Cent. Eur. J. Med. • 8(5) • 2013 • 565-570
DOI: 10.2478/s11536-013-0206-1

Central European Journal of **Medicine**

Bioelectrical impedance analysis or basic anthropometrical parameters for evaluating weight loss success?

Research Article

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Received 13 February 2013; Accepted 21 May 2013

Abstract: Background. Overweight and obesity present risk for development of metabolic diseases. Reduction of the amount of excess fat with conservation of lean body mass is desirable in the course of reduction regime. It is possible to use the method of body impedance measurement for assessing the changes in body composition. Method. The method of body impedance measurement – Bioelectrical Impedance Analysis - BIA was used for assessing the changes in body composition. Results. A statistically significant body weight decrease was registered in Group A. Simultaneously, neither a significant decrease in total body fat and abdominal fat no decrease in waist circumference was registered. A significant decrease in total body fat and abdominal fat and decrease in waist circumference was registered in Group B, but there was not any significant decrease in lean body mass. Conclusions. The research has proved the importance of targeted reducing diet while simultaneously applying aerobic exercise regime. This method leads to desirable changes in body composition, what can be proved by the BIA method.

Keywords: *BMI • BIA • Fat-free mass (FFM) • Total body water (TBW)• Body fat (BF) • Weight reduction*

1. Introduction

Obesity and overweight are significant health issues that seem to be on the rise while causing serious problems to both the individuals and the whole population. They have been also indicated as growing global public health problems by the World Health Organization (WHO), according to which the obesity prevalence has doubled since 1980. The official figures from WHO show that there are 200 million obese men and almost 300 million obese women in the world and other 1.5 billion people are at least slightly overweight [17,18].

Obesity is a condition of unbalanced nutrition with implication of a positive energy intake. It is defined as an excessive accumulation of fat in the body. Due to the well-documented correlation between central obesity and disease risk, often considering visceral abdominal fat (VAF) as the major cause, the location of excess weight (and weight loss) appears to be particularly important [6].

The prevalence of obesity and associated comorbidities has been increasing, which underscores the importance of developing effective strategies for reducing obesity and risk of metabolic diseases in women. It has been argued that the diet-induced weight loss as well as aerobic and resistance exercises are effective treatments for reducing metabolic risk factors [2,7]. The resulting effect of reduction in excess body weight should be not only be a decrease in body weight, but also and primarily, a decrease in body fat. The negative energy balance induced by reducing diet with a simultaneous increase of energy expenditure through appropriate

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aerobic exercise represents the right reduction regime. The indicated method was monitored in our study. The aim of the study was to prove the impact of reducing diet along with aerobic exercise regime on the changes in body composition. The next aim was to compare the results with the group in which only reducing diet without any aerobic exercise regime was implemented.

There are several clinical tools that can be used to indicate a total and regional adiposity. These include the body mass index (BMI), waist circumference (WC), skinfolds, bioelectrical impedance analysis (BIA), hydrostatic weighing, and air-displacement plethysmography. These measurements range from simple anthropometrical tools to more sophisticated measurements that are not commonly used in clinical practice [3,12]. Depending on models and equations used by BIA for calculation of body composition values, the BIA method in some cases has been reported to overestimate or underestimate the fat mass, while it generally leads to underestimating the body fat in obese individuals. Nevertheless, it appears that BIA is a fairly accurate predictor of the fat mass and fat-free mass (SEE = 2 to 3 kg) with smaller errors of estimate compared to BMI and other anthropometrical measurements [1,4,5,15].

It has been demonstrated that the density of bones and the quality of muscles influence to a certain degree the weight. By using the impedance measurements along with a person's height and weight and body type (gender, age, fitness level), it is possible to calculate the percentage of body fat, fat-free mass, hydration level, and other body composition values. Conventional BIA normally uses Dual-energy X-ray absorptiometry (DXA) as its method of reference. BIA is able to measure precisely the soft tissue composition (fat and fat-free or lean) and the bone minerals (mass and quality) of an individual. BIA not only gives information about the amount of fat, but also determines the distribution of adipose tissue [10].

2. Material and methods

The study was approved by the local ethic board. All enrolled subjects signed the informed consent.

