Bioimpedance in medicine: measuring hydration influence

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Abstract. The aim of the paper is to present results of our ongoing research focused on the influence of body hydration on the body impedance measurements and also on the influence of the frequency used for the measurement. The question is why to measure human body composition and if these values have beneficial results. First goal of the work deals with a question of measuring human body composition. The performed measurements showed certain influence which must be verified by repeated experiments.

1. Introduction
The most popular and publicly well-known are the studies using the Body Mass Index (BMI) as a single parameter indicating the degree of obesity (or slimness). However it cannot tell anything about the body composition. This parameter is very specific because it does not take into account human body composition. This fact means that 180cm, 90kg sports man and 180cm, 90kg lazy man can have the same BMI. The BMI is the same but just at glance we can tell who is healthier. Because of that body composition is very important, with values of body composition it is easier to predict and treat diseases connected with obesity.

It is known that density of bones and quality of muscles influences the weight to a certain degree. That means that two persons having the same height and waist size might have relatively high difference in weight due to the differences in body composition. Thus, a method allowing measurement of more informative quantities is necessary in order to evaluate the amount of body fat more objectively and precisely. A method that would be able to measure important body composition more precisely and cheaper is needed.

There are several methods to determine body composition such as DXA that is considered being the reference method. Despite all benefits, this method has also disadvantages. A practical limitation of DXA is exposure of the subject to ionizing radiation (<5 µSv). Another disadvantage is price of this method. Other methods are e.g.: W/H circumference, measurements with calipers and so on.

The Body Impedance Analysis (BIA) represents one of the methods for classification of body composition. This method uses electrical current that passes through the body. This current is then measured and from these values there are calculated parts of body composition such as FFM (fat free mass), TBW (total body water), ICW (intracellular water), ECW (extracellular water), fat% and so on. At present the most frequently used frequency for elementary devices is 50 kHz. The question is
whether this frequency is correct. Or would be another one better? BIA can be performed on various devices. Starting with basic single frequency bipedal devices and ending with high end devices that are using multi frequency tetra polar electrodes system. It is crucial to know which value is needed and due to this choose right device. For example, for basic examination basic device is enough, but these devices could be often biased. So it is crucial to use proper device.

This is very true for obesity as 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.

Obesity is characterized by Body Mass Index (BMI) > 30kg/m² and by body fat increase. It is possible to use a number of methods including the measurement of body impedance for observing the body fat mass. Body impedance depends on body composition, i.e. on the amount of water in individual tissues.

Many of the studies [1,2] performing the BIA for various purposes (e.g. relevance to diagnosing metabolic disorders, cardiovascular risk, assessment of degree of obesity, etc.) usually do not mention level of hydration of examined subjects and frequency used during the measurement. This led us to formulation of the following three goals of our study.

2. Goals
   The first goal is to find out what effect liquid consumption has to the measurement and to which degree the measured values are influenced by level of hydration. Impedance has the highest value in fat tissue that contains only 10 – 20 % of water. In fat-free mass that contains 70 – 75 % of water the values are lower. For the measurement under standard conditions it is assumed that the body is within normal hydration ranges. If a person is dehydrated then the amount of fat tissue can be overestimated.

   The second goal is to identify importance of frequency on measuring. The reason is that the recently developed devices for clinical purposes allow multi-frequency measurement. It is assumed that it may lead to more precise measurements of specific parts of the body, and that each frequency can have specific importance.

   The third goal of this work was to compare two devices InBody 720 and Tanita MC-180 MA in extreme body weight. We consider that every device uses specific software (equations) for calculating body parameters.

3. Methods
   For the first measurement there was taken a group of 15 individuals. They received 1,3 l of water to find out the importance of body hydration. Measurements were taken before drinking, 40 minutes after drinking, then 30 minutes later and the last measurement was taken before going to toilet.

   In the second experiment the group of 15 individuals was measured. Two devices InBody 720 and Tanita MC-180 MA were used. Tanita MC-180 MA device is able to measure on frequencies 5 kHz, 50 kHz, 250 kHz and 500 kHz. InBody 720 device is able to measure on frequencies 1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz and 1 MHz. We used for comparison only four frequencies available on both devices. We studied changes of impedance values in dependence on changing frequency.

