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Evaluation of Effects of Hydration and Dehydration Status On Body Composition Analysis Using Bioelectrical Impedance Method

Sermin Algül[1*], Oğuz Özçelik[2]

[1]*Van Yuzuncu Yil University, Faculty of Medicine, Department of Physiology*
[2]*Kastamonu University, Faculty of Medicine, Department of Physiology*

Abstract

We aimed to evaluate effectiveness of bioelectrical impedance analysis (BIA) method on the body composition analysis under the condition of acute water intake and excretion in young healthy male.
Thirty male with normal body mass index were participated to this study. Each subject consumed 500 mL water every 30 minutes for three times (total of 1500 mL water). During study, body composition analysed five times using foot-to foot BIA, one at basal, then three times after each water consume and lastly after excretion of bladder. Body fat mass, fat percent, total body water and fat free mass were measured and recorded. Anova test used to analyse data and $p<0.05$ was accepted as significant.
There were systematic increases in body fat mass and fat percent following each 500 of water intakes. However, body water levels did not change at 500 mL and 1000 mL water intakes and significant changes observed at 1500 mL of water intakes. In addition, water excretion caused significant decrease in fat mass in all subjects while it did not occur in water measurement. There was positive correlation between water intake and fat mass changes.
Conclusion: As a results, BIA based body composition analysis failed to measure valid fat mass and water content under the condition of increased and decreased body water levels in healthy males. Thus, clinician or scientist should consider underestimation of water and higher estimation of fat mass values using BIA method in subjects who has high body water and fat mass contents for crucial clinical decision.

Key Words: Bioelectrical impedance analyses, fat mass, fat free mass, total body water, fitness

Introduction

Bioelectric impedance analysis (BIA) is a non-invasive method that can be applied easily and practically to evaluate body composition. BIA is a widely used method in clinical and sports sciences to evaluate body composition analysis for determining fitness, health and treatment status of athletes, normal or ill individuals (1-3). BIA method is calculating body composition indirectly with formulas based on the resistance of tissues against electrical current (4). The determination of adipose tissue and its ratio in body composition, the amount of body water and lean mass separately, effectively and reliably is one of the clinically important issues. It is known that the increased fat ratio of the body includes significant risks in terms of hypertension, dyslipidaemia, diabetes or coronary heart diseases (5). For this reason, it has been shown that measurements are made with BIA effectively in disease groups triggered by the increasing amount and ratio of body fat (6). On the other hand, it has been shown that BIA effectively performs body composition analysis in chronic obstructive pulmonary patients where muscle mass loss has a negative effect on the prognosis of the disease (7). It is used in determining body composition, especially water conditions, in dialysis patients (8). BIA is also used effectively in the follow-up and prognosis of cancer (9) and diabetes (10) patients. In addition to studies showing that BIA management gives effective and reliable results in body composition analysis, there are studies showing that its effectiveness is not valid, especially with changes in body hydration (10, 11). On the other hand, there is also a study showing that acute water intake induced changes of body hydration status did not caused statistically significantly change in the effectiveness of BIA measurements (12-14). The aim of this study is to determine the response of body composition

*Corresponding Author: Sermin Algul, Van Yuzuncu Yil University, Faculty of Medicine, Department of Physiology, Van, Turkey
E-mail: serminalgul@hotmail.com
ORCID ID: Sermin Algül: 0000-0003-2489-3619, Oğuz Özçelik: 0000-0002-2391-9883
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distribution during acute water intake and after excretion with the food-to food BIA method and to determine the measurement efficiency of this method in hydration and dehydration conditions on healthy young male subjects.

