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ORIGINAL ARTICLE

Effects of aerobic interval training versus continuous moderate exercise programme on aerobic and anaerobic capacity, somatic features and blood lipid profile in collegate females

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Abstract

Introduction. Regular physical activity has many positive health benefits, including reducing the risk of cardiovascular diseases, metabolic diseases and some cancers, as well as improving the quality of life.

Objectives. The aim of the study was to examine the effects of 8-week aerobic interval cycle exercise training (AIT) compared to continuous cycle exercises of moderate intensity (CME) on the aerobic and anaerobic capacity, somatic features and lipid profile.

Material and methods. The research was conducted in 88 volunteers aged 19.5±0.6 years, who were randomized to three groups of organized physical activity (OPA), who exercised 3 times per week in 47 min sessions: (I) AIT (n=24) comprising 2 series of 6x10 s sprinting with maximal pedalling cadence and active rest pedalling with intensity 65%–75% HRmax, (II) CME (n=22) corresponding to 65%-75% HRmax, (III) regular collegiate physical education classes of programmed exercises (CON; n=42). Before and after OPA anthropometrics, aero- and anaerobic capacity and lipid profile indices were measured.

Results. In AIT, a significantly greater decrease of waist circumference and WHR was noted when compared to CON, and a significantly greater reduction of sum of skinfolds than in CON and CME. Improvement in relative and absolute VO_2max (L/min and ml/kg/min) was significantly higher in AIT than CON. Work output and peak power output in the anaerobic test improved significantly in AIT, CME and CON, but independently of training type. OPA was effective only in reducing triglyceride concentrations in CME and CON groups, without interaction effects in relation to training type.

Conclusion. It was found that 8 weeks of OPA was beneficial in improving somatic and aerobic capacity indices, but AIT resulted in the greatest improvement in somatic indices (waist circumference, WHR, sum of skinfolds) and in VO_2max, compared to CME and CON programmes.

Key words
interval training, aerobic exercise, health, risk factors, women

INTRODUCTION

Regular physical activity has many positive health benefits, including reducing risk of cardiovascular diseases, metabolic diseases and some cancers, as well as improving the quality of life. In contrast, lack of physical activity is associated with higher risk of civilization diseases and risk of death from general causes, and particularly from cardiovascular events [1, 2].

An adequate level of physical activity, apart from appropriate nutritional habits, is necessary to maintain optimal values of physiological indices related to health, especially physical fitness, body composition and lipid profile [3, 4].

Modality (intensity and volume) of physical activity has an essential effect on achieved health benefits [1]. According to recommendations of the European Society of Cardiology and the Polish Society of Cardiology addressed to adults, energy expenditure on physical activity should be not less than 1,000 kcal/week and optimal levels should exceed 2,000 kcal/week [5]. In compliance with the WHO recommendations, the physical activity level for maintaining a good health condition should include at least 150 minutes of aerobic exercises with moderate intensity per week, or at least 75 minutes of intensive aerobic exercises, or an equivalent total volume of moderate and intensive physical activity. Additional health benefits can be expected when physical activity is increased above 300 minutes per week. Furthermore, health benefits can be gained when additionally stretching and resistance exercises performed twice a week are included [6].

Many studies have confirmed the profitable effects of physical activity on indices of health, including: decreasing BMI, reducing fat tissue, increasing lean body mass, decreasing resting heart rate and profitable modification of lipid profile [1, 7, 8].

It has been shown that physical training including interval aerobic exercises of high intensity (aerobic interval training – AIT) compared to continuous training with moderate intensity and constant load (continuous moderate exercise – CME) provided additional benefits in terms of reduction

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of metabolic risk factors in women, as well as reduction of cardiovascular risk factors [9]. Very recent studies present different effects of AIT and CME on cardiovascular fitness, heart function and improving body composition in some specific populations in relation to training volume, session frequency and intensity modalities [10,11,12]. However, there is still a need for establishing the most effective exercise protocols that could be carried out by insufficiently active subjects.

