



Effect of maximal exercise on percent body fat using bioelectrical impedance analysis in active males

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Abstract

Objectives: The purpose of this investigation was to determine the effect of maximal exercise on percent body fat (%BF) using bioelectrical impedance analysis in highly active male athletes at university.

Design: The subjects of the study consisted of fifty-two (52) males with mean age of 21.68 ± 1.66 years old, height of 164.46 ± 5.21 cm and weight of 57.69 ± 6.61 kg. All of the subjects joined the study voluntarily and were students in Akdeniz University School of Physical Education and Sport.

Methods: All participants made two visits to the laboratory on separate days. On the first visit, anthropometric measurements were collected, orientation with the respiratory metabolic mouthpiece and treadmill was provided. During the second visit subjects exercised on a treadmill at different workloads in order to familiarize them to the treadmill. Percent body fat was assessed using a leg-to-leg bioelectrical impedance analyzer (BIA; Tanita Model TBF-300A). BIA measures of %BF were obtained immediately before and within five minutes following the exercise test.

Results: Differences were found between pre and post exercise bioelectrical impedance values. There is significant difference respectively in weight, BMI, Body fat Percent, impedance ($p < 0.001$) and fat mass, fat free mass, total body water values ($p < 0.05$).

Conclusions: Maximal exercise can effect the bioelectrical impedance analysis measurement.

Keywords: Bioelectrical impedance analysis, body composition, exercise, percent body fat.

INTRODUCTION

Assessment of body composition has been of interest to researchers, educators, coaches, athletes, and other individuals who are concerned with physical fitness (Ross et. al., 1989; Oppliger et. al., 1991; Deurenberg et. al., 1991; Civar, 2002).

The specific uses of body composition analysis in athletes include the determination of the appropriate weight for competition, particularly in sports such as gymnastics where appearance is important and in weight-limit sports such as wrestling. Knowledge of the typical body composition of athletes in different sports is helpful in determining appropriate target weights and in evaluating the effects of training programs (Williams and Pale, 1998; Segal, 1996). Unfortunately, the ideal weight and fat percentage of an athlete for optimum performance are not known precisely (Ross et. al., 1989).

Bioelectrical impedance analysis (BIA) was developed in the 1960s and has emerged as one of the most popular methods for estimating relative body fat. BIA is relatively simple, quick, portable and noninvasive and can be used in diverse setting including private clinicians' offices, wellness centers and hospitals (Lukaski et. al., 1986; Calderwood, 1996; Chertow, 1995; Lohman, 1992; Stock, 1995).

Leg-to-leg bioelectrical impedance analysis (BIA) is a fast, easy to administer, and relatively inexpensive method of evaluating body composition (Lukaski et. al., 1986; Nunez et. al., 1997; Chertow, 1995). The BIA method introduces a low level electrical current into the body and measures the lower-body impedance, or resistance to the current flow as the individual stands on a scale-like platform (Andreacci et. al., 2006; Nunez et. al., 1997).

Differences have been identified in the results of the studies about BIA. These differences indicate that further studies should be done to see if the equations used were appropriate for the population or not. The issues such as types of training and the intensity of exercises used in the groups were overlooked and only sedentary and activity levels were taken into consideration (Civar, 2002).

The purpose of this investigation was to determine the effect of maximal exercise on %BF estimated by BIA in male athletes at university.

METHODS

Participants

Fifty-two (52) males (age : 22.54 ± 1.11 yr; height : 163.80 ± 5.46 cm; weight: 56.01 ± 6.38 kg) university students from Akdeniz University School of Physical Education and Sport volunteered to participate in the study.

Experimental design

All participants made two visits to the laboratory on separate days. On the first visit, anthropometric measurements were collected (Lohman, 1988), orientation with the respiratory metabolic mouthpiece and treadmill was provided. During the second visit subjects exercised on a treadmill at different workloads in order to familiarize them to the treadmill. Each participant was given a set of written guidelines to adhere to before her designated testing date. The guidelines included the following: 1) no large meals 4 hrs before the test; 2) no vigorous exercise 12 hrs before the test; 3) empty bladder 30 minutes before the test; 4) no alcohol consumption 48 hrs before the test; 5) no diuretic medications before the test; 6) consumption of liquids limited to 1% of body weight 2 hrs before the test. Subjects participated in the measurements after staying hungry for a period of 1 night.