Materials and Methods

A total of 30 young healthy sedentary male subjects participated in this study. The age, height and body mass index of the subjects (Mean ± SD) are 21.2 ± 1.6 years, 178 ± 6 cm and 21.81 ± 2.0 kg / m^2, respectively. In order for the subjects to participate in the study, they must be in the 18-25 age range and have a normal body mass index (18.5-25 kg / cm^2). In addition, the participants in the study should not be using alcohol, smoking or any drugs, and should not have an acute-chronic metabolic, cardiac and respiratory system disease that could affect the measurements. After obtaining approval for the study from the local ethics committee (Registration No: 2019.01.15 and Decision No: 2017-KAEK-189_2019.02.28_13), all subjects participated in the study after reading and signing the consent form. All subjects were in the study laboratory between 08:00-10:00 am, with an empty stomach, bladder and gastrointestinal tract, following an overnight fast. The subjects were evaluated with bare feet, using the sedentary mode with the BIA method (TBF 300A JAPAN). It was paid attention that the subjects were at rest before the measurement (15). The first body composition measurement was taken at baseline. Subsequently, the subjects were given 500 mL of normal bottled water to increase hydration. The subjects were kept for 30 minutes in order to distribute the water in the body. The second BIA measurement was made and recorded. After this measurement, the subjects were given the second 500 mL of water (1000 mL in total). It was held for 30 minutes again. The third measurement was made afterwards. Following this, the third 500 mL (total 1500) of water was drunk. It was waited 30 minutes. The fourth measurement was made. Following the hydrating period consisting of these three stages, the subjects were recorded by determining the state of decrease in the fifth and last measurement hydration after urinating. In this study, the subjects were given hydration increasing water regularly at 30-minute intervals. In the follow-up, the body composition analysis assessment based on the BIA method of reducing the increased hydration in the body with mixing was determined in steps.

Statistical Analysis: Descriptive statistics were presented as Mean ± Standard deviation. Repeated Measures Analysis of Variances (ANOVA) was used to compare group means. Following the ANOVA, Duncan multiple comparison test was used to identify different groups. For determination linear relationships among the variables, Pearson correlation analysis was carried out. Statistical significance level was considered as 5% and SPSS (ver: 21) statistical program was used for all statistical computations.

Results

Table 1 shows the body composition values measured by the BIA method during water intake and disposal obtained as a result of the study performed on healthy young male subjects with normal body composition. Following basal measurement, intake of 500 mL water for three times at 30 min intervals resulted in an increase in body weight 1.47 ± 0.04 kg (mean increase of 2.1%). At the end of the study, after the bladder emptying, an average of -536 ± 40 g decrease in body weight was observed. The water and lean mass amounts of the subjects did not show a statistically significant increase in the measurements with BIA at 500 mL (0.4%) and 1000 mL (0.8%) water intake, and a statistically significant change was observed in 1500 mL water (1.1%) intake ($p < 0.05$) (Table 1). The change in the amount of water and fat mass after the 500 mL water intake section is given in Figure 1. There were decreases in fat and water measurement in 2 subjects compared to their baseline values (Figure 1). Another important finding obtained in the study is that statistically significant increases were observed in the amount of body fat and percentage values in water intake at all steps (Table 1). It was determined that the total body fat amount measured by BIA of the subjects showed statistically significant increases in the amount of water taken, 3.1% (500 mL), 6.2% (1000 mL) and 9% (1500 mL) ($p < 0.05$). Figure 2 shows the percentage changes in the amount of fat and water measured by BIA after the individuals' intake of 1500 mL of water. While an increase was observed in the fat changes of all individuals, an increase was observed in the amount of water in other individuals except one. It was determined that subjects showed statistically significant increases in body total fat percentage measured by BIA with the amount of water taken 2.4% (500 mL), 4.8% (1000 mL) and 6.8% (1500 mL) ($p < 0.05$). Although different

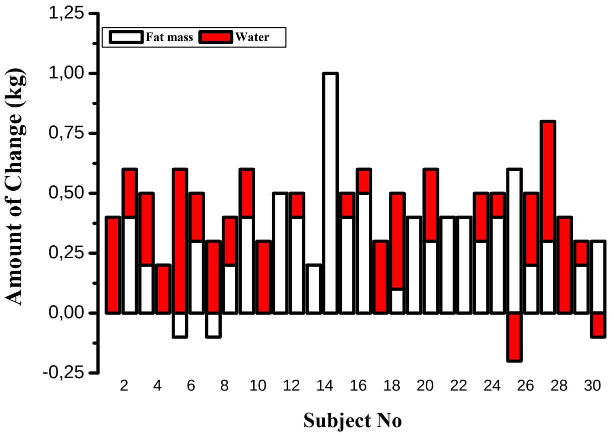

Fig. 1. Change of total body water (red) and fat mass (white) in response to the 500 ml of water intake using bioelectrical impedance method for each subject