OBJECTIVES

The purpose of the current study was to examine the effects of 8-week aerobic interval cycle exercise training compared to continuous cycle exercises of moderate intensity on the aerobic and anaerobic capacity, somatic features and lipid profile in collegiate women.

It was hypothesized that 8-week aerobic cycle exercise programmes would significantly improve aerobic capacity, somatic features and blood lipid profile, but a programme of aerobic interval training would produce even greater improvements than a continuous moderate exercise programme.

MATERIAL AND METHOD

Subjects. Eighty-eight previously untrained collegiate females, aged 19.5±0.6, volunteered for this study. Participants were randomized to the aerobic cycle interval training (AIT, n=24), continuous moderate cycle exercise training (CME, n=22) or a control group (CON, n=42), which participated in regular collegiate physical education classes. All participants attended the 8-week training; groups AIT and CME had 3 training sessions per week and the CON group had their regular physical education classes once a week. Time of the sessions and mean intensity of exercise in both intervention protocols were very close to recent recommendations of optimal training loads for subjects from an incorporated age group [13]. Subjects' fitness level assessed by maximal oxygen consumption, was assessed as low (Tab. 1). Subjects were instructed about the aim and methods of examination and were recommended to continue their normal dietary and physical activity practices throughout the study, but to refrain from alcohol and exercise for 48 h before each trial. Participants were encouraged to fully participate in their group programmes. For each participants, all tests were performed before the (pre-) and after (post-) training period.

The study protocol was approved by the Ethic Committee at the University of Physical Education in Warsaw, Poland (Approval No. 001–89–1/2010) and the study conformed to the Declaration of Helsinki. Written informed consent was obtained from all subjects before the study began.

Aerobic interval cycle exercise training (AIT). Mechanically-braked cycle ergometers (HESS Co., Poland) were used for training. In AIT protocol, each training session consisted of a 10-min warm-up at a workload adjusted to 60% HR max, 32-min main stage and 5-min cool-down stage. Total time of this protocol was 47 min. In the main stage of the protocol, each participant performed 2 bouts of 6 high-intensity sets consisting of: 10 s of sprinting with maximal pedalling cadence and 1 min active recovery at intensity adjusted to 65–75% HRmax. After each bout, the participants covered 10 min of active recovery at workload adjusted to 65–75%. A decrease in participant's HR at the current workload presaged to increase in pedalling cadence.

Heart rate (HR) was monitored with use of a heart rate monitor (Polar Electro Inc, Lake Success, NY) during each phase of protocol.

Continuous moderate cycle exercise training (CME). Mechanically-braked cycle ergometers (HESS AG., Poland), the same as for AIT, was used in the CME protocol. Each training session consisted of 10-min warm-up, a 32-min stage of continuous moderate exercise stage, and 5-min cool-down stage. In the main stage of the protocol, participants exercised at 65–75% HRmax intensity.

Control group (CON). The CON group participated in typical collegiate physical education classes adjusted for time of exercise to 47 min. Participants were asked to maintain their regular physical activity.

Measurements

Somatic features. Anthropometric measurements included: body mass, body height, 6 skinfolds (biceps, triceps, subscapular, suprailiac, abdominal, and medium calf), waist and hip circumferences. Body mass was measured with a weight scale (model: BC 418MA, Tanita Co., Tokyo, Japan) to the nearest 0.1 kg, and body height with a stadiometer to the nearest 0.1 cm. Skinfold measurements were performed by an experienced technician, using a Harpenden caliper (British Indicators Ltd., St. Albans, UK) with a contact surface pressure of 10 g/mm. The mean of 3 measurements was used for representing skinfold thickness. Waist-to-hip ratio (WHR) and body mass index (BMI) were calculated.

