Changes in bioimpedance depending on conditions

Zmiany w bioimpendancji w zależności od warunków

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Wstęp. Wiadomo, że gęstość kości i masa mięśni istotnie wpływają na masę ciała. Oznacza to, że dwie osoby mające tę sama wysokość i obwód pasa mogą mieć istotnie różna masę wynikająca z różnicy w składzie ciała.

Metody. Badaniami objęto siedmiu pracowników uniwersytetu w przedziale wieku 25-67 lat. Pomiarów masy ciała i wysokości dokonano metodami standardowymi, a uzyskane wyniki stanowiły podstawę do obliczenia wskaźnika wagowo-wzrostowego BMI (Body Mass Index). Badania składu ciała wykonano metodą bioimpendancji z zastosowaniem różnych substancji do smarowania elektrod: smar standardowy, woda, roztwór soli, żel do EEG, krem do rąk z olejem nakładany na ręce, krem do rąk bez oleju nakładany na ręce, krem do rak z i bez oleju nakładany na ręce i stopy, krem do rak bez oleju i krem do stóp na bazie wody.

Wyniki. W zależności od zastosowanych warunków badania zmieniały się wartości oporności. Najwyższa korelację uzyskanych wyników stwierdzono przy częstotliwości 250 kHz. Wykazane zmiany zawartości tłuszczu w ustroju wahały się w granicach 4.43-21.95% i zależały od warunków pomiaru.

Wniosek. Warunki i miejsce pomiaru składu ciała metodą bioimpedancji mogą istotnie wpływać na wynik. Warunki i miejsce pomiaru istotnie wpływają na wynik zawartości tłuszczu i beztłuszczowej masy ciała, przy stosowaniu podobnych warunków rezystancji.

Słowa kluczowe: *bioimpedancja, skład ciała, BIA, tkanka tłuszczowa*

Background. It is known that the density of bones and quality of muscles influence the weight to a certain degree. That means that two persons of the same height and waist size might manifest a relatively high difference in weight due to the differences in body composition.

Methods. Seven subjects of the university in the age group of 25 to 62 years were included in the monitoring. The height and weight were measured in the standard way and BMI was calculated. All individuals were measured in these conditions: normal conditions, application of water, solution saline, EEG gel, hand cream with oil-hand application, oil-free hand cream-hand application, hand cream with oil-hand and foot application, oil-free hand cream-hand and foot application, oil-free hand cream and water-based foot cream.

Results. The changes in resistance differ depending on the conditions from these values and a correlation has been made and best values for the correlation have frequency of 250 kHz. We proved the dependence of changes in the amount of body fat on reliance on conditions of measurements ranging from 4.43% to 21.95%.

Conclusions. The conditions of measurements of body composition by using the method of bioimpedance can significantly influence the result of the measurements in the area of body composition. The conditions of measurements influence the results in the area of the amount of body fat, lean body mass; it applies similarly to the resistance values.

Key words: *bioimpedance, body composition, BIA, body fat*

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Introduction

Nowadays BMI (body mass index) is a parameter that is often used in studies to indicate a degree of obesity (or slimness). BMI is a calculated value that uses the patient's height and weight. Therefore two persons of the same height and weight can have the same BMI but their body composition can be diametrically different. The focus only on BMI can lead to biases in classification if no other information is obtained. Hence BMI should be used in big studies as a first approach before further investigation.

It is known that the density of bones and quality of muscles influence the weight to a certain degree. That means that two persons of the same height and waist size might manifest a relatively high difference in weight due to the differences in body composition.

Thus, a method allowing the measurement of more informative quantities is necessary in order to evaluate the amount of body fat more objectively and precisely. Obesity does not refer to excessive body weight but it refers to the condition in which the individual has an excessive amount of body fat. Many laboratory and field assessment techniques exist for estimating a person's body composition.

The Body Impedance Analysis (BIA) represents one of the methods for classification of body composition.

This method uses electrical current that is injected into the body. This current is measured and from these values parts of body composition are calculated, such as FFM (fat free mass), TBW (total body water), ICW (intracellular water), ECW (extra cellular water), fat%, etc.

Nowadays the devices for impedance measurements range from basic to very complex. Basic machines use just single frequency measurements and mostly have only one pair of electrodes. More complex devices use a wider range of frequencies and mostly have more electrodes which allow segmental measurements of a body. This feature is important e.g. for measurements of a single body part in case of hydration or other problems.

It is crucial to know which value is needed in order to choose the right device. E.g. for basic examination a basic device is enough, but these devices could be often biased. So it is crucial to use a proper device.

It is possible to determine the patient's obesity in more than one way. One method of the obesity characterization is Body Mass Index (BMI) > 30 kg/m^2 and by body fat increase. But as discussed earlier, the question is if BMI alone is sufficient for the obesity classification. Another classification of obesity was determined by WHO as a body fat ranges for standard adults [1].

