CHANGES IN BODY COMPOSITION AS A RESULT OF VARIOUS-INTENSITY TRAINING ON A CYCLOERGOMETER

by

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The objective of the study was to evaluate the changes observed in the level of lean body mass, body fat and body hydration after applying four types of training of variable intensity, as well as the analysis of body composition within a period of 4 weeks starting from the moment of the initial training. The study included 43 students from the Academy of Physical Education, who were divided into 4 groups. The training on the cycloergometer included 5 sprints interrupted by a two-minute rest period: group I – maximal sprints performed with a load constituting 10% of the body weight (BW), group II – maximal sprints performed with a load constituting 5% of BW, group III - 3-minute sprints at average power of 250 W, pedaling frequency 80 rpm, group IV - 3-minute sprints at average power of 250 W, pedaling frequency 45 rpm. Body composition were evaluated before the commencement of the training, after four weeks of the training and after two and four weeks from the cessation of training. A method of bioelectrical impedance was applied with the use of a BIA RJL System Inc. analyzer. Throughout the period of the experiment no significant differences between the groups were observed as far as the total body weight of the tested subjects.

However, body hydration increased significantly after four weeks of training in groups I and III. After two weeks from finishing the training the water level rose further significantly in all groups. Upon analyzing changes in the level of lean body mass (LBM) and body fat (FAT) directly after 4 weeks of training, higher LBM values were ascertained in groups I, II and III ($p<0.05$). Those values were significantly higher in all the groups in the 2nd and 4th week after the cessation of training. A lower level of body fat (FAT) was recorded directly after four weeks of training in groups I and II. Two weeks after the cessation of training a further, significant reduction occurred in all groups. However, in week 4, body fat level tended to return to the values recorded in the period directly after the cessation of training. No significant differences between the groups were observed with respect to all the values measured.

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Introduction

Adaptive changes occurring in muscles as a result of training depend on the type of training (Abernethy et al. 1990, Thoth et al. 1994). Speed training increases the activity of the anaerobic metabolism enzymes (Cadefau et al. 1990, Jacobs et al. 1987, Linossier et al. 1993, Rodas et al. 2000, Sharp et al. 1986, Simoneau et al. 1987) and the level of energy substrates in the muscles (Cadefau et al. 1990). Bogdanis et al. (1996a,b) as well as Trump et al. (1996) proved that in high-intensity intermittent sprints the body uses aerobic metabolism during the rest periods for re-synthesis of reduced PCr level and in order to dispose of lactic acid accumulated during exercise (Tomlin and Wenger 2001). At the same time, training with small resistance for prolonged periods of time (running, swimming, cycling) increases maximal oxygen uptake (VO_{2max}) (Gaiga and Docherty 1995, MacRae et al. 1992, Phillips et al. 1995).

Applying training that includes intermittent sprints in competitive sports such as: soccer, volleyball or basketball is beyond any doubt. Currently, a method of intermittent sprints with variable intensity and load is being used more and more frequently in recreation training done on the cycloergometer, i.e. so-called „indoor cycling” or „spinning”. This method consists in a series of long, moderate-intensity sprints interrupted by short, variable-intensity sprints (Dabrowska 2002). In the course of one programmed training unit dramatic changes are introduced both with respect to intensity and load. According to the assumptions made by the authors of „spinning”, such kind of training should have a significant influence on particular body composition.

The literature gives examples of different opinions to the subject of change in body composition as a result of intermittent sprints. Studies by Hickson (1980), Houston and Thomson (1977) describe significant changes in total body weight and in body composition, and Thorstensson et al. (1975) recorded a change only in the total body weight. However, MacDougall et al. (1998) and Sleivert et al. (1995) did not observed any changes in total body weight, while findings of Allemeier et al. (1994) did not indicate any significant changes in body composition. The above-referred studies analyzed changes in total body weight and components measured only after direct finishing of training. The literature does not give any examples, which would describe remote effects of variable-intensity intermittent sprint training on any changes in body composition in the post-training period.

The objective of the study was to evaluate the changes in the level of lean body mass, body fat and body hydration after applying four types of training with variable intensity, performed on a cycloergometer, as well as the analysis of body composition within a period of 4 weeks after the cessation of training.

