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CHANGES OF BODY COMPOSITION PARAMETERS AFTER MAXIMUM AEROBIC LOAD USING BIA METHOD

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Abstract

Introduction: In the course of a spiroergometric test external physiological symptoms and internal response of the organism to the load can be followed. It is clear that gradual load increase up to "vita maxima" must at the same time lead to changes in body hydration. The question is whether the change is big enough to be manifested in the results of measurements of body composition by the bioimpedance method.

Objective: The purpose of the present study therefore is to find out the scope of change of body hydration post maximum aerobic load by means of bioimpedance device TANITA 418 MA using the Treadmill Test and to assess potential effects of this change on the resulting values of the body composition parameters.

Methods: The research population included 78 males with regular physical activity. Their body composition was measured by the tetrapolar bioimpedance scales TANITA 418 MA, and the maximum aerobic performance ($\dot{V}O_2max$) was measured by means of a test with gradual load increase (GXT) on the treadmill. The length of the aerobic load was up to 12 minutes.

Results: The found differences in total body water and body fat values after the spiroergometric measurement ranged within the error level of the device used.

Conclusion: The load length (up to 12 min.) is sufficient for manifestation of both the external and the internal physiological symptoms as the response of the organism to aerobic load, but does not suffice for finding out changes in the body composition parameters.

Key words: *total body water, hydration of organism, body fat, spiroergometric test*

Introduction

Functional diagnostics of athletes forms an integral part of a successful training process [1]. The diagnostics involves assessment of both functional prerequisites and morphological conditions of the assessed individual. Assessment of morphological conditions mainly includes assessment of body composition, which is currently considered not only an indicator of the individual´s health state and nutrition quality but also a determinant of preparedness of the athlete´s organism for a training unit and race load in the sporting area. Monitoring of changes of body composition can also be used for assessment of the effect of physical exercise (training) on the athlete´s organism and thus for assessment of appropriateness of the exercise used (the athlete´s training) on the organism and thus for assessment of adequacy of the exercise [2-4]. There are a number of methods for estimation of body composition in field practice. The widely used ones include the method of bioelectric impedance (BIA) [5], whose advantages include simple operation, low time demand and financial feasibility. This non-invasive method is based on spread of alternate current of low intensity through biological structures. The principle of the method is based on distinctive electrical properties of tissues, fat and body water. Fat-free matter containing a large proportion of water and electrolytes is a good conductor, unlike the fat tissue, behaving like an insulator [6]. That is why the basic parameter measured by BIA is the total body water (TBW), whose values are calculated by regression equations from the impedance values. The body hydration status can therefore significantly affect the overall result of body composition measurement [7]. Bunc states that body hydration changed by 0.5 l (intake or loss) can already affect the result within the range of 2-4 % of the absolute value [8]. The values therefore show that this method is very body hydration sensitive. This fact also reflects in standardization of measurement conditions stated both in professional literature references [5,6,9] and in the instructions for use of the individual devices using this measurement method. The included recommendations and limitations therefore logically relate to activities that may affect body hydration. The standard conditions include limited physical activity before the measurement. The mostly too general instructions represent a problem, though. Neither the volume nor the intensity of physical activity to be avoided before the measurement are defined. Therefore there is the question of the physical activity after which the tested individual can still be measured, or after what time interval after the activity. This problem can be encountered in practice for example when planning diagnostic testing units, which mostly include not only measurements of body composition but also various motion tests and load tests.

Assessment of functional prerequisites for physical performance is based on load tests using model load of sub-maximum or maximum intensity. Bicycle ergometer or Treadmill Test are used in the laboratory for these tests [10].

Coaches mostly require measurement of maximum aerobic performance of the athletes they are to train ($\dot{V}O_2max$), assessing endurance assumptions of the individual and determining their anaerobic threshold. In the course of a spiroergometric test external physiological symptoms (sweating, skin reddening etc.) as well as internal response of the organism to the load (heartbeat, ventilation, consumption of O_2 …) can be monitored. It is clear that gradual load increase up to "vita maxima" must at the same time lead to changes in body hydration. The question is whether the change is big enough to be manifested in the results of measurements of body composition by the bioimpedance method. The purpose of the present study therefore is to find out the scope of change of body hydration post maximum aerobic load by means of bioimpedance device TANITA 418 MA using the Treadmill Test and to assess potential effects of this change on the resulting values of the body composition parameters.