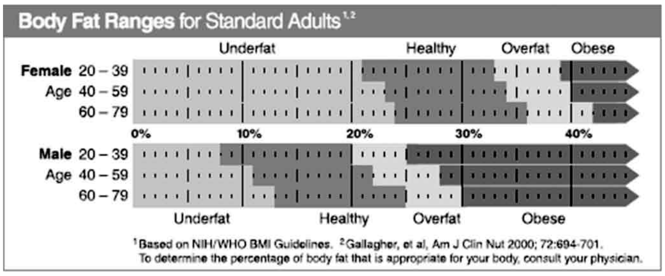

Fig. 1. Ranges of fat mass (FM) from the WHO guidelines

Ryc. 1. Zmiany masy tłuszczowej (FM) wg WHO

This obesity classification should be better because it takes into account not just weight and height but also body fat% which is a definition of obesity.

From this perspective the method able to measure or calculate body fat % should be more precise than just BMI or any other method. For the body composition measurement it is possible to use several methods and bioimpedance is one of best.

Many of the studies [2-5] performing BIA for various purposes (e.g. relevance to diagnosing metabolic disorders, cardiovascular risk, assessment of degree of obesity, etc.) usually do not mention patients and electrode status and frequency used during the measurement. Also no information about environmental conditions is given. This led us to formulation of the following two goals of our study [6-8].

Aims

The first part of the work deals with a question of measuring human body composition – how and why. The task is to find out the role of environmental conditions. The goal is to find out what effects have different hand- and feet-measuring conditions such as sweat, usage of gels and moisturizers. It is assumed that changes in measurement conditions may lead to mistakes and biases of values for specific parts of the body.

The second goal is to measure and evaluate the body impedance changes and to find out if frequency does have importance on these conditions. And if frequency of 50 kHz is sufficient for measurements a wider range of frequencies should be used.

Materials and methods

Seven subjects of the university in the age group of 25 to 62 years were included in the monitoring in the first task. The height and weight were measured in a standard way and BMI was calculated. The BMI mean was 23.05±5.86. All individuals were people having average values of biological parameters. The Tanita MC 180 MA device was used.

Tanita MC-180 MA is able to measure on frequencies 5 kHz, 50 kHz, 250 kHz and 500 kHz. It is also possible to do segmental measurements.

All individuals were measured in these conditions: normal conditions, application of water, solution saline, EEG gel, hand cream with oil hand application, oil-free hand cream-hand application, hand cream with oil-hand and foot application, oil-free hand cream-hand and foot application, oil-free hand cream and water-based foot cream. For better outcome every measurement was doubled and average values were used.

In the second task, a multi-frequency eight-electrode approach of body impedance was considered. BIA was carried out on the following frequencies: 5kHz, 50 kHz, 250 kHz and 500 kHz.

Results and discussion

The results measured and observed during the changes of conditions are shown in tables one and two. For better understanding also the change of body fat % and resistance is shown in Figure 2 and Figure 3.

The results of the first set of measurements show that the values confirm the hypothesis that the level of body composition can by influenced by measurement conditions. If we consider the first measured values in table I is 100% then the values of other measurements vary between 102.49% and 76.42%.

Table I. Changes of body fat % depending on conditions
Tabela I. Zmiany procentowej zawartości tłuszczu w zależności od warunków

Body fat % /% zawartości tłuszczu	Patients /Pacjenci					
Meas no	1	2	3	4	5	6	7
1	22.05	3	6.15	37.2	24.7	11.3	21.6
2	22.6	3	6.05	37.45	24	11.05	20.9
3	22.15	3	5.8	37.45	23.85	11.1	20.8
4	22.2	3	5.6	36.4	22.95	10.9	20
5	22.1	3	6.05	37.5	24.05	11.25	20.9
6	21.7	3	4.8	37.8	22.9	11.25	20.8
7	22.45	3	4.7	37.55	24.85	11.35	21.6
8	21.9	3	5.15	38.05	24.35	11.15	20.55
9	21.5	3	5.6	37.8	24.3	10.45	19.5

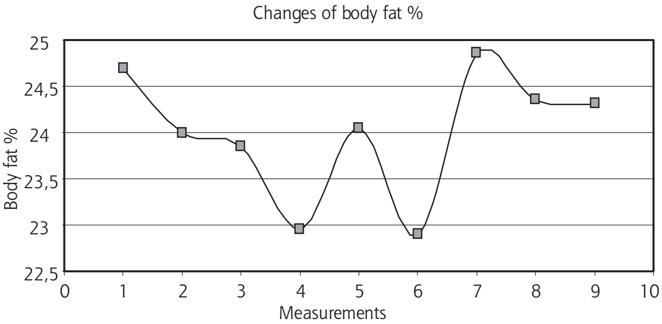

Fig. 2. Changes of body fat % depending on conditions

Ryc. 2. Zmiany procentowej zawartości tłuszczu w zależności od warunków

Table II. Changes of resistance depending on conditions
Tabela II. Zmiany oporności w zależności od warunków

