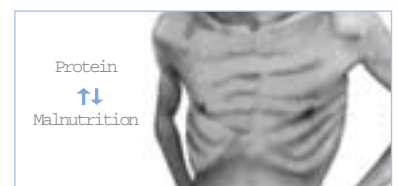
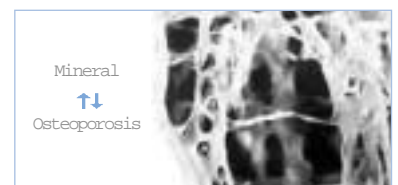
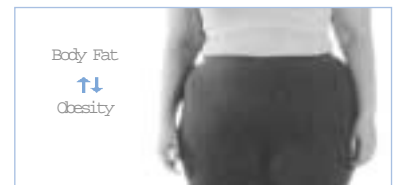
### Why is body composition analysis important?

It is the fat free mass that determines the body shape. Being at a certain weight does not necessarily mean being fit and in shape. What guarantees the beautiful body is the balanced ratio of fat free mass to fat mass.

### *Being at the same weight does not always guarantee the same body shape!*

**When you are under weight-control**, along with the weight, the amount of each component and its proportion in your body change. As muscle is heavier than the same volume of fat, a person with more muscle looks slimmer. Although it could be very important, weight alone is not a clear indicator of good health because it does not distinguish how many pounds are from fat and how many pounds are from fat free mass. Therefore, it is your body composition that is important, not your weight, and the well-balanced ratio of its components is a critical health indicator.

**A healthy person** maintains a balanced body composition. However, if this balance gets disturbed, the following can occur; obesity, malnutrition, edema and osteoporosis. The purpose of body composition analysis is to evaluate the body function and improve health. Therefore, it is to pursue personal health and fitness by understanding the fundamental body condition such as muscle development, nutrition and possible obesity through regular body composition check-ups.



## ABOUT BODY COMPOSITION...

- What is body composition?
- What is fat free mass?
- What is body water?
- How much body fat is recommended for a healthy person?
- Why % Body fat is more important than BMI?
- What is happening to your body when you are on a diet?

	RA	LA	DIFF
150kHz	355.9	359.6	3.7
100kHz	345.3	344.2	-1.1
70kHz	306.1	307.4	1.3
50kHz	272.3	274.5	2.2
30kHz	261.0	263.3	2.3
10kHz	253.1	254.9	1.8
5kHz	16.4	15.6	-0.8
30kHz	31.4	30.4	-1.0
150kHz	24.1	24.4	0.3

NECK = 36.2cm

ABD = 96.2cm

ACH = 30.8cm

THIGH = 51.7cm

AMC = 26.6cm

CHEST = 95.1cm

HIP = 119.0cm

AC = 30.8cm

THIGH = 51.5cm

Density Degree = 112 %

B C M = 34.8 kg

B M C = 2.89 kg

B M R = 1510kcal

90 ~ 110

27.5 ~ 33 %

2.36 ~ 2.58

1396 ~ 1624

What is body composition?

*What is body composition? What does it mean to you?*

*Basically, body composition is main components making up the body.*

Most body composition analyses divide body composition into two components : body fat and fat free mass. InBody720 divides body composition into 4-components comprising total body water(intracellular water and extracellular water), protein, mineral and body fat.

What is fat free mass?

Fat free mass includes everything in your body except fat-muscle, bones, organs and fluids, etc. By exercising regularly and eating a healthy, balanced diet, it is possible to achieve and maintain a desirable ratio of fat to fat-free.

*Fat free mass is*

*what is left when body fat was taken out from body weight.*

Fat free mass is composed of water, protein and mineral of your body. Protein is the main component of muscle and the amount of protein in your body determines your basal metabolic rate (BMR). Therefore, developing muscles is to make your body the more efficient energy-consuming machine. By increasing muscle mass, you get higher your basal metabolic rate (BMR). Moreover, mineral is the main component of bones supporting the structure of your body, and since it is closely associated with the amount of personal physical activity, more muscle content means more bone mass.

