Biology of Sport, Vol. 20 N°4 , 2003

EFFECTS OF "FAT-BURNING" EXERCISE AND LOW-ENERGY DIET ON LIPID PEROXIDATION PRODUCTS (TBARS) IN PLASMA OF SUBJECTS WITH OVERWEIGHT OR OBESITY

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Abstract. The aim of the study was to determine the combined effect of low-energy diet and recreational, "fat burning" exercise, on the concentration of thiobarbituric acid-reacting lipid peroxidation products (TBARS) in blood plasma of male and female subjects. Male and female subjects (n=11 and 18, respectively), aged 41.0±9.2 and 43.7±8.8 years, respectively, of BMI equal to 33.6±5.0 and 32.3±4.8, respectively, volunteered to participate in the study lasting two months. During that time, they were on a low-energy diet (600–1200 kcal) and exercised 3 times a week at an individually adjusted intensity. This resulted in a significant decrease of lipid peroxidation products (TBARS) in plasma despite an intensified lipolysis. The antioxidant protection was strengthened due to bioflavonoids and vitamins contained in the diet. Well balanced (with regard to intensity, form and duration) exercises, together with individually adjusted diet, brought about normalised body mass and composition, without negative effects on lipid metabolism. ***(Biol.Sport 20:321-330, 2003)***

Key words: Lipid peroxidation products (TBARS) - Aerobic exercise - Diet - Body composition

Introduction

Physical exercise is one of the physiological factors affecting catabolic processes and increasing the concentrations of metabolic products. Increased levels of lipid peroxidation products due to oxygen stress are associated with intense,

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competitive sports, and were reported by many authors [5,6,9,20]. Various authors attribute the degree of peroxide generation to the intensity and volume of workloads but the results are often controversial [7,11,14,18].

Apart from calorie intake restriction, aerobic exercises represent the most effective stimuli recommended for weight control and for resuming proper body composition [1,26]. Besides, the utilisation of individual substrates and generation of metabolic products, depend on the intensity and duration of exercise, as well as on diet composition and quality, and alterations in these factors significantly affect the metabolic paths [10,13,16,25,33].

The aim of this study was to determine the combined effect of low-energy diet and recreational, "fat-burning" exercise, on the concentration of thiobarbituric acid-reacting lipid peroxidation products (TBARS) in blood plasma of male and female subjects.

Material and Methods

The study was conducted on 11 men and 18 women with overweight or obesity, members of a fitness club in Warsaw. All subjects underwent a cycle ergometer exercise test and medical examination prior to being qualified for the study. They were informed about the study objective and methods, and gave their signed consents to participate. The study was approved by the local Commission of Ethics. Somatic characteristics of subjects are presented in Table 1. All subjects exercised systematically for two months and stayed on a low-energy diet adhering strictly to the protocol (Fig. 1).

Table 1
Mean values (±SD) of somatic data of subjects before the experiment

	Men (n=11)	Women (n=18)
Age (years)	41.0±9.2	43.7±8.8
Body height (cm)	177.3±8.1	166.4±6.3
Body mass (kg)	104.5±16.8	89.9±18.3
BMI	33.6±5.0	32.3±4.8

"Fat-burning" exercises were applied 3 times a week and lasted 60 min each. Exercise intensity was kept at heart rate range from 120 to 160 bpm.

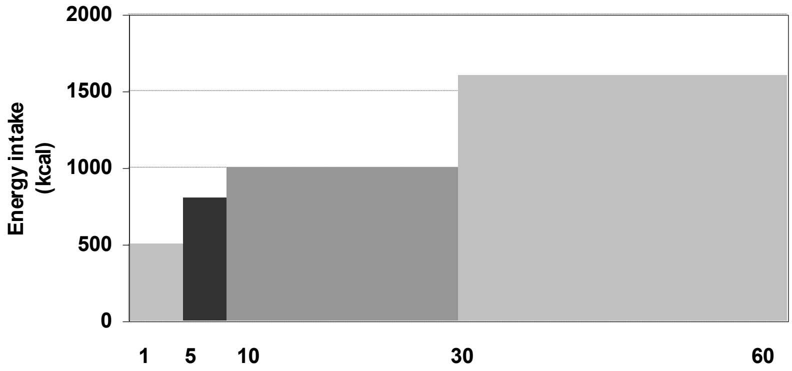

Fig. 1
Dietary restrictions (kcal) throughout the 2-month experiment

For the first 5 days, the calorie intake was highly restricted (500-600 kcal, i.e. about 25% of daily energy demand for women at that age), as the diet consisted of fresh fruit and vegetable juices, 1-1½ l/day. Other permitted drinks included light herb or natural tea and mineral water. That very low-energy, exceedingly low-carbohydrate and nearly fatless diet (VLED) leads to a deeply negative energy balance but supplies large quantities of vitamins and minerals.

From Day 6 till 15, a traditional, fibre-rich diet was applied. At the beginning, it was vegetarian (vegetable soups, bread), then was gradually supplemented with protein-rich products (eggs, low-fat cheese, meat), and subsequently with fats, preferably of plant origin. Energy intake increased to 800-1100 kcal [1].