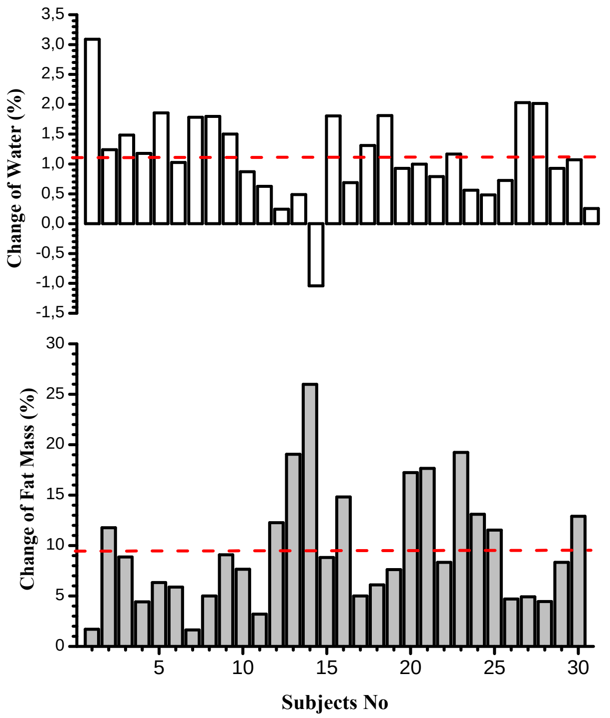

Fig. 2. Measurement of changes in body water (White column) and fat mass (grey column) values after 1500 ml water intakes for each subject using bioelectrical impedance analysis. Horizontal line represents mean value of all subjects

measurements of fat and water status were obtained among subjects, on average the answers showed an increase of 280 grams of fat and an increase of 190 grams of water. With the increase of water intake to 1000 mL, all subjects showed an increase in the amount of 560 g of body fat and 340 g of body water. At the final level, 1500 mL of water intake, an average of 810 g of fat and 480 g of water were observed in the water and fat amounts of all subjects except one. Following water intake, an average loss of 536 ± 40 g in

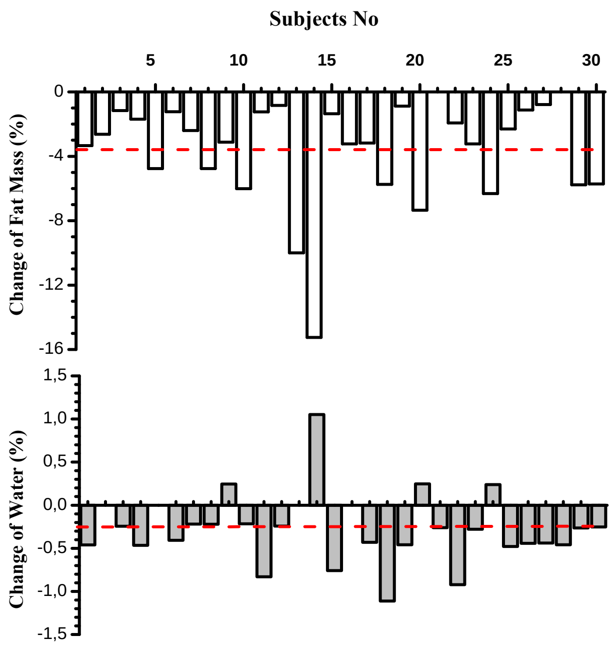

Fig. 3. Measurements of percent change of body fat mass (white column) and body water for each subject using bioelectrical impedance method after water loose by urine. Horizontal line represents mean values for all subjects

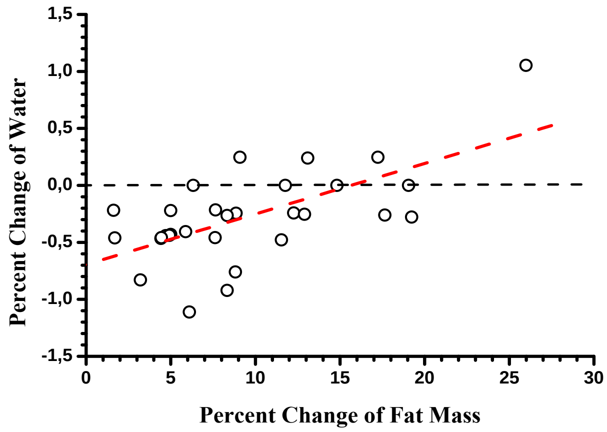

Fig. 4. The correlation analysis between percent change of fat mass and body water after 1500 ml of water intake using bioelectrical impedance method (R=0.63786)

body weight was observed in BIA measurements made after the subjects were emptied of their bladders by micturition after the point they could not bear. As a result of acute water excretion, a decrease was observed in body fat measurements (-380 ± 110 g) by BIA method in all subjects (Figure 3). The amount of water change decreased in 22 subjects, remained constant in 4 subjects and increased slightly in 4 subjects, a decrease of -116 ± 30 g was observed (Figure 3). Following the

