

BIA

Bioelectrical Impedance
Analysis and Human
Wellness.



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Abstract

Bioelectrical Impedance Analysis, or **BIA**, is a quick, safe, and non-invasive technique used to measure body composition.

Traditional weighing scales measure body weight. A recent technology trend in weighing scales is to incorporate a BIA function. This functionality allows the measurement of the body's impedance to a weak electrical current and BIA can provide a comprehensive breakdown of the body's fat and lean muscle mass. A body with more muscle will have a lower impedance than a body with more fat. This is because water is an excellent conductor of electricity, and the body stores water in muscle, while fat has a low water content.

Using BIA to understand body composition is helpful in pursuing personal health and fitness goals. Increasing muscle and decreasing body fat is desirable for improved fitness, increased basal metabolism, and overall well-being. Vyvo Technology has incorporated BIA functionality in its Leggera weighing scales and also in its wearable devices, which can measure BIA to an exceptional level of accuracy, making it an invaluable tool in pursuing wellness goals.



The Importance of Physical Activity, and the Drawbacks of Excess Body Weight

Sedentary lifestyles with low levels of physical activity often lead to increased stress and depression (as well as increased risk factors relating to heart disease).^{1,2,3} Low levels of physical activity and the coronavirus pandemic have contributed to the epidemic of obesity, poor weight management, and chronic disease.⁴ Moderate exercise levels can lead to improved health and wellness outcomes and a better overall quality of life, as it helps improve cardiovascular health, build muscle, and burn fat.^{5,6}



Physical activity brings with it many long-term benefits that have been associated with lowering the risk for chronic diseases and improving life expectancy in middle-aged and older adults. The average life expectancy for an adult in the United States is 78.7 years.⁷ Physical activity has been shown to reduce mortality risk factors in many chronic diseases such as arterial hypertension, diabetes mellitus (type 2), dyslipidemia, coronary heart disease, stroke, and cancer.⁸ Moderate physical activity has also been shown to lower the death rate from all causes by 30% compared to those who didn't engage in physical activity. Clearly, living an active lifestyle has benefits.

Using body weight as the sole measurement to progress toward fitness goals is counterproductive because it only reports the total weight and not the proportions of muscle and fat.



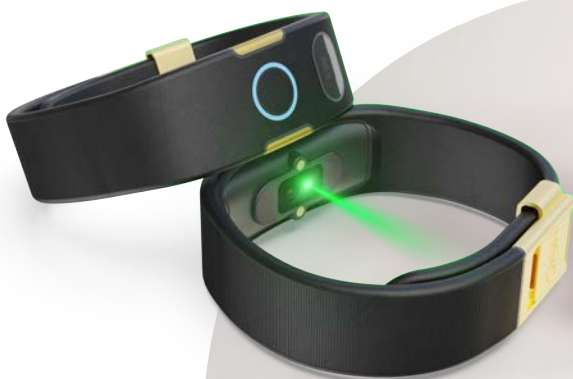
As most fitness programs will help to burn fat and build muscle, even if only modestly, it may not be possible to see any change in body weight (or body weight may even increase) having adhered to a fitness program for several days or weeks, even though overall physical health is improving, possibly because muscle is denser than fat. If the focus is solely on weight measurement, then a lack of visible progress could lead to frustration and abandonment of the fitness program.

The Value of BIA

Bioelectrical Impedance Analysis (BIA) is a superior metric for better understanding body composition, described as the “measurement of body fat in relation to lean body mass.” BIA allows for “early detection of an improper balance in body composition, which may help foster earlier intervention and perhaps prevention. BIA may also provide a measurement of fluid and body mass that can be a critical assessment tool for health status assessment.”⁹ For those seeking to build muscle and lose fat, the insight provided by BIA is ideal. Besides the BIA measurement itself, this analysis returns values for other useful metrics, such as total body water (TBW).



Users of wearable devices and the Leggera Health Scale from Vyvo Technology can benefit from highly accurate and reliable BIA measurements obtained using these devices.



How Vyvo's BIA Works

At Vyvo Technology, we're helping people become the greatest version of themselves by keeping them informed about their body's condition which enables them to act appropriately to what their body is asking for.