In the second month of experiment, recommended daily energy intake amounted 1000-1200 kcal, and subjects were requested to put down all extra products consumed. Every subject was given detailed menus, balanced with respect to energy content and food product proportions. The assessed daily energy intake in that period amounted to 1200-1600 kcal.

On Days 1, 30 and 60, body composition and TBARS concentrations in plasma were determined, and on Days 1 and 30, sodium, potassium and magnesium ions in blood were assayed.

The following methods and procedures were used:

Electrolytes in blood: Fasting blood was withdrawn from the antecubital vein in the morning. Sodium, potassium and magnesium ions were determined with the use of Nova 8 analyser (Profutura, USA).

TBARS in plasma: Heparinised plasma was used with the addition of BHT (to prevent PUFA oxidation). Lipid peroxidation products were determined by reacting with thiobarbituric acid according to Buege and Aust [3] and expressed in $\mu mol \cdot l^{-1}$.

Body composition: Bio-impedance analyser (BIA-RJL System Nc with Weight Manager 2a software, USA). The measurements were conducted in duplicate, in recumbent position, arms along the trunk. Two electrodes were placed in the mid-point of the palm (upper side), two other ones – in the mid-point of the foot (upper side). Relative contents of fat, lean body mass (LBM) and water were recorded.

Conventional statistical procedures (STATISTICA® software) were used in data analysis.

Results

The monitored, reduced energy intake throughout the study period lasting two months resulted in significant changes in body mass and body components (Table 2).

Table 2
Mean values (±SD) of physiological variables recorded in men and women on three occasions

Variable	Day 1	Day 30	Day 60
	Men (n=11)		
Body mass (kg)	104.47±16.79	97.31±14.47**	93.82±13.93**
BMI	33.27±4.96	31.42±4.33*	30.15±4.28**
Fat content (kg)	32.55±9.59	26.40±8.42**	23.27±7.69**
LBM (kg)	71.95±8.31	71.24±8.28	71.39±7.11
Water content (kg)	52.67±6.09	52.15±6.05	52.25±5.19
Na ($mmol \cdot l^{-1}$)	147.2±0.40	-	146.90±0.60
Mg ($mmol \cdot l^{-1}$)	0.52±0.02	-	0.51±0.03
K ($mmol \cdot l^{-1}$)	4.34±0.21	-	4.42±0.32
VO_2max (ml/kg/min)	34.69±8.57	36.20±6.62*	42.11±6.34*

Women (n=18)			
Body mass (kg)	89.90±18.3	85.7±17.1*	81.80±17.5**
BMI	32.30±4.80	30.0±4.5*	29.30±4.4*
Fat content (kg)	36.70±13.5	33.2±12.7**	29.40±12.2**
LBM (kg)	53.20±6.40	52.6±6.3	52.50±6.3
Water content (kg)	38.90±4.70	39.0±4.2	38.40±4.6
Na ($mmol \cdot l^{-1}$)	145.40±1.10	-	145.20±1.3
Mg ($mmol \cdot l^{-1}$)	0.52±0.03	-	0.57±0.03*
K ($mmol \cdot l^{-1}$)	4.20±0.30	-	4.10±0.40
VO_2max (ml/kg/min)	29.40±4.40	33.76±4.56*	34.60±4.32*

Significantly different from the respective value on Day 1: *P<0.05; **P<0.01

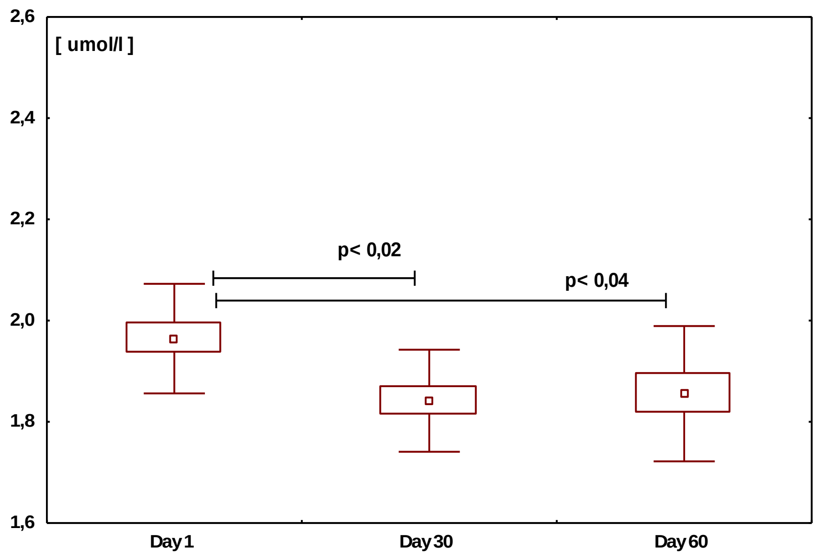

Fig. 2
Mean values (±SD) of lipid oxidation products (TBARS) in plasma of men (n=11)

Body mass and fat content significantly decreased, especially in men, LBM and water content remaining unchanged. No significant shifts in either sodium or potassium were noted, but magnesium significantly increased in women.