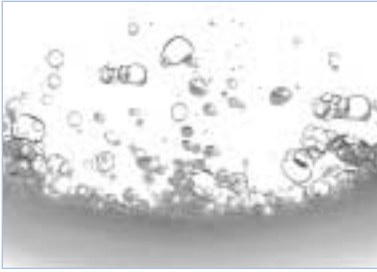
Since young women with low muscle content are at increased risk for osteoporosis after menopause, they need to exercise regularly to increase their muscles for prevention.

In muscle cells are mitochondria, one of small cellular organelles known as the powerhouses of your body. When you develop muscles, the number of mitochondria increases consuming more fat, the main energy fuel. Diet without any physical activity will cause the loss of muscle content as weight decreases. This is not good for health at all and is merely the temporal weight loss. Therefore, in conducting a weight loss program, it is very important to observe the ratio between fat and muscle(fat free mass).

Weight changes by dietary treatment mean changes in the amounts of both fat and fat free mass, and physical activity helps to maintain and increase fat free mass. Generally as you grow older, the size and strength of muscle decrease and the metabolic rate gets lowered. It results in having more excessive fat eventually than before although you uptake the same amount of calories. Therefore, at senescence with regular check-ups for body composition, much effort is required to maintain fat free mass.

Fat cells, on the other hand, do not have any such amazing abilities like muscle tissue. In fact, body fat above the level of essential fat is considered storage fat and is actually a source of fuel that can feed the mitochondria and help keep your body running. A certain amount of storage fat is also important for cushioning and protecting the bones, muscles and organs, and for temperature regulation. However, high levels of body fat can adversely affect temperature regulation, as well as overtax the body's organs and systems over time.





### What is body water?

Looking at your constituents alone, humans are not much more than an organized bag of seawater-between 50% and 70% of your body weight is made up of water.

Body water is such a vital component that its balance is the basic indicator of health and fitness. Fat Free Mass, made up of about 73% water, contains most body water. Thus, the more body fat indicates the less body water. As fat content increases, the percentage of lean tissue decreases causing total body water to drift down to 50%.

### Functions of body water

Because of its unique chemical and physical characteristics, water plays several key roles in your life processes. Water, being a liquid portion of blood, participates in almost all of the metabolism of your body. Water in blood serves as **an important vehicle for metabolic procedures** - transporting oxygen and nutrients to cells and removing metabolic wastes. For instance, various substances such as nutrients, hormones and antibodies are carried by water from plasma to interstitial fluid. Likewise, wastes are taken out of the cells. Without such an effective transportation system, cells cannot be fed on nor survive. Therefore, water as transportation for substances in the body is very essential in life.

Body water also serves as **an important regulator of body temperature**. In a way, cells in your body are similar to an engine in a motor vehicle. As fuel from the engine burns, lots of heat is released, and to avoid overheating, a cooling device called radiator is required. Your body needs the same system to release the heat from cells out of it; otherwise proteins will become denatured. However, several thousands of cell layers constitute your body thus, remarkably slowing down the process of releasing heat directly out of your body. Therefore, interstitial fluid and plasma act as a cooling device of your body just like those in motor vehicles. Heat inside your body is absorbed by plasma first, and circulates through blood vessels. It is then delivered to your skin and finally exits the body. However, **the cooling system of your body works effectively when there are adequate amounts of plasma and interstitial fluid**.

With radiators running out of water, engines in motor vehicles get overheated. Likewise, the cooling system of your body cannot function properly with insufficient body water. Therefore, balanced body water is critical in temperature regulation and efficiency of the circulatory system. When you exercise in hot weather, it is impossible to release all the excessive heat out of the body only with the cooling system. In this case, the secretion of sweat compensates the first mechanism for temperature regulation and works as the second mechanism of body water.

