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Management of the Human Body Based on Bioparameters

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Abstract: The main parameters estimated by this method are reflected, among which are the amount of fluid in the body, body mass index, basal metabolic rate, bone and fat mass, level of physical development, and others, as well as their reference values depending on gender and age. The main characteristics of bioimpedance analysis are given, as well as a comparative assessment of bioimpedancemetry and anthropometry. The types of equipment used in the research and their differences are described.

Keywords: physical development, electrical impedance. tria in medicine and anthropological research.

To date, bioimpedance analysis is successfully used in their practice by doctors of various specialties: nutritionists, endocrinologists, doctors of other fields [2]. The technique provides the doctor with a large amount of valuable information, indicates the need for laboratory and functional studies, and helps in determining the tactics of treatment.

The first mention of the study of the electrical conductivity of biological objects is usually attributed to the works of V. Thomson, dated 1880. The fundamental results in this area were obtained at the beginning and middle of the 20th century. These include: the establishment of typical values of specific resistance and dielectric constant of tissues, organs and liquid media of a living organism, as well as the identification and partial explanation of the dependence of the conductivity and dielectric constant of biological fluids and cell suspensions on the frequency of the probing current.

The term "bioimpedance" became generally accepted in foreign publications of the second half of the twentieth century to characterize the electrical properties of biological objects with a cellular structure. The electrical impedance of biological tissues has two components - active and reactive resistance. The substrate of active resistance are biological fluids (extra- and intra-cellular), which have an ionic mechanism of conduction. The substrate of reactive resistance is cell membranes. To assess the total body water (TOB), lean muscle mass (LMM), skeletal muscle mass (SMM), as well as extracellular fluid (ECF), active resistance values of different frequencies are used. By the value of the reactive component of the impedance, the values of basal metabolism (RO) and active cell mass (ACM) are calculated [1; 3].

Bioimpedance analysis (BIA) is a contact method for measuring the electrical conductivity of biological tissues, which makes it possible to assess a wide range of morphological and physiological parameters of the body. In bioimpedance analysis, the active and reactive resistances of the human body and/or its segments are measured at various frequencies. On their basis, body composition characteristics are calculated, such as fat, cell and skeletal muscle mass, volume and distribution of water in the body [1].

The practical application of bioimpedance analysis to characterize the composition of the human body to assess the water sectors of the body, and then other components of the body composition, is usually associated with the work of the French anesthesiologist A. Thomasset, performed in the early 1960s.

This research method was actively practiced in sports medicine already in the middle of the 20th century. It made it possible to objectively control the amount of muscle mass in an athlete, his physical activity and endurance. In accordance with regular measurements, the load, diet, diet were corrected, the daily calorie content was calculated. This ensured the achievement of high results [4].

E. Hoffer with co-authors showed a high correlation between the impedance index and the RVO value, which opened up opportunities for using the method in body composition studies. The first mass-produced bioimpedance analyzers appeared in the United States in the late 1970s. Numerous foreign publications show the accuracy and reliability of bioimpedance assessments of body composition in comparison with reference methods [5].

The history of Uzbekistan research and development in the field of bioimpedance analysis has more than 70 years. The first works on this topic were published in the 1930s by B.N. Tarusov, and at the same time, the production of bioimpedance equipment for assessing the survival rate of transplants based on data on their electrical conductivity began in small batches.

Thus, starting from the 2020s and up to the present, the method of bioimpedance analysis, based on measuring the electrical conductivity of various human tissues, has been used by specialists for more than 65 years in various fields of activity: in medicine, sports, education, science, space and military activities, etc. [1; 3].

BIA is based on the determination of the electrical impedance of biological objects.

Impedance is the total electrical resistance of tissues. This value has two components: active and reactive resistance. Active, or ohmic, resistance characterizes the ability of tissues to thermal dissipation of electric current. The reactance is characterized by a phase shift of the current relative to the voltage due to the capacitive properties of cell membranes capable of accumulating an electric charge on their surface [6].

The physical essence of the bioimpedancemetry method is to measure the body's electrical resistance (impedance) using a bioimpedance analyzer. Since different tissues have different resistance, using a bioimpedance meter, you can accurately measure and determine the content of water, fat and muscle components in the body. In this case, two pairs of electrodes are used in the "arm - torso - leg" circuit using a probing sinusoidal current of constant frequency and low power (no more than 500-800 μA).