Material and methods

The study was carried out on 43 students of physical education who were divided into four groups to perform training on a cycloergometer, which consisted of five sprints interrupted by two-minute rest period: group I (n = 9, age 22.2±1.8, body height 178.1±6.5 cm) – the maximal sprints done with a load constituting of 10% of body weight (BW), group II (n = 11, age 22.5±0.9, body height 180.7±7.6 cm) - the maximal sprints done with a load constituting of 5% BW, group III (n = 12, age 23.3±1.1, body height 182.3±7.7 cm) - 3-minute sprints with average power of 250 W, pedaling frequency 80 rpm, group IV (n = 11, age 22.7±1.5, body height 183.3±5.2 cm) - 3-minute sprints with average power of 250 W, pedaling frequency 45 rpm. The full characteristic of the study participants can be found in table 1. The groups did not show any significant differences as far as anthropometric features were concerned.

The study was approved by the Scientific Research Ethics Committee. The participants were informed about the objective of the study and the methods applied as well as about the possibility of withdrawal from the experiment at any stage of the study. All subjects expressed their consent in writing to the participation in the study. All measurements were taken in the morning.

Before the commencement of the experiment the study participants became acquainted with all the measurements and performed the Wingate test on the Monark 824E cycloergometer (Sweden) according to the standard methods described in the work by Inbar et al. (1996).

Table 1. Average values (±SD) of body weight, BMI and water content and the significance of the differences of the average values between the measurement results obtained before the study (0) and the subsequent measurements: (4) – after four weeks of training, (6, 8) – after two and four weeks from the cessation of training, * – p<0.05.

Variables	*Group*	0	4	6	8
Weight [kg]	I	77.8±10.5	78.0±10.3	78.2±10.1	78.6±10.2
	II	78.0±11.1	78.0±11.3	78.4±12.0	78.7±12.3
	III	80.5±11.6	81.2±11.4	80.7±11.4	80.3±11.3
	IV	81.2±8.4	81.0±8.6	81.4±8.6	81.2±8.3
BMI [$kg*m^{-2}$]	I	24.47±2.44	24.51±2.41	24.57±2.31	±24.71±2.45
	II	23.79±2.16	23.78±2.12	23.88±2.20	23.95±2.33
	III	24.09±2.12	24.33±2.12	24.19±2.07	24.03±1.98
	IV	24.15±2.33	24.09±2.33	24.19±2.23	24.16±2.33
Water [kg]	I	48.20±5.62	49.11±5.30*	49.37±4.82*	49.42±4.94*
	II	47.53±5.68	48.16±5.48	48.66±6.04*	48.43±6.29*
	III	49.29±6.0	50.20±5.76*	50.22±5.87*	50.23±5.89*
	IV	50.57±4.92	50.89±4.45	51.36±4.85*	50.97±4.37
Water [%]	I	62.22±2.73	63.11±2.67*	63.33±3.0*	63.0±2.78
	II	61.18±2.36	62.09±3.14*	62.36±2.77*	63.0±2.52
	III	61.58±2.84	62.0±2.66	62.5±3.0*	62.75±2.8*
	IV	62.36±2.73	62.82±2.23	63.36±2.16*	62.82±2.32

Training with maximal sprints and load: 10% BW – group I and 5% BW - group II; training with 3-minute sprints with average power 250 W and pedaling frequency: 80 rpm – group III and 45 rpm – group IV;

The study participants from all the groups were trained for 4 weeks 4 times a week on the Monark 824E cycloergometer (Sweden) connected to the computer which was supplied with „MCE v. 4.0” software (Staniak 1994). The test and the training sessions with maximal sprints were carried out in a sitting position, without standing on the pedals, starting from a standstill position. The feet were attached to the pedals with straps. The experiment participants were strongly encouraged to achieve the maximal speed in a shortest possible time and to maintain such speed until the end of the test. In case of 3-minute sprint training with power of 250 W the study participants had to keep the pedaling frequency at a constant level on the cycloergometer. The „MCE" programme enabled to measure and calculate the maximal power, and the amount of work output. A single training session covered:

- Group I – 5 maximal sprints during which the study participants had to perform: in the first sprint - 100% of the work pre-defined in the Wingate test (19.36±2.58 kJ), and in the remaining four sprints - 50% of the work (with a load of 10% of the body weight).
- group II – 5 maximal sprints during which the study participants had to perform: in the first sprint - 100% of the work pre-defined in the Wingate test (19,16±2,30 kJ), and in the remaining four sprints - 50% of that work (with a load of 5% of the body weight).
- group III – five 3-minute sprints with average power of 250 W and work output of 45 kJ (pedaling frequency 80 rpm, a weight of 31.0 N hung on the cycloergometer's pan).
- group IV - five 3-minute sprints with average power of 250 W and work output of 45 kJ (pedaling frequency 45 rpm, a weight of 55.0 N hung on the cycloergometer's pan).