Aerobic and anaerobic capacity

Aerobic capacity. Aerobic capacity was expressed as estimated maximal oxygen uptake (VO_2 max), obtained using the cycle ergometer test and the Åstrand-Ryhming nomogram from the steady state heart rate (HR) and work load. The test was conducted on a Monark bike ergometer, model 874E (Monark Exercise, Vansbro, Sweden). Prior to testing, the participants were fitted with a heart rate monitor (Polar Electro Inc, Lake Success, NY) linking the heart rate response to the ergometer using a telemetry system. The pedal rate was set at 50 revolutions per minute. The test was initiated from a 1 W/kg load and continued for 6 minutes to reach a target rate of 135–150 bpm. If HR was lower or higher than the target rate, the workload was adjusted to bring the heart rate into the desired range and an additional 6 minutes of cycling was performed [14].

Anaerobic capacity. Participants performed the anaerobic test (AnT) on a mechanically braked cycle ergometer (Ergomedic 874E, Monark, Sweden) according to the procedures of the Quebec test [15]. The testing session started with a standardized 5-min warm-up of cycling and after a 5-min rest the AnT began with a load of 7.5% body mass (BM). The participants were instructed to accelerate to their maximal pedalling rate and verbally encouraged to maintain this pedalling cadence as long as possible throughout the 10-s test. Computer software (MCE, JBA Staniak, Poland) automatically calculated peak power (PP), defined as the highest mechanical power expressed in W/kg of body mass, as well as total work (Wtot) and time to peak power output (T).

Blood lipid profile. All lipid measurements were carried out at the biochemistry laboratory of the University of Physical Education in Warsaw, Poland. The pre- and post- training venous blood samples were obtained from the participants between 08:00–10:00 after a 12-h overnight fast. Citrated and EDTA venous plasma sample were centrifuged at 1,500 g for 10 min at 4 °C, and stored at -80 °C for later analysis performed with standard colorimetric assays. LDL concentration was calculated from the Friedewald formula. Reference values were assessed according to the Third Report of the National Cholesterol Education Programme (NCEP) 2003 [16]. Blood samples were taken independently from phases of the menstrual cycle.

Statistics. Two-way (3-group × 2-time) repeated measures ANOVAs were performed to detect whether the 3 groups differed in rates of change in somatic, physical fitness, or lipid profile indices during the 8 weeks. The main effects for the group were not of interest; only the main effect for time and the interaction between group and time were analysed. The Wilks lambda statistic, transformed to F, was used to test for significance. The family-wise alpha level of 0.05 was held constant for each univariate ANOVA by using a modified Bonferroni procedure. A modified Bonferroni *post hoc* test was performed for each variable with a significant group x time interaction to determine which groups differed from each other at the time of post-test, after adjusting for pre-test results. The method allowed for use of the pre-training scores as co-variates, thereby allowing pairwise comparisons of adjusted means. For those variables with a significant main effect for time, with no significant group x time interaction, a *post hoc* test was performed to determine which groups improved significantly over time. Level of statistical significance was set at $p<0.05$.

RESULTS

In initial assessment it was confirmed that no significant differences existed among the 3 groups of women in any of the somatic, physical fitness or lipid profile variables (Tab. 1).

Somatic features. A group–time interaction was observed for waist circumference ($p<0.001$), WHR ($p<0.05$) and sum of skinfolds ($p<0.01$). As a follow-up to the significant interaction, ANOCVA and Bonferroni's *post hoc* test were performed on each of the somatic variables, with the adjusted significance level, to control for type I error. *Post hoc* analyses indicated that the AIT group had a greater improvement in waist circumference than CON ($p<0.05$), and only a tendency for a higher ($p=0.06$) change was noted for AIT, when compared to CME. For the WHR results, the AIT group was significantly lower than the CON group at post-test ($p<0.05$). No other pairwise comparisons were significant for WHR. The AIT group had a significantly greater improvement in the sum of skinfolds than CON ($p<0.001$) and CME ($p<0.05$). For body mass and hip circumference, the BMI group x time interaction was not significant ($p> 0.05$); however, the main effect for time was significant ($p<0.001$, $p<0.001$, $p<0.001$, respectively). *Post hoc* analyses of these variables indicated that the AIT, CME and CON groups improved significantly ($p<0.001$, $p<0.05$ and $p<0.05$ respectively) in BMI, while body mass decreased significantly only in AIT ($p<0.001$), and hip circumference decreased significantly in AIT, CME and CON ($p<0.01$; $p<0.001$ and $p<0.001$ respectively). Comparison of rate of relative changes of selected somatic variables in the 3 groups is presented in Figure 1.