Electric current can flow around cells and through cells. Cell boundaries are formed by membranes, which, in their electrical properties, are capacitors that depend on the frequency of the alternating current. The equivalent circuit of a biological object contains the resistance of the extracellular fluid, the resistance of the cellular fluid, and the capacitance of membranes [1].

The specific resistance of biological tissues, determined for a given current frequency, can vary significantly under the influence of physiological and pathophysiological factors: the kidneys and lungs change their electrical conductivity with different blood and air filling, muscle tissues - with different degrees of muscle contraction, blood and lymph - with a change in the concentration of proteins. ¬kov and electrolytes, foci of damage (compared to normal tissue) - as a result of edema or ischemia of various nature, tumors and other causes. This makes it possible to use bioimpedancemetry for a quantitative assessment of the state of organs and systems of the body in various diseases, as well as for detecting changes in tissues caused by drug, orthostatic, physical and other loads.

BIA of body composition consists primarily in assessing the amount of fluid in a biological object, since it is the liquid medium that creates the active component of conductivity. Estimation of fluid volume in the body by impedance is carried out using physical and/or empirical models [1; 3].

The electrical impedance of biological objects is measured using special devices - bioimpedance analyzers. Depending on the set of AC frequencies used, bioimpedance analyzers are classified as single-frequency (at one frequency, usually equal to 50 kHz; in this case, the reactive component of the muscle tissue impedance is close to the maximum), two- or multi-frequency (several AC frequencies are used). current in a wide range - from 1 kHz to 1.3 MHz). In the latter case, the method is called bioimpedance spectrometry [3].

Today, more than 100 thousand bioimpedance analyzers are used in the world: in scientific research, clinical and sports medicine, nutrition and cosmetology.

There are several types of devices for measuring bioimpedance, but the principle of operation is the same for all. One of the measurement methods looks like an ECG. This is the so-called horizontal type of bioimpedance meters. First, the doctor enters into the computer program such data as age, gender, weight and height, waist, hips, wrist circumference. A person is laid down, special sensors are connected to his wrists and ankles - electrodes through which a weak alternating current of low power is supplied [7].

Other types of bioimpedance measuring devices are more like medical scales - this is a vertical type of bioimpedance meters. The patient stands with his bare feet on the platform where the electrodes are located, holds his hands on the retractable handles, on which the electrodes are also located. At the same time, the legs should be spread apart so that they do not touch each other, and the hands do not touch the body.

Most often in the practice of a dietitian, the horizontal type of bioimpedancemetry is used, the vertical version is used in sports medicine [8].

Equipment required for bioimpedance studies includes:

- ✓ bioimpedance analyzer connected to a personal computer with special software installed on it;
- ✓ a couch with a width of at least 85-90 cm (to enable examination of obese patients);
- ✓ stadiometer;
- ✓ scales with a measurement range of up to 150-180 kg and a division value of 0.1 kg;
- ✓ measuring tape to determine the circumference of the waist and hips.

Measurements are carried out in less than one minute, while not only a doctor can apply electrodes and take readings, but also nursing staff trained to work with the device. The results obtained during this safe, painless, non-invasive and fast procedure are analyzed by a computer program and presented in the form of convenient on-screen forms with comments [9]. In addition to the indicators of the survey just conducted, the protocol contains comparative information, taking into account the parameters of previous measurements entered into the database.

Preparation of the patient before the bioimpedancemetry procedure includes the following items:

- ✓ a week before the examination should stop taking diuretics;
- ✓ two days before the procedure, you must refrain from drinking alcohol, tea and coffee;
- ✓ the last intake of water and food should be no later than 3-4 hours before the examination;
- ✓ half an hour before the procedure, the patient should empty the bladder;
- ✓ before the start of the examination, it is recommended to spend 7-10 minutes lying on a horizontal surface (preparatory time increases in hot or cold weather in order to preliminarily acclimatize the patient);
- ✓ room temperature during the procedure should be 22-25 °C.

Immediately before the hardware examination, the necessary measurements are made: height, weight, waist and hips are determined. All measurements, as well as the last name, first name, patronymic, gender and date of birth of the subject are entered into the database of the computer program [8].