For the purpose of the study we have recruited 57 healthy female (with the average age of 39.0±8.0 and BMI 29.1±3.1 kg/m^2) from the residents of Hradec Králové district, Czech Republic. The subjects meeting the inclusion criteria (BMI > 27 kg/m^2 and stable weight in the last 6 months, not taking any medication, vitamins or mineral supplements) were randomly divided into two groups.

The first group (Group A), 36±6 years of age (n = 28), was assigned only a reducing diet. The second group (Group B), 40±9 years of age (n = 29), in addition to the same reducing diet went through the aerobic exercise regime: twice a week aerobic exercise lasting for 60 minutes with intensity 60% max of pulse rate. The sessions rested on a 60-minute-long exercise on the Gravity GTS® device.

Both dietary intervention groups were instructed to follow energy – restricted diet, food selection and portion size and attended face-to-face visits for nutrition education. The dietary habits during the study were assessed using a three-day consumer dining record (it was reported each week). The Nutridan software (®2003 Danone Institute Foundation) was used to calculate the amount of consumed energy in kJ, sugars, proteins and fats in the diet. For setting restriction concerning food energy intake, energy consumption was monitored by checking the menu. The energy expenditure was assessed by indirect calorimetry using Resting Energy Expenditure – REE (analysis of O2 consumption and CO2 production in the outgoing air – using an indirect calorimetric analyzer Deltarac MBA-100, Datex, Instrumentarium Corp., Finland). The food energy intake was decreased by 15% in comparison with the energy need.

The basic anthropometrical parameters (height, weight, waist circumference) and measurement of body composition (% fat, muscle and abdominal fat) were observed to assess the success of the reduction programs. BMI (kg/m2) was calculated from weight and height as follows

$$BMI = \frac{weight}{height(m)^2} \qquad (1)$$

The body composition values were measured and obtained using a four-electrode device InBody 720 (Biospace Co., Ltd, Japan) with measuring on frequencies of 5 kHz, 50 kHz, 250 kHz, 500 kHz and 1 MHz. BIA measurement was performed under standard conditions – in the morning on an empty stomach after defecation and urination. The persons were wearing underwear and the temperature in the room where the measurement was performed was 22°C with constant relative air humidity.

Duration of controlled reduction programs was 24 week. Compliance with the program was higher in Group B (90.6%) than in Group A (84.8%).

Differences in observed parameters before the reduction procedure and 4 months after the reduction procedure were calculated using mean and standard deviations (SD). The two-sided tests were employed to determine whether a change within any specific group was significant. The P values of < 0.05 were considered as significant.

3. Results

The starting and ending outcomes after the 4-month weight reduction therapy based on the restriction of energy intake (Group A) and on the restriction of energy intake complemented by physical activity (Group B) are presented in Tables 1-5. There were no significant differences between the groups in age, all monitored anthropometrical parameters and caloric intake. The total amount of controlled exercise time for Group B was 2 h/wk. Tables 1 and 2 present anthropometrical parameters measured using the elementary methods (BMI, weight, WC).

Table 1 shows differences between the starting and ending outcomes of BMI (kg/m^2) and weight (kg). In this table significant changes in body weight and BMI were observed in Group A (P values of < 0.05), but no significant changes of weight and BMI were observed in Group B. In Table 2 an opposite outcome was reported. There were significant changes in Group B (P values of < 0.05–WC, P values of < 0.01–Abdominal Fat) ; this is due to the changes in body composition because there was a measurable increase in muscle mass and simultaneously decrease in fat mass.

Tables 3–5 show parameters obtained by BIA approach. It is obvious from Table 3 that changes in Group B were statistically significant (P values of < 0.001). These outcomes are due to the physical exercise in Group B. Tables 4 and 5 also show that Group B had a significant (P values of < 0.05) change in body composition parameters. According to these tables it is obvious that physical exercise has a major impact on body composition. This is in correlation with the assertion that reducing diet should not only cause the body weight loss, but also change the body composition.

Table 4 shows changes in TBW in both groups. In Group A the changes in TBW were not significant, but in Group B the change in TBW was significant.