There were a 2-minute rest periods between the sprints in all groups.

The purpose of hanging such a weight on the cycloergometer's pan in groups I and II was to influence directly the pedaling frequency in each maximal sprint. The weight of 10% of body weight (BW) caused a lower average frequency of pedaling compared to the weight of 5% BW, which forced a different training intensity at the same work output by both groups.

Throughout the entire period of the experiment the study participants did not perform any additional training nor did they take any supplements.

The body composition were measured on Monday before the commencement of training (0), after four weeks of training (4) as well as two (6) and four (8) weeks from the cessation of training.

For the diagnostic purposes the BIA - RJL System analyser and Weight Manager 2a software were used. The measurements were carried out in a horizontal position with arms lying along the body. Two electrodes recording electrical resistance of particular body tissues were attached to the back of the hand, half the length of the third metacarpal bone, and two of them on the foot, half the length of the second and third metatarsal bone. Having obtained the results of the resistance and the reactance, lean body mass (LBM in % and kg), body fat (FAT in % and kg) as well as the water content (in % and kg) were assessed. The test was performed two times for each person. For the final analysis the average values from two measurements were taken (Wit et al. 1998).

In order to compare the study results, the ANOVA variance analysis was used with repeated measurements. The significance level of the differences between the average values was evaluated post hoc – with the LSD (least significant difference) test. All calculations were made with the use of the STATISTICA™ programme (v. 5.5, StatSoft, USA).

Results

Throughout the entire period of the experiment no significant changes were observed in total body weight of the participants in all studied groups. However, after four weeks of training, body hydration increased significantly in groups I and III. Two weeks from the cessation of training the water content continued to increase significantly in all groups (Table 1).

Upon analyzing changes in LBM and FAT directly after 4 weeks of training, higher LBM values were ascertained in groups I, II and III ($p<0.05$) compared to the results from before the commencement of training (Table 2). Those values proved to be significantly higher in all the groups in week 2 and 4 after the cessation of training ($p<0.05$). When measuring FAT in groups I and II directly after four weeks of training, it was found to be lower (maximal sprint, 10% and 5% BW load). After 2 weeks from the cessation of training, further significant reduction of that index was observed in all the groups ($p<0.05$). However, 4 from the cessation of training FAT values returned to the level recorded in the period directly after the training ended. The percentage changes in the differences of LBM, FAT and LBM/FAT ratio are presented graphically (fig. 1-3).

No significant differences were found with respect to all the values measured between particular groups throughout the entire period of the experiment.

Table 2. Average values (±SD) of the lean body mass (LBM) and body fat (FAT) and the significance level of the differences of the average values between the measurement obtained before the study (0) and the subsequent measurements: (4) – after four weeks of training, (6, 8) – after two and four weeks from the cessation of training, * - p<0.05

Variables	Group	0	4	6	8
LBM [kg]	I	65.88±7.68	67.08±7.27	67.43±6.56*	67.52±6.72*
	II	64.92±7.75	65.79±7.48	66.50±8.27*	66.16±8.61*
	III	67.33±8.21	68.56±7.91*	68.62±8.01*	68.62±8.02*
	IV	69.11±6.73	69.49±6.08	70.16±6.61*	69.60±5.97
LBM [%]	I	84.78±3.56	86.44±3.75*	86.67±3.91*	86.22±3.96*
	II	83.55±2.95	84.91±4.16*	85.18±3.79*	84.55±4.65*
	III	84.08±3.66	84.67±3.60*	85.42±4.21*	85.83±3.88*#
	IV	85.36±3.78	86.18±2.64	86.36±2.80*	85.82±3.34
FAT [kg]	I	11.91±4.0	10.88±3.98*	10.72±4.43*	11.10±4.33
	II	13.04±3.99	12.16±4.65*	11.87±4.52*	12.50±4.36
	III	13.12±4.47	12.68±4.50	12.12±4.67*	11.66±4.38*
	IV	12.05±3.59	11.51±3.16	11.16±2.94*	11.61±3.44
FAT [%]	I	15.22±3.56	13.56±4.33*	13.33±3.91*	13.78±3.96*
	II	16.46±4.52	15.09±4.16*	14.82±3.79*	15.46±3.42*
	III	15.92±3.66	15.33±3.60	14.58±4.21*	14.17±3.88*#
	IV	14.64±3.78	13.82±2.64	13.64±2.80*	14.18±3.34