During the procedure, the patient should lie on his back, being isolated from surrounding electrically conductive objects. There should be no contact between the inner surfaces of the thighs (up to the groin), as well as between the inner surfaces of the arms and the torso (up to the armpits). Watches, chains, rings and metal bracelets should be removed from the patient's hands, and metal objects around the neck should be moved to the chin. Appropriate areas of the skin before attaching the electrodes should be wiped with alcohol.

When working with a bioimpedance analyzer, it is possible to perform measurements using two types of sensors: disposable stickers (stickers) or reusable clip electrodes, which are also used in electrocardiography. The use of disposable sticker electrodes provides higher measurement accuracy, since the stickers are securely attached to the skin, which eliminates the possibility of their displacement.

The location of the electrodes on the hand using stickers should be as follows: the middle of the red electrode should be above the articulation of the metacarpal bones and the base of the phalanges between the index and middle fingers. The middle of the black electrode is located above the articulation of the bones of the hand and forearm.

When placing electrodes on the leg using stickers, the middle of the red electrode should be above the articulation of the bones of the metatarsus and the base of the phalanges between the second and third fingers. The middle of the black electrode is located above the articulation of the bones of the foot and lower leg [8; 9].

Upon completion of the diagnosis, the patient is given a protocol with all indicators, which are reflected not only in text, but also in graphic and schematic formats. The data obtained is stored so that over time it will be possible to undergo a control examination and evaluate the functional state of the body in dynamics, after the end of the course prescribed by the doctor.

Comparative evaluation of bioimpedancemetry and anthropometry

Among the operational methods for determining the composition of the human body, anthropometric methods are the most popular in world practice, and in recent years, bioimpedance analysis has been successfully used [3].

The history of the use of anthropometry to determine body composition goes back almost 85 years and, apparently, originates in the work of J. Matejka, who in 1921 proposed formulas for determining the amount of fat, muscle and bone tissue in vivo based on measuring the thickness of skin-fat folds [10].

Anthropometry is a set of methodological techniques in anthropological research for measuring (somatometry) and / or describing (anthroposcopy) the human body as a whole or its individual parts, as well as for characterizing their variability. Within the framework of anthropometry, there are separate areas associated with the measurement of the bones of the skeleton and skull (osteometry, craniometry.

Among anthropometric methods, an alternative to bioimpedance analysis of body composition is the calculation of body mass index using the body mass index (BMI) formula: BMI = weight, kg / (height, m)2 [13]. However, such a calculation gives a rather average value. In assessing obesity and other disorders of the trophic status at the individual level, the body mass index has poor diagnostic sensitivity (about 50%) and has serious shortcomings.

Bioimpedance analysis of the body provides objective data on the composition of the biological tissues of a particular patient and indicates possible deviations and functional disorders in the body [14].

Undoubtedly, the interpretation of the obtained data requires a highly qualified specialist.

The indicators obtained by bioimpedancemetry adequately reflect the constitutional features of the organism. At the same time, the value of fat mass, determined using anthropometric calculation formulas, has a high correlation with the mass of fat obtained with BIA. This fact is quite obvious and predictable, however, according to various researchers, the correlation coefficients between these parameters vary widely - from 0.5 to 0.98, and the differences in the results of BIA and caliperometry sometimes reach 15%. This fact indicates the need for careful selection of formulas for calculating body composition in the absence of the possibility of bioimpedancemetry.

The total amount of water in the body, the level of basal metabolism, bioelectrical parameters of tissues cannot be calculated on the basis of anthropometry. Nevertheless, the listed indicators are essential in the study of body composition, since numerous studies confirm their significance as informative criteria for the boundaries of normal and pathological variability of individual organs, systems, and the body as a whole [15].

Possibilities of bioimpedancemetry

Based on bioimpedancemetry data, the following indicators can be assessed:

- individual value of ideal weight;
- the amount of adipose tissue in kilograms and in relation to the total weight;
- the amount of extracellular fluid (blood, lymph);
- the amount of intracellular fluid;
- the amount of fluid in the body in a bound state (in edema);
- quantity in kilograms and percent of active cell mass (muscles, organs, brain and nerve cells);
- BMI;
- basal metabolism (kcal) - metabolism in 24 hours at rest;
- the ratio of sodium and potassium ions in the body (Na^+/K^+);
- deviation of the measured values from the norm;
- the dynamics of change.