From the general point of view it can be indicated that Group A reports a higher weight loss than Group B. Our results demonstrate that the decrease of weight in Group A was significant, but the decrease in fat tissue

Table 1. Classical anthropometrical parameters– Changes in weight and BMI at both group (group A only on diet, group B combination of diet and physical activity (* P values of < 0,05)

		Weight (kg)				BMI (kg/m^2)			
		Baseline	Out come	Differences		Baseline	Out come	Differences	
Group A	Mean	89.7	83.9	- 5.8	*	29.0	27.2	- 2.0	*
	sd	8.8	5.2	4.9		3.2	3.1	1.2	
Group B	Mean	88.6	84.7	- 4.5	n.s.	29.1	27.9	- 1.2	n.s.
	sd	8.5	3.8	5.2		2.9	3.0	1.1	

Table 2. Classical anthropometrical and BIA parameters – Changes in WC at both group (group A only on diet, group B combination of diet and physical activity (* P values of < 0,05) and BIA–Changes in abdominal fat mass at both group (group 1 only on diet, group 2 combination of diet and physical activity (* P values of < 0,05, ** P values of < 0,001)

		Waist circumstance (cm)				Abdominal Fat (cm^2)			
		Baseline	Out come	Differences		Baseline	Out come	Differences	
Group A	Mean	99.5	90.3	- 7.5	n.s.	121.0	105.2	- 15.5	n.s.
	sd	11.1	10.9	2.1		39.2	38.5	12.4	
Group B	Mean	98.8	87.5	- 10.9	*	124.2	100.1	- 53.7	**
	sd	10.6	10.7	3.2		39.9	36.9	58.8	

Table 3. BIA – Changes in muscle mass (kg) and Body fat (kg) at both group (group A only on diet, group B combination of diet and physical activity (* P values of < 0,05, ** P values of < 0,001)

		Muscle Mass (kg)				Body Fat (kg)			
		Baseline	Out come	Differences		Baseline	Out come	Differences	
Group A	Mean	28.5	28.1	- 0.9	n.s.	29.7	23.7	- 6.2	n.s.
	sd	4.7	5.3	4.5		11.5	9.8	7.3	
Group B	Mean	27.5	30.7	7.1	*	31.3	22,.	- 13.6	*
	sd	5.3	5.2	5.4		11.3	9.4	15.5	

Table 4. TBW(kg) – Significance of changes in monitored parameters between groups (* P values of < 0,05)

		TBW (kg)			
		Baseline	Out come	Differences	
Group A	Mean	40.076	37.956	- 2.12	n.s.
	sd	6.064	6.00	0.064	
Group B	Mean	43.25	39.84	- 3.41	*
	sd	15.87	10.95	-4.92	

and muscle mass was insignificant. The subjects in Group B achieved a lower weight loss in comparison with Group A. In Group B the results show a significant decrease in fat tissue and a significant increase in muscle mass.

These outcomes are very crucial because they clearly describe that only diet does not have sufficient impact on the body fat reduction. The decrease in body fat should be the target of weight reduction.

Comparison of the effects of different types of reducing programs on the changes in visceral abdominal fat (VAF), body fat (BF) and muscle mass (MM) showed significant differences between both groups. The changes in weight and BMI were not significant (Table 5).

4. Discussion

The National Institute of Health (NIH) in the United States has developed BMI categories for classifying underweight, normal weight, overweight, and obesity in Caucasians. These cut-offs appear to be appropriate for non-Hispanic blacks, but they are likely too high for some Asian populations [14]. At present, in large-scale epidemiological studies (or clinical practice guidelines), BMI is used to identify persons who are overweight or obese. There is, however, a considerable variability in body composition for any given BMI. Abdominal obesity is commonly assessed using WC. The NIH has published sex-specific WC thresholds (men: 102 cm, women: 88 cm) to denote increased health risk within each BMI category. WC is also commonly used to assess changes in abdominal obesity and offers a stronger prediction of changes in intra-abdominal fat than the waist-to-hip ratio or BMI [6-8,11].