Resistance	Patients /Pacjenci						
Meas no	1	2	3	4	5	6	7
1	349.4	546	468.9	501.8	594.9	466.6	723.1
2	355.6	520	468.3	504.3	585.5	463.5	711.5
3	351.5	533	466.0	504.5	583.9	463.8	710
4	352.2	519	464.6	489.6	572.3	461.6	698.7
5	350.0	534	469.2	504.9	586.8	466.0	712.1
6	345.8	534	464.6	508.8	572.6	465.6	710.9
7	355	534	464	505.7	597.4	467	722.25
8	349.2	526	469.2	513.8	591.0	465.3	706.1
9	344.6	525	472.9	509.9	590.3	457.5	697.6

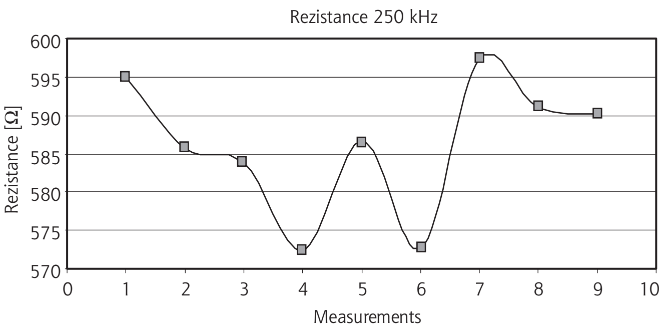

Fig. 3. Changes of resistance depending on conditions

Ryc. 3. Zmiany oporności w zależności od warunków

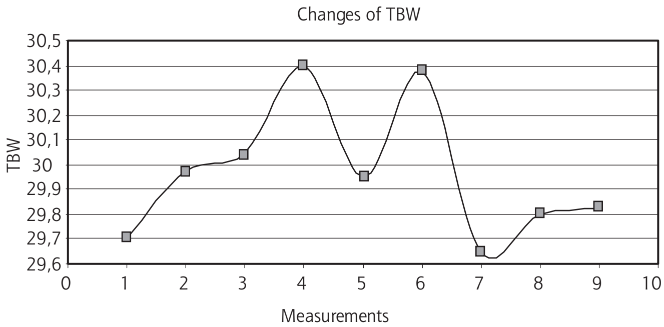

Fig. 4. Changes of TBW depending on conditions

Ryc. 4. Zmiany TBW w zależności od warunków

Table III. Changes of body impedance during measurement in person no. 1
Tabela III. Zmiany impedancji dla pacjenta nr 1

Changes of resistance (Ω) depending on conditions				
Measurement no.	R(5kHz)	R(50kHz)	R(250kHz)	R(500kHz)
1	474.65	398.8	349.4	338.45
2	482.8	405.35	355.6	344.15
3	479.9	402.3	351.55	340
4	481.45	402.65	352.2	340.95
5	475.35	399.15	350.05	338.8
6	470.2	394.5	345.8	334.45
7	482.6	405.1	355	344.2
8	476.5	399.45	349.25	337.95
9	470	393.65	344.6	333.25

Although the differences in some cases are not very significant it is obvious that conditions can have influence on the outcome values. It is also shown that values obtained from persons with low body fat can be biased. Some creams and moistures can dramatically change contact conditions between hand, foot and device electrodes.

As shown in Tables 1 and 2 the changes in body fat and impedance between measurements differ within the range of 4.43% and 21.95%. This shows that knowledge of application of various creams and lotions can be very important.

In Figure 4 the changes in total body water (TBW) are shown. These changes correspond to changes of condition as well but in a negative correlation.

As showed in table 3 the changes in resistance differ depending on the conditions – from these values the correlation has been made and best values for the correlation have frequency of 250 kHz.

Conclusions

In this study we have proven that changes in measuring condition can change the outcome values of a measured subject. The differences between some measurements were significant. The resistance was changed every time those conditions were different.

This leads to the importance of exact specification of the measurement conditions. Therefore the importance of the patient and device status is necessary to know. In some cases the difference between the normal status and status with sweat on hands and feet can play a significant role in the outcome values. It is necessary to know in which state the measurement is performed. Also the composition of sweat can be very important because sweat differs between patients. This is an additional information necessary for the correct evaluation. Otherwise the results of such a measurement can be biased.

It is shown that the bioimpedance method is suitable for the body composition evaluation. Also values of body fat, lean mass, total body water are accessible by this method. This method has better outcomes than just BMI and can be easily used in various conditions and patients. This method is fast, relatively cheap and has very good outcome values.

In future more measurements should be made to prove the importance of measurement conditions in the bioimpedance technique. Also further standardization in this field of body composition should be made because no standardization is made nowadays.

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