Testing procedures

During the experimental exercise session, each subject performed treadmill walking. All subjects completed the exercise workloads in the following order; Protocol of Bruce; the protocol is performed in a treadmill. The test starts at 2.75km/hr (1.7mph) and at a gradient (or incline) of 10%. At three minute intervals the incline of the treadmill increases by 2% and the speed increases as shown in the table below (table-1). Heart rate was measured continuously throughout the exercise test with electrodes (Vmax Spectra 229LV model, SensorMedics, Yorba Linda, CA, USA). Subjects were not permitted to consume any fluids during the exercise test.

Table-1: Protokol of Bruce test

Stage	Time (Min.)	km/hr	Slope
1	0	2,74	10%
2	3	4,02	12%
3	6	5,47	14%
4	9	6,76	16%
5	12	8,05	18%
6	15	8,85	20%
7	18	9,65	22%
8	21	10,46	24%
9	24	11,26	26%
10	27	12,07	28%

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Body composition was assessed using a leg-to-leg bioelectrical impedance analyzer (BIA; Tanita Model TBF-300A). BIA measures of %BF were obtained immediately before and within five minutes following the exercise test. Prior to the BIA assessment of body composition, subjects removed their shoes and socks so that height could be determined using a Stadiometer (Lohman, 1988).

Laboratory temperature was maintained at a constant same temperature for all tests and BIA measurements. Testing was administered at the same time of day for all subjects.

Statistical analysis

Statistical analyses were performed using SPSS 11.0 for Windows (SPSS Inc, Chicago, IL). All values are expressed as mean \pm standard deviation (SD).

Percent body fat measurements were conducted two times a day, before and after the exercise. Overall comparisons were made by Repeated Measurement of ANOVA. In order to detect pair wise differences, paired samples t-test was used. Paired samples t-tests (pre- and post) were used to examine the BIA body composition data in participations group. Statistical significance was established a priori at $p < 0.05$.

In order to obtain test retest reliability of BIA measurement, intra-class correlation coefficients (ICC's) were calculated.

RESULTS

Physical Description of the Subjects

Table-2 Shows the mean (M), standard deviation (SD), minimum (Min) and the maximum (Max) values of the anthropometric measurements of 52 male participations.

Table-2: The mean (M), standard deviation (SD), minimum (Min) and the maximum (Max) values of participations

n=52	Mean\pmS.D.	Min.	Max.
Age (yr)	21.68 \pm 1.66	18.22	26.53
Height (kg)	164.46 \pm 5.21	153.00	181.00
Weight (kg)	57.69 \pm 6.61	45.38	58.23
Fat (%)	18.96 \pm 3.62	13.50	32.70
BMI (kg/m²)	21.19 \pm 3.94	17.65	26.37

Bioelectrical Impedance Analysis of the Subjects

ICC for bioelectrical impedance analysis measurements; weight: 0.99 (%95 CI: 97-99), BMI: 0.99 (%95 CI: 96-98) impedance (OHM): 0.99 (%95 CI: 97-98), body fat percentage (BIA): 0.99 (%95 CI: 95-99), fat mass (FM): 0.91 (%95 CI: 95-99), fat free mass (FFM): 0.94 (%95 CI: 93-98), total body water (TBW): 0.96 (%95 CI: 92-98).

Table-3: Comparison of the body mass index (BMI), fat mass (FTM), fat free mass (FFM), total body water (TBW) and bioelectrical impedance measurements taken before and after the exercises.

n=52	Pre Exercise	Post Exercise	t	P
Weight (kg)	57.69±6.61	56.74±5.82	8.23	0.000***
BMI(kg/ m²)	21.19±3.94	20.87±3.06	7.76	0.000***
BIA (%)	18.96±3.62	17.93±3.65	7.90	0.000***
IMP (Ω)	547.60±41.67	526.34±41.82	7.43	0.000***
FTM (kg)	10.07±2.97	9.36±3.13	2.85	0.000***
FFM (kg)	45.99±4.93	46.52±5.04	-2.09	0.041*
TBW (kg)	35.08±3.73	34.67±3.60	2.19	0.033*

* and *** denote $p < 0.05$ and 0.001 respectively as compared with pre test

The differences of bioelectrical impedance values between pre and post exercise were found (table-3).