Methods

Participants

The test population consisted of healthy individuals with regular physical activity. Regarding this fact the acquired data can be used in further diagnostics of individual practicing sports in various sporting disciplines (we deal with). The total number of tested individuals was 78 (males), with mean age 19.3 ± 1.6 years. The mean body height of the tested population was 179.7 ± 5.9 cm and their mean body weight was 71.5 ± 6.6 kg.

The study protocol was approved by the Ethics and Research Committee of the University of Ostrava. All participants signed an informed consent form.

Procedures

The input as well as output values of the body composition parameters were measured by the TANITA 418 MA tetrapolar bioimpedance scale that uses the method of bioelectrical impedance (BIA). The measurement was carried out immediately before the load test under the observance of all standard measurement conditions stated in the device manual. The repeated measurement was carried out by the same device again after the completion of the load test.

Prior to the repeated measurement, the feet and palms of each probands were dried off (in order to prevent any impact on the measurement results due to the increased dampness of the contact areas) and sweat was wiped off the remaining parts of the body.

The probands underwent the measurements in underwear (both input and repeated measurement) so that the result could not be biased, e.g. by sweat absorbed in the clothes.

The maximum aerobic performance ($\dot{V}O_2max$) was determined with the use of a test with gradual load increase (GXT) that was taken on the treadmill. The Harbor protocol" [11] was modified so that the overall time was within the range of 8-12 min [12]. The time period (of the run) did not drop below 10 minutes in any proband. The average load (run) time was 10.5 minutes. If the proband was not able to keep the determined load (the proband always ran to the volitional maximum), the test was always stopped. The manipulation with the load was carried out in the following way: constant speed was maintained, while the slope of the treadmill gradually increased by 2% every minute. The test was executed on the "Lode Variant Motor-driver Treadmill" (Groningen, the Netherlands). ZAN 600 Ergo (Obertulba, Germany) was used for the analysis of O_2 and CO_2 from the exhaled air. The analyzer was calibrated prior to each test according to the producer's instructions. The heart rate (HR) was continuously monitored by a transfer from the chest belt (Polar Electra, Oy, Finland). The ambient temperature ranged from 20 to 23°C. The registered ventilation values were averaged to 30s intervals. The probands reached $\dot{V}O_2max$ it at least 2 of the following criteria were met:

1. Plateau $\dot{V}O_2max$ even in spite of the increasing load,
2. Respiratory Exchange Ratio (RER) exceeded 1.10,
3. 95% of the predicted maximum heart rate was obtained (220 – age).

Statistical analysis

Outlying observations were identified with boxplots, the distribution normality was verified by the Shapiro-Wilk test. Paired Samples *t*-test was used for assessment of mean differences. The statistical significance level was chosen for all applied tests on the level of $\alpha = 0.05$. Assessment of material significance of the mean results and the standard deviations was based on the Effect of Size pursuant to Cohen:

$$d = \frac{x_1 - x_2}{s}, \text{ where } s = \sqrt{\frac{n_1.s_1^2 + n_2.s_2^2}{n_1 + n_2}}$$

Recommendations for ES assessed by Cohen *d*:

0.2 = small change

0.5 = medium change

0.8 = big change pursuant to [13].

Statistical processing of the results was performed with the help of SPSS Statistic 19.0 software. Level of position (arithmetic mean) and variability level (standard deviation) were characterized for every metric value.

Results

Measurement of body composition focused on the following parameters: body weight, percentage of total body water and fat fraction of body weight, value of tissue resistance (bioelectric impedance). Outlying observations were not found in relation to the measured parameters and the distribution normality was not impaired.

The values of the input parameters and their change after the maximum aerobic load are presented in Table 1.

Following the spiroergometric examination the test group showed a moderate loss of body weight (0.46 kg), reflected in a decreased proportion of body water (0.31 kg). The reduced proportion of total body water corresponded with a moderate increase of resistance of the tissue (the value of bioelectric impedance increase by 9.57 Ohms). The measured change in total body water also reflected in reduced body fat (0.32 kg). The abovementioned differences in the individual parameter means were statistically significant, but regarding the small differences in the individual parameter values we included assessment of material significance by Effect of Size (Cohen *d*). The results clearly showed that the found differences were not materially significant. The measured changes cannot be defined as small either, except for the value of bioelectric impedance, which exceeded the value of 0.2 Cohen *d*.