Training with maximal sprints and load: 10% BW – group I and 5% BW - group II; training with 3-minute sprints with average power 250 W and pedaling frequency: 80 rpm – group III and 45 rpm – group IV;
- the average values differ significantly between the second (4) and the fourth (8) measurement, # - p<0.05

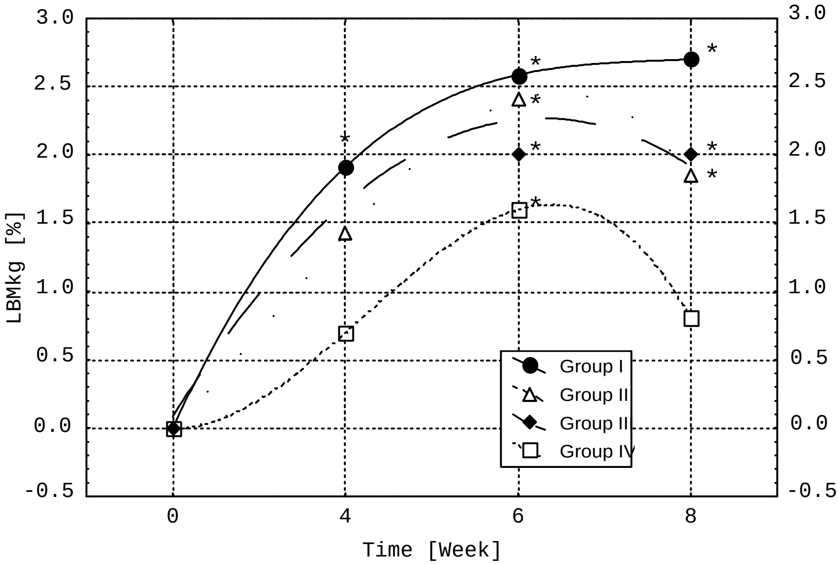

Fig. 1. Average values of changes in LBM_{kg} (calculated in relation to the measurement results obtained before the study commencement – expressed in percentage, * - p<0.05).

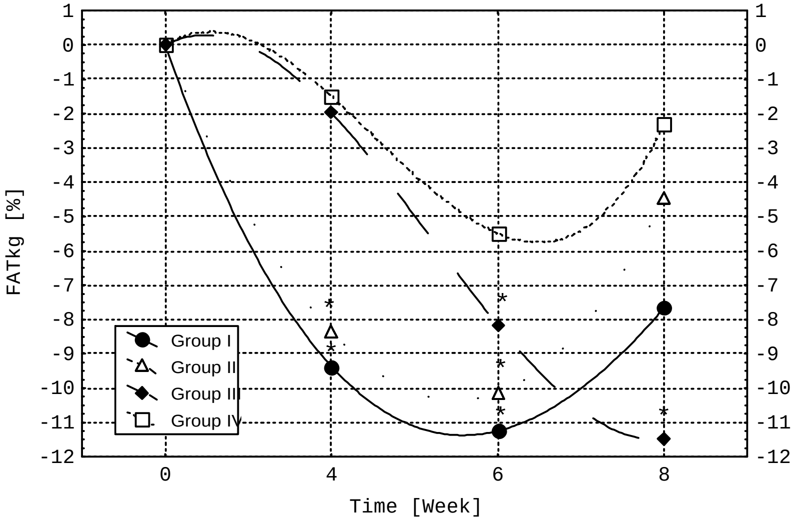

Fig. 2. Average values of changes in FAT_{kg} (calculated in relation to the measurement results obtained before the study commencement – expressed in percentage, * - $p<0.05$).