There is difference respectively in weight, BMI, the body fat Percent (BIA), impedance ($p < 0.001$) and fat mass (FM), fat free mass (FFM) and total body water (TBW) values ($p < 0.05$). There is also a significant variance between these values.

DISCUSSION

The equations used to determine the body composition are unique to the study group. When used for different groups, there are lots of literatures questioning the validity of these equations. Especially, there are results indicating that the equations developed for sedentary are not valid for athletes (Civar, 2002; Civar et. al., 2006; Civar et. al., 2003). It is natural for athletes that fat mass is lower and fatless body mass is higher than those of the sedentary, since athletes are active, have developed muscle and bone structure and exercised daily (Civar, 2002).

The validity of BIA method that has been used widely over the athletes in recent years due to its easy usage has not been proved at desired levels (Civar et. al., 2006; Civar et. al., 2003). In many studies, this is due to the number of subjects and the attributes of the work group (Lukaski and Bolonchuk, 1986; Wu et. al., 1994; Pollock et. al., 1987). The experts on the subject have indicated the further studies should be done in order to prove the validity of the BIA usage especially for athletes (Civar, 2002).

In reliability studies for the BIA, test end re-test coefficients have been observed as 0.96 and more (Lukaski et. al., 1986; Segal, 1996; Wu et. al., 1994; Gutin et. al., 1996). Validity studies for the BIA method shows that it is not consistent for different study groups (Van Loan, 1996; Williams and Pale 1998; Van Den Ham et. al., 1999; Lukaski et. al., 1986). Whether the subject is sedentary or active is taken into consideration by the software of the equipment used for the BIA measurements. The results of the BIA have been proven wrong in comparison with the results of underwater method in the validity studies (Ross et. al., 1989; Oppliger et. al., 1991; Deurenberg et. al., 1991). In order to compensate for these mistakes, equations have been developed for the BIA method usage on groups with different age, gender and activity level (Lukaski et. al., 1986; Lohman, 1992; Segal, 1996).

The greatest changes in BIA body composition variables may be expected to occur immediately post-exercise due to increases in blood flow to active muscle tissue, cutaneous blood flow, and skin temperature during the exercise bout. The examination of exercise that precedes BIA assessment by longer durations is warranted to further clarify whether the pre-testing recommendation of no exercise 12 hours before testing is necessary (Andreacci et. al., 2006).

With respect to the impact of previous exercise on the BIA measurement of body composition, Lukaski et al. reported a significant alteration in BIA determined percent fat consequent to exercise (Lukaski et.al., 1990). In contrast, Liang and Norris reported that treadmill walking or running at speeds ranging from 147–188 m·min⁻¹ and 2.5% grade had no effect on the BIA determination of percent fat (Liang and Norris, 1993). Andreacci et. al. (Andreacci et. al., 2006) and Goss et. al. (Goss et. al., 2003) reported small reductions in leg to leg BIA measurements of impedance and %BF following maximal exercise in children. Dixon and Andreacci (Dixon and Andreacci, 2009) reported that resistance exercise had no effect on the leg-to-leg BIA measurements.

Conclusion

It was found that maximal exercise can effect the bioelectrical impedance analysis measurement. The exercise leads to an additive decrease in bioelectrical impedance and thus to a decrease in the calculated percentage of body fat.

Exercise can effect BIA measurement because of increased vascular perfusion and warming of muscle tissue, increased cutaneous blood flow and vasodilatation, increased skin temperature and sweating, and sensible and insensible fluid losses.

We believe that studies such as repeated measurements on bigger groups with will reveal more accurate results. Also contributory results could be obtained by studies for different age levels. More studies should be done to see the impact of exercises performed at different intensity levels on BIA.

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