Our **Bioelectrical Impedance Analysis (BIA)** is a quick and non-invasive technique used to give an overview of the water and fat percentage in the body. Our BIA uses safe and very low-frequency electrical signals that are sent through the body, allowing our **wearable devices** and **Leggera smart scale** to gather data for analysis and calculation of the body's composition, which can be used to help manage and predict health outcomes.



Whether from wearable devices or Leggera, Vyvo uses its Life Sensing Technology™ to execute Bioelectrical Impedance Analysis. This involves medical-grade sensors specifically configured to accurately collect relevant data for remote processing. The user's data is collected using sensor electrodes placed on the external face and underside of the Vyvo Technology wearable and on the surface of Leggera. During the BIA measurement, these electrodes are in contact with the skin at two points, thereby closing the circuit and allowing the passage of the low electric current through the body to determine the body's impedance. In the case of wearable devices, the electrical current passes through the arms and torso allowing analysis of the upper body and arms, whereas with Leggera, the current passes through the legs, allowing analysis of the lower torso and legs.



Accurate BIA measurement with Vyvo Technology's BIA Algorithm

The Internet of Things (IoT)-connected Leggera smart scale and Vyvo wearable devices measure fundamental aspects of the body's composition using BIA in near real-time. These devices feed data to the cloud for processing by our proprietary algorithm developed in 2020, with the initial version released in 2021. This algorithm returns results to the user's **Vyvo Smart App**, including:



Total Body Water



Extra Cellular Water



Intra Cellular Water



Body Cellular Mass



Intra Cellular Mass



Extra Cellular Mass



Sodium/Potassium Ratio



Fat Mass



Biotype (Android/Gynoid)



Visceral Fat



Free Fat Mass



Skeleton Weight



Free Fat Mass Muscle



Body Mass Index



Body Cellular Mass Index



Basal Metabolic Rate



Protein Factor



Cardiovascular Risk

Many measurement systems that rely on the variation of the electrical flow passing through the body often do not perform a complete impedance measurement, but only measure the ohmic resistance. Vyvo Technology's BIA system detects this resistive part (with high reliability) and in addition, using its customized sensors, Vyvo's devices also detect the reactance part of the impedance, measuring the opposition to a change in the electrical current. This additional measurement is more complex to detect and is important in terms of improving accuracy and gathering extra data, which provides additional information on the body structure. The BIA system developed by Vyvo Technology makes this non-invasive yet informative technology accessible on a large scale, in an economical and simplified way, for anyone seeking to gain insights into their body composition.

The Usefulness of Body Mass Index

According to the Centers for Disease Control, “A high BMI can indicate high body fatness. BMI screens for weight categories that may lead to health problems, but it does not diagnose the body fatness or health of an individual.”¹⁰

Despite concerns that Body Mass Index (BMI) isn’t an accurate measurement of the body’s health, most scientific studies validate that it is, in fact, a standard and accurate measurement of the body’s wellness.¹¹ Based upon a study of 273,845 people, “compared with persons with BMI defined as normal, persons who were underweight, overweight, and obese were at increased risk of death over 30 years.”¹² BMI is a standard and reliable instrument to use in identifying obesity and wellness across the lifespan.



Total Body Water Measurement

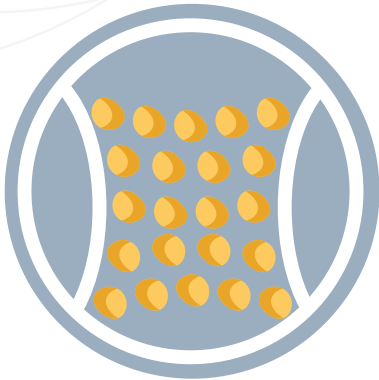
Total Body Water (TBW) is a metric used to measure the body's water composition and can be extrapolated to express how well the body is carrying out normal functions. Quantitatively, water is the predominant component of the human body, representing approximately 60% of the weight of an adult.

Water metabolism is closely related to sodium metabolism because sodium retains water. Too much sodium can cause systemic issues and damage to vital organs in the human body.

Several studies have found that the most up-to-date methods of analyzing total body water using electrodes lead to an accurate estimation of TBW in the human body.¹³ Thus, this metric is a powerful indicator of the body's hydration and can help identify times when one should modify daily activity to take appropriate action. TBW is calculated in real-time by Vyvo wearable devices and can help monitor kidney and filtration function, as well as hydration levels. Low levels of hydration can lead to mental fatigue, inability to make crucial decisions, and even brain damage. It can also be associated with an erroneous sense of hunger, triggering action which could lead to possible weight gain.