**The more active its metabolism, the more water in a cell.** This is one of the very reasons why muscle tissues contain much more water than adipose tissues. More water is required to perform the chemical reactions associated to vigorous activities of muscle. If weight decreases due to water loss, then muscle or water content of other cells will decrease as well. Water loss will cause both extracellular fluid such as plasma and intracellular fluid to decrease. On a cellular basis, the capability of energy production within a cell also decreases. **Therefore, body water is essential in performing the proper functions of your body.**

How much body fat is recommended for a healthy person?

*The standard amount of body fat for men is  $15 \pm 5\%$  of their weight and for women  $23 \pm 5\%$  of their weight.*

Body fat is an energy storehouse storing excessive energy after consuming what is required in your body and when needed it is broken down to be used as the energy source. Moreover, as phospholipid, cholesterol and essential fatty acids are important components in constructing the cellular membrane, body fat is one of the crucial components of your body.

The standard amount of body fat for men is  $15 \pm 5\%$  of their weight and for women  $23 \pm 5\%$  of their weight.

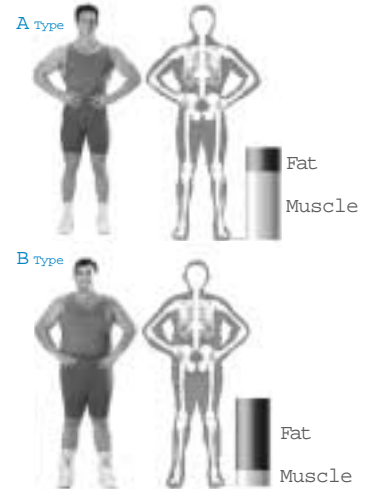
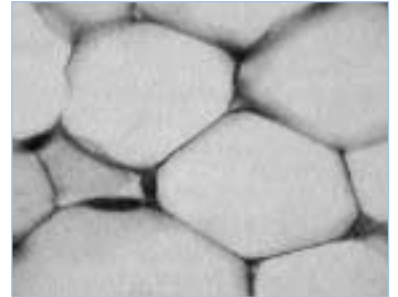
Why %Body fat is more important than BMI?

*BMI do not reflect own body composition.*

BMI is a simpler form of body mass index calculated from body weight divided by the square of the height. As conventional obesity diagnosis standard, BMI method has been widely applied in the general medicine, dietary, and sports medicine fields. However, this method is flawed in that it cannot be applied to adults with high and low levels of fat free mass, children, those over the age of 65, or pregnant female. So, BMI method detects obesity in appearance. Only measurement of %body fat makes it possible to detect obesity with less developed muscle, geriatric obesity.

If two men have same height and same body weight, BMI of each man are same. But, if % body fat of each man are 8 % and 23%, the difference of % body fat between them results in the difference of body shape, and risks of chronic diseases will be not correspond with each other. So measuring % body fat is important than BMI method calculated from height and weight simply.

Fat Cells



	Atype	Btype
Height	178cm	178cm
Weight	86.3kg	87kg
BMI	26.9 kg/m <sup>2</sup>	25.7 kg/m <sup>2</sup>
% Body fat	15%	24%

What is happening to your body when you are on a diet?

The general principle on the obesity treatment is as follows;

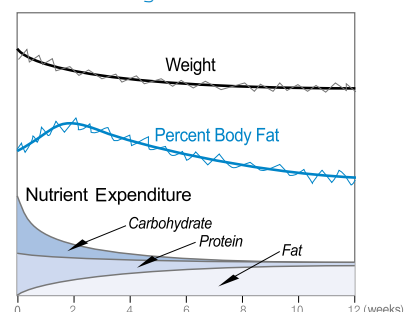
**First**, increase or at least maintain fat free mass and lose fat mass.

**Second**, keep the reduced weight.

It has already scientifically proven that the amount of calorie-intake, exercise and the changes of body composition are closely related, and for the successful diet it is very important to understand the very principle of losing weight. The absolute principle of weight loss is to consume more energy than to intake.