   An individual with BMI > 35 kg/m² was measured to compare values of these two devices in extreme body composition conditions.
4. Results

Quantitative results are shown in Table 1, Table 2, and Figure 1.

| Table 1, 2: Values of impedance (Ω) during hydration measurements on both devices |
|----------------------------------|------------|------------|------------|----------------|------------|------------|------------|
| Tanita                          | Meas 1     | Meas 2     | Meas 3     | InBody       | Meas 1     | Meas 2     | Meas 3     |
| 1                               | 208.9      | 209.5      | 210        | 1            | 273.81     | 285.47     | 266.21     |
| 2                               | 227.3      | 224.2      | 226.6      | 2            | 325.22     | 317.87     | 363.05     |
| 3                               | 277.1      | 277.5      | 281        | 3            | 363.03     | 382.17     | 429.36     |
| 4                               | 183.8      | 184.5      | 185.2      | 4            | 188.49     | 181.58     | 220.11     |
| 5                               | 219.9      | 217.3      | 218.5      | 5            | 280.29     | 273.2      | 290.91     |
| 6                               | 251.7      | 241.3      | 240.2      | 6            | 310.78     | 311.19     | 357.77     |
| 7                               | 256.6      | 252        | 254.3      | 7            | 308.69     | 311.59     | 339.89     |
| 8                               | 239.6      | 245.4      | 242.9      | 8            | 291.24     | 308.53     | 348.49     |
| 9                               | 277.1      | 277.5      | 281        | 9            | 363.03     | 382.17     | 429.36     |
| 10                              | 183.8      | 184.5      | 185.2      | 10           | 188.49     | 181.58     | 220.11     |
| 11                              | 227.3      | 224.2      | 226.6      | 11           | 325.22     | 317.87     | 363.05     |
| 12                              | 277.1      | 277.5      | 281        | 12           | 363.03     | 382.17     | 429.36     |
| 13                              | 227.3      | 224.2      | 226.6      | 13           | 363.03     | 382.17     | 429.36     |
| 14                              | 277.1      | 277.5      | 281        | 14           | 363.03     | 382.17     | 429.36     |
| 15                              | 227.3      | 224.2      | 226.6      | 15           | 363.03     | 382.17     | 429.36     |
| **Average**                     | **232.06** | **231.28** | **231.37** |              | **291.46** | **299.20** | **334.89** |

**sd**  | 23.516173  | 23.023897  | 23.129994  |              | 37.403705  | 40.895356  | 47.52057

Figure 1: History of impedance (Ω).

Figure 2: History of TBW (kg).

On table 1, 2 and figure 1 there is shown progress of impedance during hydration. From these outcomes it is obviously seen that consumption of water is noticeable but it depends on subject. And it also depends on each used device. From our research it is shown that in general consuming 1.3 l of mineral water does not have so high importance, but only when we use comparable devices. In figure 2 there is shown progress of TBW during hydration.

Next goal was following progress of impedance during change of frequency. These trends are shown in figure 3.

Figure 3: Progress of impedance Tanita and Inbody.

In this figure there is shown progress of impedance dependent on frequency on both devices. The dependence of impedance on frequency was very significant. However, further studies are needed to confirm which frequency is best for measurements or if all four frequencies are necessary.

The last goal was to compare two devices to find out which device is more suitable for measuring and whether there is a significant difference in these devices. We used extreme conditions. The result of this comparison is shown in figure 4.
From figure 4 it is obvious that there is a difference between these two devices but the difference is not so significant. So it is possible to replace these devices and outcome values should not differ so much.

5. Conclusions
The outcome of this study is that these devices are comparable for measurements of extreme conditions. Correlation of impedances and other body composition values were very high. The dependence of impedance on frequency was very significant. Therefore a deep analysis is necessary which frequencies to use. Third outcome was that hydration has not significant influence on changes of body impedance. Work still continues to prove whether hydration of an individual has certain influence on body composition, such as FFM, TBW.

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References
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