Fat Mass and Body Composition

Fat Mass (FM) is a measure of adipose tissue. Excess body fat is a risk factor in numerous diseases such as heart disease, hypertension, respiratory failure, and type 2 diabetes.¹⁴ To decrease Fat Mass, caloric intake must be less than the number of calories the body uses during its daily activities.

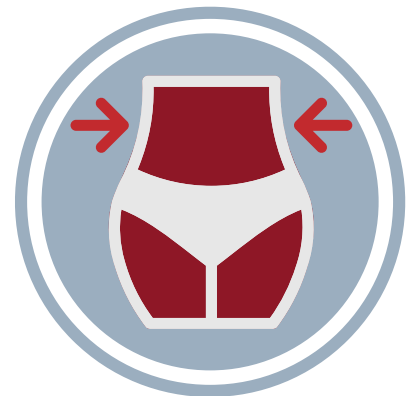


This metric is useful in understanding the health and composition of the human body, and, as a ratio, used to indicate the wellness of a patient. "Low fat-free mass (FFM) or high-fat mass are abnormal body composition phenotypes associated with morbidity."¹⁵ Depending on where the adipose tissue is located, this can indicate that a patient is at risk for medical conditions such as coronary heart disease or life-threatening obesity. Understanding FM can encourage the wearable device users to incorporate more activities into their daily routine and which will positively impact these risk factors.

Basal Metabolic Rate and Body Composition

Basal Metabolic Rate (BMR) is used to understand the energy needed to perform basic functions which the human body carries out at rest. BMR describes energy requirements that the body needs to carry out basic vital metabolic functions (such as respiration, blood circulation, digestion, maintenance of body temperature, the activity of the nervous system).

Basal metabolic rate is measured in kilocalories or kilojoules and is calculated according to body weight. It is not as accurate in cases of very overweight individuals. For this reason, it is usually related to the lean body weight rather than total weight.



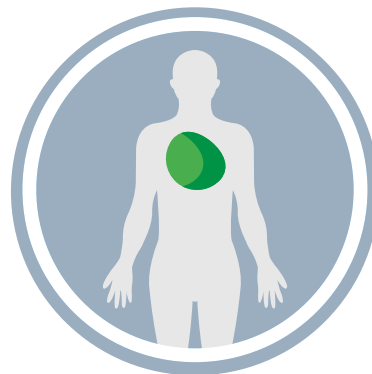
BMR is often used in the fitness and exercise industry and is a major component in formulas used to calculate the metabolic rate. Along with other critical bioparameters, by monitoring this data, it is easier to construct a full picture of the body's health and wellness.



Assessing Body Composition Using Body Cell Mass (BCM)

Body Cell Mass (BCM) is the calculation of the total mass of all the cellular elements in the body, which constitute all the metabolically active tissue of the body.¹⁶ Body cell mass provides an understanding of the body's health because the value rises or falls at a specific rate when a patient has a chronic disease with symptomatic unintentional weight loss, such as AIDS and terminal cancer.¹⁷

BCM can be related to body composition in that it is a representation of the body's biological components. The BCM includes “muscle tissue, organ tissue, intracellular and extracellular water and bone tissue. In normally nourished individuals, muscle tissue accounts for approximately 60% of the BCM, organ tissue accounts for 20% of BCM, with the remaining 20% made up of red cells and tissue cells.”¹⁸ Good health is reflected by maintaining BCM close to these levels. Monitoring significant BCM changes can be useful in providing early warning of an underlying health problem.



Assessing Body Composition Using Biotypes (Android / Gynoid)

In 1950, **Jean Vague** introduced the distinction between **android obesity** and **gynoid obesity**, observing that the first was associated with a greater risk of hypercholesterolemia, hyperuricemia, hypertension, and reduced carbohydrate tolerance.

How does Body Cellular Mass (BCM) relate to body composition and pathologic obesity? In physiological conditions, males and females are distinguished by a different distribution of the fat mass (Figure 1-2). Body forms are linked to the relationship between male (androgenic) and female (estrogenic) hormones.

In the case of pathological conditions, these differences can be exacerbated, distinguishing two main types of obesity: **android** (or apple), typical in men; and **gynoid** (pear), typical in women.