Total body weight is considered as a combination of fat and lean mass. Lean, or lean, includes extracellular mass (connective tissue, extracellular fluid) and active cell mass (muscle and organ cells, nerve cells). The value of each indicator depends on several factors, in particular on the sex and age of the subject [16].

The higher the percentage of active cell mass in the body, the more energy a person spends (including the cost of food thermogenesis, basal metabolism and physical activity) and the faster he loses weight, since the main burning of calories occurs in the AKM. With a deficit of active cell mass, fat accumulation will continue even with a low caloric content of the diet [13]. In a healthy person, the percentage of AKM is about 75-85% of the weight. With its lower content, one can assume the pathology of the thyroid gland (with increased metabolism) or the liver. With a decrease in the proportion of AKM, body weight decreases, however, cellular nutrition and the functions of internal organs are disturbed. The study of body composition helps to avoid adverse effects. It is no less useful to conduct bioimpedancemetry during training and diet in order to intensively gain muscle mass. Normally, it leaves 30-40% of body weight. The more active the power physical load, the more the muscle mass increases and, accordingly, the higher the indicator [14]. The process of weight gain should occur due to an increase in the content of dry muscle mass in the body, however, often with an unbalanced diet, an increase in body weight also occurs due to a large amount of body fat. And here again, regular monitoring with the help of a bioimpedance analyzer will help.

Lack of bone mass can be a sign of osteoporosis, a violation of the structure of bone tissue, which leads to an increased risk of fractures. Often this condition is observed with an unbalanced diet with a deficiency of calcium, magnesium and some vitamins in the diet, a sedentary lifestyle, metabolic disorders, diseases of the gastrointestinal tract. You are also more likely to develop osteoporosis if you are overweight or underweight. Calcium is the main structural element of bone tissue, and therefore the deficiency of this mineral is reflected in a decrease in the proportion of bone mass in the body. Calcium is also necessary for muscle function, blood clotting and the functioning of the nervous system.

Adipose tissue is necessary for the body, because it is a store of energy, vitamins and fatty acids, which are participants in vital processes. Fat cells perform protective and heat-insulating functions, accumulate and synthesize certain hormones. However, excess fat mass causes numerous disorders in the body. Firstly, for the purpose of blood supply to adipose tissue, the network of blood vessels increases, which creates an additional load on the heart. Secondly, slags and toxins accumulate in fat cells. Thirdly, there are hormonal disorders. Fourthly, with a significant excess weight, the load on the joints and spine increases, and fifthly, the risk of developing vascular atherosclerosis increases, which, in turn, leads to serious consequences in the form of heart attack and stroke [6]. A more accurate conclusion about specific disorders in the body and the prognosis of diseases can be made by measuring the volume of fat mass in various areas of the human body, which is performed with bioimpedancemetry.

The optimal level of the fat component in percent for women, depending on age: up to 30 years old - 20-28%, 30-39 years old - 21-29%, 40-49 years old - 22-29%, 50-59 years old - 23 -31%, after 60 years - 24-32%.

In men: up to 30 years old - 18-24%, 30-39 years old - 19-26%, 40-49 years old - 19-27%, 50-59 years old - 20-29%, after 60 years old - 22-31% .

This parameter evaluates the physical condition in accordance with the ratio of the amount of fat and muscle mass in the body. If the subject becomes more active and the amount of body fat decreases, then the fitness rating also changes accordingly. Even if total weight does not change, muscle mass and fat levels may change [7].

There are nine levels of physical development. The first is hidden fullness. It is characterized by a small skeleton, completeness. It seems that the person is physically healthy, but in fact there is a high fat content and reduced muscle mass. The second is the presence of fullness (average skeleton, fullness, high fat content and average muscle mass). The third is a strong build (large skeleton, fullness, high fat content and large muscle mass). Fourth - insufficient training (small muscle mass and average fat content). Fifth - standard (average muscle mass and fat content). The sixth is the muscle standard, characterized by large muscle mass and an average fat content. Seventh - thinness (low muscle mass and low fat content). Eighth - thinness and the presence of muscles (low fat content, but a sufficient amount of muscle mass). Ninth - expressiveness of muscles (low fat content, but above average amount of muscle mass).

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