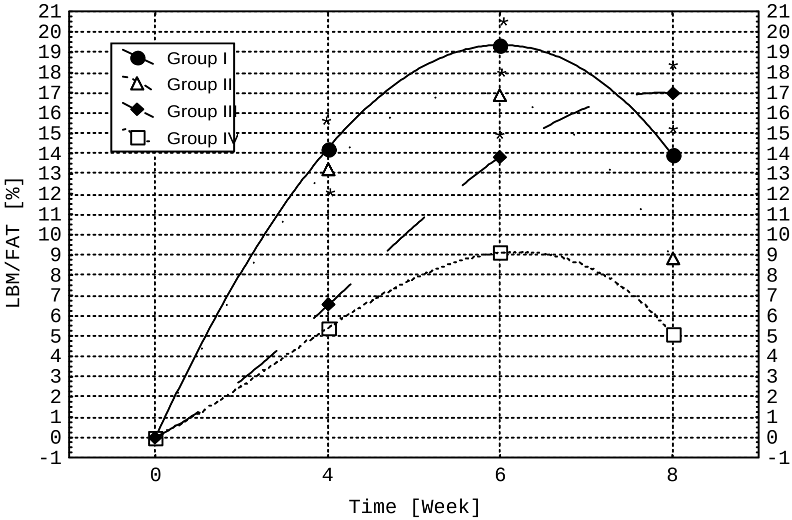

Fig. 3. Average values of changes in FAT/LBM (calculated in relation to the measurement results obtained before the study commencement – expressed in percentage, * - $p<0.05$).

Discussion

Apart from influencing the development of the physical efficiency level of the vascular and respiratory systems, systematic physical exercise, being part of the recreation training or sport training, influences also body composition. Intensity of exercise, level of the load and training methods applied play an important role in determining the direction of such changes. The study by Wilmore et al. (1978) showed that, after a 10-week of circuit strength training with short (15 s) intervals between sets lasting up to 30 s, LBM increased significantly in female and male groups and FAT decreased significantly but only in females. Total body weight did not change significantly in case of both groups. In the study of Hickson (1980), the participants trained in three groups: strength (S), endurance (E) and mixed training (S+E). In group (S) a significant change in body weight was ascertained from 75.8±3.4 to 77.7±3.3 kg and a non-significant change in FAT from 14.5±1.4 to 13.7±1.1. In group (E) a significant change in body weight and in FAT was observed from 77.0±4.9 to 74.8±4.2 kg and from 17.8±2.5 to

14.2±1.6 respectively. In group (S+E) body weight and FAT did not change significantly. A similar experiment was carried out by Sleivert et al. (1995). Body weight and measurements did not indicate any changes throughout the period of training. The variable-intensity training applied in this study to all four groups resulted in significant changes in all analyzed body composition when comparing the values obtained before the training and those obtained after 2 and 4 weeks from the cessation of the experiment. At the same time the differentiation of the training character achieved through applying maximal sprints with variable intensity and 3 min. sprints with average power of 250 W (with different pedaling frequency 45 and 80 rpm) did not find any implication in the analyzed values of particular body components. Significant changes in lean body mass, body fat and water content level were found in all the groups regardless of the load and intensity of the sprint. The results obtained were not significantly different between groups. At the same time, any changes in the body composition did not entail any significant change in total body weight of the studied subjects in all the groups.

The results concerning total body weight, which were obtained in this study, comply with works of other authors. The study of McKenna et al. (1993) consisting of 7 weeks of sprint training on a Monark cycloergometer (load 7.5% BW) with maximal, 30 s sprints, showed no significant change in total body weight. Similarly, in the studies of MacDougall et al. (1998) and Sharp et al. (1986), total body weight did not change significantly after training with maximal, 30 s sprints. However, the study of Allemeier et al. (1994) showed that a 6-week training with maximal, 30-second sprints did not cause any significant change in body weight, LBM or %FAT directly after the experiment. The results of Allemeier et al. (1994) stay in opposition to our results, in which we recorded significant changes in LBM and FAT in both groups exposed to training with maximal sprints lasting 27-40 s.

In consideration of the data quoted from the literature and the data from our experiment a conclusion can be drawn that the changes in body composition observed during the study, after being disposed to such kind of strain, do not last long and the values of the indices subjected to analysis tend to return to base values after 4 weeks from the cessation of training. Lack of changes in total body weight during the period of the experiment seems to point out that despite significant changes in the proportion of lean body mass to body fat, such type of training can influence body composition, although such changes are only short term.

In conclusions, the four weeks training on the cycloergometer resulted in a significant increase in LBM_{kg} in group III (3 min. sprints with average power 250 W, pedaling frequency 80 rpm) and in a decrease of body fat in groups I and II (maximal sprints, with a load of 10% and 5% BW) after the four weeks of training (immediate effect). Still after two weeks from ceasing the training the significant increase in $LBM_{\%}$, LBM_{kg} and the significant decrease in $FAT_{\%}$, FAT_{kg} could be observed in case of all the individuals in all the groups. However, 4 weeks after the cessation of training FAT tended to return to the values recorded directly after the training cessation. At the same time, no significant differences were recorded in case of all the values measured between particular groups.

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