Table 1. Pre- and post-training mean (±SD) values of selected variables in subjects from AIT, CMS and CON groups

	Pre-training			Post training			Effects		Significance of rate of changes
	AIT	CME	CON	AIT	CME	CON	Time	Interact	
Body mass (kg)	61.1 ± 7.4	63.5 ± 8.7	60.3 ± 9.9	59.9 ± 6.8	62.9 ± 8.5	59.8 ± 9.8	***	ns	ns
Body height (cm)	168.4 ± 5.5	166.2 ± 5.2	167.0 ± 5.6	168.6 ± 5.3	166.3 ± 5.2	167.1 ± 5.6	*	ns	ns
Hip circumferences (cm)	91.6 ± 5.5	94.5 ± 6.9	91.1 ± 7.4	89.8 ± 4.8	91.9 ± 5.8	89.3 ± 6.4	***	ns	ns
Waist circumferences (cm)	66.5 ± 5.1	67.6 ± 6.7	65.1 ± 6.8	63.2 ± 4.5	65.6 ± 6.2	64.4 ± 6.1	***	***	AIT<CON *
WHR	0.73 ± 0.04	0.70 ± 0.04	0.72 ± 0.05	0.71 ± 0.04	0.72 ± 0.05	0.72 ± 0.05	ns	*	AIT<CON *
BMI	21.6 ± 2.1	22.9 ± 2.6	21.6 ± 3.2	21.0 ± 2.0	22.7 ± 2.6	21.4 ± 3.1	***	ns	ns
Sum of skinfolds (mm)	9.09 ± 2.08	9.82 ± 2.06	9.17 ± 2.78	8.56 ± 1.93	9.70 ± 2.00	9.24 ± 2.46	*	**	AIT<CME*; AIT<CON***
Total cholesterol (mmol/l)	4.7 ± 0.7	4.7 ± 0.5	4.6 ± 0.6	4.5 ± 0.5	4.7 ± 0.6	4.5 ± 0.6	ns	ns	ns
LDL cholesterol (mmol/l)	2.4 ± 0.6	2.5 ± 0.4	2.3 ± 0.5	2.3 ± 0.5	2.5 ± 0.5	2.4 ± 0.5	ns	ns	ns
HDL cholesterol (mmol/l)	1.9 ± 0.4	1.8 ± 0.3	1.9 ± 0.5	1.8 ± 0.4	1.8 ± 0.4	1.8 ± 0.5	ns	ns	ns
TG (mmol/l)	0.9 ± 0.4	1.0 ± 0.4	0.9 ± 0.4	0.9 ± 0.3	0.8 ± 0.3	0.8 ± 0.2	**	ns	ns
Work output (J/kg)	62.8 ± 6.4	63.1 ± 6.2	63.5 ± 7.6	67.3 ± 6.7	67 ± 5.2	66.1 ± 7.8	***	ns	ns
Peak power output (W/kg)	7.7 ± 0.8	7.8 ± 0.6	7.8 ± 0.9	8.2 ± 0.8	8.1 ± 0.7	8.0 ± 0.9	***	ns	ns
Time to peak power (s)	7.8 ± 1.1	7.3 ± 1.2	7.7 ± 1.4	7.5 ± 1.3	7.3 ± 0.8	7.1 ± 1.3	*	ns	ns
VO2max (ml/kg/min)	36.2 ± 7.2	36.6 ± 6.6	37.6 ± 5.9	41.7 ± 7.1	39.8 ± 6.7	38.3 ± 7.1	***	**	AIT>CON *
VO2max (l/min)	2.2 ± 0.4	2.3 ± 0.4	2.3 ± 0.4	2.5 ± 0.5	2.5 ± 0.4	2.3 ± 0.4	***	*	AIT>CON *