The mean differences of the monitored parameters were probably statistically significant for the reason of the low dispersion of the body composition parameter values, pointing to quite considerable homogeneity of the tested population.

Discussion

The body weight reduction by 0.46 kg measured in our test population, corresponds to the reduction mentioned by authors of similar studies [14-16]. These authors noticed body weight loss following aerobic load within the range of 0.4–1.1 kg. They tested aerobic load by bicycle and rowing ergometers. Only the time of the load differed (up to 30 min.). As for hydration changes these authors mainly describe changes in the ratio of extracellular and intracellular body water. These changes represent a significant factor of body fluid balance [17]. To be able to grasp the body hydration changes you must use not only an appropriate device but also an appropriate equation [18], which may be a problem, for the manufacturers of the devices rarely mention the equations in the documents provided to the users. The extracellular and intracellular body water values can be measured by the BIA method with radio frequency instruments only. TANITA 418 MA, used by us, does not unfortunately allow for these measurements. We were also unable to measure potential changes in the transient resistance between the skin and the leads which might affect the results [19].

The decreased total body water proportion by 0.31 kg represents change level of about 0.4% of the result. The percentage of body fat level, derived in the case of the BIA method from the basic variable (total body water), was reduced from 13.18% to 12.82%. The decrease was therefore by 0.36% of body fat. This change represents change level of 2.7% of the result. This difference corresponds to the common error reported for the BIA method. The most frequently reported common error of body fat specification ranges between 1.5 and 3% of the absolute value [5,20-22]. The same error was also found for the device used for body composition measurement in the context of this study. Kutáč and Gajda verified the device error with the help of the typical (standard) error of measurement pursuant to Hopkins [23,24]. The found error value was 0.38% of body fat, representing result error on the level of 2.13%. The difference found thus did not have to represent the actual change in the values of the monitored parameters but it could be an error in measurement.

Limitations of the study

The obtained results may be affected by the scope of the selected test population, the diagnosed individuals, based on the focus of the Motion Diagnostics Center on sporting individuals, and last but not least by the considerably homogeneity of the test population, shown by the low dispersion of the values of the moni-

Table 1. *Input values of the monitored parameters and their changes after the spiroergonomic examination*

Parameter	Input values		Output values		Statistic	Sig	*d*
	M	SD	M	SD			
BW (kg)	71.57	6.65	71.11	6.66	+ 18.58	0.00	0.06
TBW (kg)	46.73	4.64	46.42	4.54	+ 10.39	0.00	0.06
BF (kg)	9.44	2.41	9.12	2.67	+ 10.51	0.00	0,12
Imp (Ω)	533.51	39.81	543.08	41.98	+ 5.67	0.00	0.23

BW – body weight, TBW – total body water, BF – body fat, Imp – bioelectrical impedance, M – mean, SD – standard deviation, Statistic – result of *t*-test, Sig – result significance, *d* – value of Cohen d (Effect of Size) tored parameters. Another limitation is represented by the device used for body composition measurements. The results can be considered valid mainly for the given type of the tetrapolar bioimpedance scales.

Conclusions:

- The used load test, which is a common part of the functional examination of sportspeople, did not affect the resulting values of the monitored parameters of body composition (total body water, body fat). The changes found in both parameters did not exceed the level of the device error.
- The load length (up to 12 min.) is sufficient for manifestation of both the external and the internal physiological symptoms as the response of the organism to aerobic load, but does not suffice for finding out changes in the body composition parameters.
- Change of body weight does not always represent a reliable benchmark for changed body hydration. This fact is pointed out by a study dealing with estimation of changed body hydration from changed body weight [25].
- If changes of body composition following aerobic load are to be grasped by the BIA method, it is necessary to use radio frequency devices for the measurements, which allow for measurement of extracellular and intracellular body water, and aerobic load time must be longer than 12 minutes.

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Declaration of interest

The author reports no conflicts of interest.

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