Table 1. The mean (±SD) values of body weight (BW), fat mass, fat percent, fat free mass (FFM) and :total body water (TBW) at the basal, after water intakes for three times at amount of 500 ml and after water loss by urine (last)

	Basal	500 ml	1000 ml	1500 ml	Last
BW (kg)	69.66±1.6	70.22±1.6	70.75±1.6	71.13±1.6	70.60±1.6
Fat mass (kg)	9.01±0.7	9.29±0.7	9.57±0.7	9.82±0.7	9.44±0.7
Fat percent (%)	12.52±0.7	12.82±0.7	13.12±0.7	13.37±0.7	12.93±0.7
FFM (kg)	60.65±1.0	60.93±1.0	61.18±1.0	61.31±1.0	61.16±1.0
TBW (kg)	42.32±0.5	42.51±0.5	42.66±0.6	42.80±0.6	42.68±0.5

water excretion, the body fat and water changes of the equivalents were found as 426 ± 50 g fat increase and 356 ± 50 g water increase compared to basal. After 1500 mL of water intake of the subjects, a positive correlation was observed between the percentage of change the amount of fat and the amount of water obtained by BIA measurement (Figure 4) $r = 0.63786$ ($p < 0.0001$).

Discussion

Body composition analysis is an important issue in the clinical evaluation of the nutritional status of individuals, in determining the changes in the condition of body tissues and the effects of these changes on the clinical status of individuals, in determining the course of the disease in individuals and in determining the quality of life. Determining efficient and valid body composition using BIA method is vitally important in clinical medicine (16, 17). In addition, it is a frequently used method as a guide in determining the results of scientific studies that will help with the aim of treatment in athletes (18), in health screenings of the general population (19, 20) and in clinical exercise study groups (21, 22). Therefore, valid and reliable body composition analysis is of vital importance. The important findings we obtained in this study lead to questioning the reliability and validity of the measurement in the body composition analysis of the BIA method when the body water balance changes in the direction of intake or expulsion. In the results of BIA, an increase in the amount of water taken into the body results in an increase in adipose tissue rather than an increase in total body water (Figure 4). As a standard, the water taken by everyone may affect the body weight of individuals at different rates or the distribution or location in the body (stomach, intra-extracellular area or bladder) may be among the factors that affect the calculation. In a study, it was reported that 1% increase in body fat percentage may occur with 591 mL of water intake, which is considered to be statistically normal (23). In contrast, body fat percentage values measured by BIA in this study regularly increased with the amount of water taken. In a study, it was reported that BIA based body composition analysis after intense electrolyte content, high fat and carbohydrate meals gave erroneous results, while the margin of error was low and at an acceptable level in the measurements made at the end of liquid and other foods (24). It has been shown that BIA can effectively evaluate the body composition of cancer patients (25). In a study conducted with haemodialysis patients, it was shown that water taken during dialysis can be determined effectively by BIA (26). On the other hand, it has been reported that body composition before and after haemodialysis may be results invalid measurements (27). Conditions such as oedema or ascites can cause the amount of body fat to be measured high and the amount of water measured low. In this study, the total body water amount did not show a similar increase in BIA measurement, despite the amount of water taken regularly, and the result was obtained in the form of fat-weighted increase (28). It has been suggested that water status change can be determined effectively in patients with renal impairment (29). It has been suggested that impairments in body composition analysis during acute hydration may be due to changes in resistance or deterioration of osmotic balance (12, 30). BIA is a frequently used method in body composition analysis of obese patients and in determining the effectiveness of treatment with changes during treatment (2, 12). However, in this study, the amount of body fat and fat percentage values increased regularly with the amount of water taken (Table 1). This result is in line with the low efficiency of the BIA method in body composition analysis in morbid obese patients with high oedema (31). As a result, it was determined that when the hydration state of the body changes, the BIA measurement causes the body composition to be calculated more than the amount of fat in the body and less than the amount of water in the body. Considering the important finding obtained in this study, we suggest that it is of vital importance to consider possible margins of error before making a decision in measurements where the BIA method is used for body composition analysis in cases such as oedema, hydration or dehydration.

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