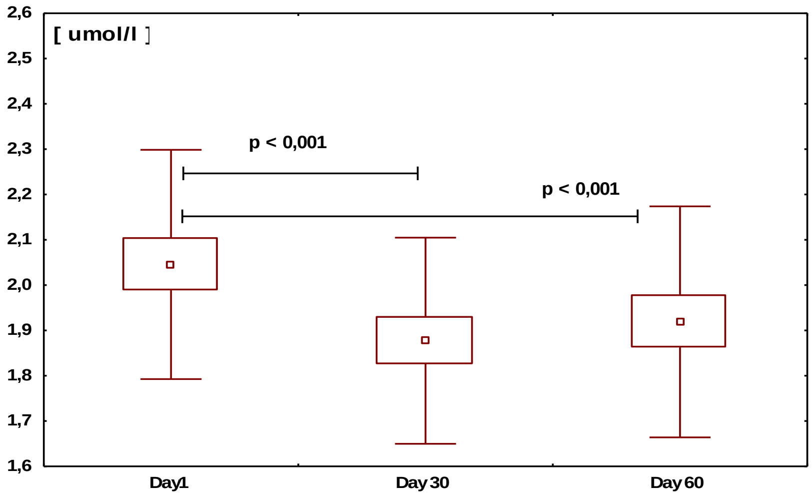

Fig. 3
Mean values (±SD) of lipid oxidation products (TBARS) in plasma of women (n=18)

Changes in TBARS concentrations are presented in Figs. 2 and 3. The levels of TBARS significantly decreased following 30 days of low-energy diet and exercise and then remained constant until the end of experiment.

Discussion

Systematic participation in a controlled programme of physical exercise lasting two months, combined with low-energy diet, brought about a significant reduction in TBARS levels in the first month of experiment in all subjects. After that, no further changes in TBARS were observed which could have been due to the following factors:

Firstly, the form and intensity of heart rate-controlled, submaximal exercise, resulted in a significant ($P<0.001$) decrease in fat content, without altering LBM or water content. Under such conditions, an efficient utilisation of adipose tissue was possible, despite intensified lipolytic processes. Such metabolic pattern persists also in the post-exercise recovery, as reported by Leutholtz *et al.* [17] and Thompson *et al.* [24]. Moreover, it was reported that moderate, aerobic exercises reduce peroxidation processes and toxic effects of free radicals, without increasing the activities of enzymes involved in oxidative phosphorylation, unlike at a high oxygen uptake by mitochondria [11,22,30]. Such workloads were also reported to amplify the pentose cycle efficiency in erythrocytes [8,14,15].

Secondly, systematic participation in aerobic training increases subject's aerobic potential and, thus, general functional performance [1,8]. The applied training resulted in a significant increase in relative VO_2max, by 21 and 18% in men and women, respectively. That kind of training was regarded as protecting from cell damage resulting from pro-oxidative-antioxidative imbalance by inhibiting peroxidative processes [8,15]. Similar observations were reported for muscle and liver cells in trained animals [4,11,12,32].

The significant reduction in TBARS levels observed after 30 days of exercising, may indicate such period to be sufficient, e.g. increasing the activities of mitochondrial enzymes and, in result, decreasing in myocytes generation of reactive oxygen species and their passage into the blood stream [29]. The reduction of TBARS despite practising "fat burning" aerobic exercises might be associated with increased antioxidative potential and increased activities of superoxide dysmutase, glutathione peroxidase and katalase in erythrocytes [3,14].

Probably, due to a high content of juices, fruit and vegetables in diet we have observed no unfavourable changes in sodium and potassium, Moreover, we noted significant increase in magnesium in women, despite a profound dietary energy deficit.

A vitamin-rich diet was reported to inactivate the reactive oxygen species, to inhibit lipid peroxidation and to modify the antioxidant defence [23,27,28]. Supplementation with antioxidant vitamins, e.g. C and E, brings about TBARS decrease in human and animal plasma [9,16,21,32].

It seems likely that TBARS decrease observed in this study was mainly due to low-energy diet of a fairly high content of polyunsaturated fatty acids (PUFA), which serve as substrates for free radicals, together with the above mentioned vitamin and bioflavonoid supplementation. On the other hand, no significant changes in TBARS levels in the second month of the experiment despite continuing aerobic training, was probably due to supplementing diet with fats (1500 kcal) while maintaining a high antioxidative potential [19,22,31].

It could be suggested that in order to restore a proper body composition in obese subjects, the metabolism should not only be aimed at getting rid of fat excess but, at an increased energy expenditure, at supplying necessary products for an efficient metabolism.

Conclusions

1. Bioflavonoids and vitamins contained in diet increased the antioxidant potential, reduced the exercise-induced oxidative stress and improved lipid peroxidation, as evidenced by significant reductions of TBARS in plasma.

2. Well balanced (with regard to intensity, form and duration) exercises, together with individually adjusted, low-energy diet, brought about normalised body mass and composition in male and female overweight or obese subjects, without negative effects on lipid metabolism.

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Accepted for publication 14.04.2003

The study was supported by grants No. III.90 (APE) and D.3.1 (I.S.)