Android obesity, also called central, visceral, truncal, or "apple obesity" is typically exhibited in males. It is associated with a greater distribution of adipose tissue in the abdominal, thoracic, dorsal, and cervicofacial regions.

Android obesity is also associated with a high deposition of fat in the intravisceral area (abdominal or internal).



Gynoid obesity, also called peripheral, subcutaneous, or "pear," is typically exhibited in females. It is characterized by a distribution of the adipose masses in the lower half of the abdomen in the gluteal and femoral regions. In gynoid obesity, fat is mainly present in the subcutaneous compartment, resulting in a high ratio of superficial to deep fat.¹⁹

The most dangerous obesity, related to cardiovascular and metabolic complications, is android, whether it occurs in men or appears in women. The two forms of obesity are typical, but not exclusive of the two sexes; in fact, the cases of men with gynoid morphotype and women with android morphotype are not rare.

Fig. 1-2: Graphical representation of male and female adipose tissue distribution.

The Sodium/Potassium Ratio

A body's **sodium/potassium ratio (Na/K)** provides insight into the body's ability to maintain the balance between sodium and potassium, both inside and outside cells. An abnormal sodium-potassium ratio can be an indication of poor cellular function, including impaired ability to absorb nutrients, eliminate metabolic waste, and maintain muscle tension and contraction.²⁰ The ideal value is a ratio of around **0.85 for men** and **1.00 for women**. A value of **1.60** indicates that there is **60%** more sodium in the cell, suggesting water retention (overhydration) and protein malnutrition. A value of **0.60** indicates strong dehydration and/or energy malnutrition (suggesting that daily calories must be increased).



Conclusion

Bioelectrical Impedance Analysis (BIA) is a simple, painless and non-invasive way to measure body composition, and it provides measurements for a number of bioparameters, making it much more useful than just monitoring weight alone. Vyvo Technology devices make BIA easy to do, and the Vyvo Smart App conveniently processes and presents reports, and track the metrics determined by BIA.

Legal Disclaimer

Unless otherwise specified, Vyvo Technology wearable devices and related services are not medical devices and are not intended to diagnose, treat, cure, or prevent any disease. With regard to accuracy, Vyvo has developed products and services to track certain wellness information as accurately as reasonably possible. The accuracy of products and services from Vyvo Technology is not intended to be equivalent to medical devices or scientific measurement devices.

Consult your doctor before use if you have any pre-existing conditions that might be affected by your use of any Vyvo Technology product or service.

Useful Terms

Body Cell Mass (BCM): The metabolically active component of the organism. Each person has a minimal BCM below which it is not recommended to fall below, due to a decrease in both lean muscle mass and metabolism. It is the fundamental value that must be monitored over time.

Extracellular Mass (ECM): The extracellular mass is composed of body tissues located outside the cells. It is therefore made up of plasma, fluids, tendons, dermis, collagen, elastin, and skeleton.

Total Body Water (TBW): Total Body Water is the total amount of water inside the human body. Water represents about 60% of the weight of an adult individual. If the water measurement is normal, all the parameters measured from bioimpedance analysis will be reliable. Can be further divided into:

Intracellular Water (ICW): Intracellular water is the amount of water retained by the body cells, also understood as the fluids contained within the cell.

Extracellular Water (ECW): Extracellular water represents the amount of water that is outside cells inside the body. From the percentage of extracellular water it is possible to identify states of dehydration or water retention.

Fat Mass (FM): Fat Mass is the actual weight of fat in the body.

Sodium/Potassium Ratio (Na/K): Sodium/Potassium ratios can be used to measure the possible risk of certain fluid imbalances and can help diagnose blood pressure conditions. The ideal value is a one-to-one ratio of sodium to potassium.

Body Mass Index (BMI): The Body Mass Index, represents the ratio between the weight and height of an individual and is used as a weight state indicator.

Basal Metabolic Rate (BMR): The Basal Metabolic Rate, represents the energy expenditure of a living organism, in conditions of mental and physical rest, fasting for 12 hours, and this represents the energy necessary for performing the basic vital metabolic functions.

Protein Factor (PF): Protein factor may indicate the level of protein in the body.

Biotype = Biotype is a group of factors shared by a group of organisms (eg. men and women). Factors or anatomical features usually described are body shape (pear and apple) when discussing obesity in humans.

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