Changes in nutrients, used as the raw materials for energy consumption when dieting, and the consequent changes of body composition are divided into 4 stages.

Diet and Weight Transition



**glycogen**

*A carbohydrate made of multiple units of glucose containing a highly branched structure; sometimes known as animal starch. It is the storage form of glucose and is synthesized (and stored) in the liver and muscles.*

**glucagons**

*A hormone made by the alpha cells of the pancreas that stimulates the breakdown of glycogen in the liver into glucose; this raises the blood glucose level. It also performs other functions.*

**gluconeogenesis**

*The production of new glucose molecules by metabolic pathways in the cell. Amino acids usually provide the carbons for these new glucose molecules.*

**ketone**

*Incomplete breakdown products of fat containing three or four carbons. These contain a ketone chemical group, hence, the name. An example is acetoacetic acid.*

**The 1<sup>st</sup> Stage**

Your body uses glucose as the main energy source when moving. Glucose is the final product hydrolyzed from carbohydrates. It circulates through blood, is controlled by insulin to be taken up to tissues and used as energy. Glucose provides energy for each day and the surplus is stored as glycogen in the liver and muscle. If there is not enough carbohydrates to consume due to starvation or being under a low-carbohydrate diet, muscle uses up glucose from blood first and then uses the stored glycogen as the main energy source by glycogenolysis. Since carbohydrates contain the carbon, hydrogen and oxygen in the proportion to form water (2-4g of water/glycogen), when it is consumed, water comes out. This is why the amount of urine increases when you are on a diet. During the first stage of a diet, you can easily experience rapid weight loss due to water loss. The common sense of weight loss is to lose body fat and have the decreased body fat percentage, but as seen in the figure, body fat ratio increases. Since the amount of body fat lost during this period cannot follow the weight loss, it results in increased percent body fat against reduced weight.

**The 2<sup>nd</sup> Stage**

After all of the carbohydrates in your body have been consumed as energy for the first 2 days at the first stage, your body can turn proteins and fats into glucose other than carbohydrates by gluconeogenesis. In other words, if the great amount of proteins is used as energy source, muscle tissues in your body will shrink and this may risk your health. Therefore, physical activity should be carried out with a diet to minimize muscle loss. As proteins contain water, similar to carbohydrates, the exhaust of water also increases during the second stage. Simply by abstaining from eating, you can lose 1kg per day regardless of the amount of water consumption because 0.2kg of body fat can release 1800kcal, adequate per day. Again, rapid weight loss occurs due to water loss and once you have a regular meal, weight will return back to normal very easily.

**The 3<sup>rd</sup> stage**

This is the period when your body actually starts to use body fat as an energy source and reduce protein consumption. Carbohydrates and proteins provide 4kcal/g. However, proteins are not an efficient energy source because nitrogen has to be removed beforehand. Whereas, fats provide 9kcal/g making it more efficient by twofold. Therefore, weight decreases much slowly compared to the earlier stages of a diet during which carbohydrates and proteins are used as energy source. Moreover, since body fat contains little water, after degradation water is hardly exhausted. Unlike other tissues, the brain uses only glucose as its energy source and after a couple of days with an empty stomach, all glucose and stored glycogen will run out. During this time, the brain uses 'ketone body' which reaches the maximum amount on the tenth day of continuous starvation.

**The 4<sup>th</sup> stage**

When body fat is used as an energy source, both weight and percent body fat decrease and it is the true diet. With water-only dietary for 10 days or more, the body reached this stage. If it is a just low calorie diet, it takes 2~4 weeks. At the fourth stage, you lose 0.1~0.2 kg per day at the most. Your body copes with the long-term starvation to adjust the basal metabolic rate and burns only 0.1~0.2 kg of fat per day, which is equivalent to the amount for keeping homeostasis.