It is important to remember that obesity is defined as excess body fat. The only accurate way to measure body fat is to measure body composition. BIA represents one of the methods for classification of body composition. This method uses the flow of electric current that passes through body parts. Electric voltage is then measured in the whole body or in specific body regions. The change in voltage provides values for calculating the body composition in specific fields such as fat-free mass (FFM),

Table 5. BIA – Significance of changes in monitored parameters between groups (* P values of < 0,05, ** P values of < 0,001)

	Changes Æ (SD)				
	Group A		Group B		Significance
	Mean	SD	Mean	SD	
Weight (kg)	-5.8	4.9	-4.5	5.2	n.s.
BMI (kg/m²)	-2	1.2	-1.2	1.1	n.s.
WC (cm)	-7.5	2.1	-10.9	3.2	*
VAF (cm²)	-15.5	12.4	-53.7	58.8	**
MM (kg)	-0.9	4.5	7.1	5.4	*
BF (kg)	-6.2	7.3	-13.6	15.5	*

total body water (TBW), BF %, VAF, etc. Our outcomes show the importance of this method. It is clear that using only anthropometrical measurements for estimation of the correct body mass loss is insufficient. Hence a method that is able to measure body composition is needed. It is possible to estimate correctness of the body mass reduction only with a method that measures changes in muscle and fat mass. The decrease in weight is an insufficient marker for assessing the correct change in body composition.

Increased physical activity can increase the heart rate and change hemodynamic conditions and blood perfusion in different areas of the body, which could lead to changes in impedance and consequently could change the value of TBW, ECW, ICW [5]. We discovered in our observation a significant ($P < 0.05$) change in TBW in Group B. Nevertheless, this change was conditioned by the increase in physical exercise because the changes in TBW in Group A were not significant. The change in TBW is due to the increase in muscle mass and decrease in fat mass, which is related to the improved body composition of the patient. The change in TBW is also related to intra- and extracellular water and this can also indicate better hydration status and hemodynamic conditions.

A normal balance of body fat to lean body mass is associated with good health and life longevity. The issue of excess fat in relation to lean body mass, a condition known as altered body composition, can greatly increase risk of cardiovascular disease, diabetes and more. The BIA method enables earlier detection of an improper balance in body composition which allows for earlier intervention and prevention than using BMI or WC alone [9,13,16].

Our research has proved that a reduced diet that is not supplemented by adequate physical activity results in not only a loss of adipose tissue, but also an unwanted loss of muscle mass (Tables 3, 4, 5). This means, if the evaluation of Group A were based only on the basic anthropometrical parameters such as BMI and waist circumference, we would not have any evidence of this unwanted loss of muscle mass.

Through applying the standard anthropometrical methods, Group A undergoing only the diet would be considered more successful as it evidenced a greater loss of weight.

The BIA method used in our study measured even body composition (the amount of body fat, muscle mass and abdominal fat). Using basic assessment methods for body weight (body weight, BMI), Group A was more successful (a statistically significant decrease in body weight and BMI), but the decrease in fat tissue was statistically insignificant. The results in Group B have proved a lower decrease in body weight, but a statistically significant decrease in body fat, abdominal fat and increase in muscle mass , which is more beneficial as it reduces the risk of developing metabolic diseases. The targeted reducing diet along with physical activity has an unambiguously positive impact on body composition. Not only does it decrease the body weight, it also changes the body composition, especially decreasing the body fat and conserving or increasing muscle mass, which are desirable during reduction of body weight. Our monitoring has proved it in Group B.

5. Conclusion

Monitoring was aimed at influencing the body weight in persons suffering from overweight or obesity by using the reducing diet. The reducing diet in Group A was based on restriction of energy intake by 15 %. In Group B a controlled aerobic exercise regime was added to the reducing diet. We registered a statistically significant decrease in body weight in Group A. There was no significant decrease in body fat and abdominal fat in this group. An insignificant loss in muscle mass occurred. The reducing diet in Group B was based on reduction of food energy intake and on aerobic exercise regime. There was a statistically insignificant decrease in body weight, a statistically significant decrease in waist circumference, decrease in body fat and abdominal fat, and simultaneously increase in muscle mass.

The achieved results positively represent suitability of using not only the reduction of food energy intake, but also simultaneously the increase of energy expenditure through an aerobic exercise regime.

Our research clearly shows that the target of weight reduction should not be only the reduction of weight but the change in body composition. This leads to the increase in muscle mass and to the decrease in fat mass. A health body can be obtained using this strategy.

Measurement of body composition by the BIA method noticeably contributed to revealing the changes in body composition. The desirable effect of decrease in body tissue was achieved in Group B in our study.

Acknowlegement

Supported by the Ministry of Defence of the Czech Republic, grant No. VZ MOO FVZ 0000502 and CTU in Prague No. MSM 6840770012

Conflict of interest statement

The authors stated that there are no conflicts of interest regarding the publication of this article.

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