AIT – aerobic interval training group; CME – continues moderate exercise group; CON – control group; Interact – interaction time x group effect; WHR – waist-to-hip ratio; BMI – body mass index; LDL – low-density lipoprotein; HDL – high-density lipoprotein; TG – triglycerides; VO2max – maximal oxygen consumption; *, **, *** – statistical significance level of p<0.05, p<0.01, p<0.001, respectively.

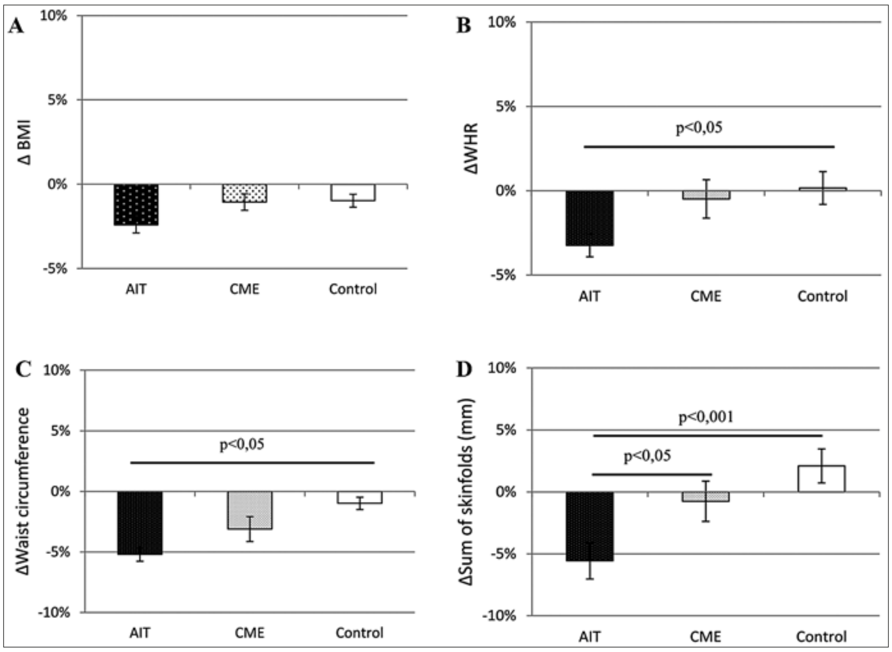

Figure 1 a-d. Changes (mean±SEM) in BMI (a), WHR (b) waist circumference (c) and sum of skinfolds (d) among subjects from AIT (black bars), CME (grey bar), and control (white bar) groups after 8 weeks of training

Aerobic and anaerobic capacity. A group-time interaction was found only for relative and absolute values of VO_2max. For both relative and absolute VO_2max results, the AIT group had significantly greater improvements than the CON group (p<0.05).

The main effect for time was significant for each anaerobic capacity index. *Post hoc* analyses of peak power indicated that the AIT, CME and CON groups improved significantly in work output (p<0.001, p<0.05 and p<0.05, respectively). Moreover, AIT, CME and CON groups improved significantly in peak power output (p<0.001, p<0.01 and p<0.01), but time to peak power decreased significantly only in CON (p<0.01). No other pairwise comparison was significant for physical fitness outcomes. Comparison of rate of percentage changes of selected exercise capacity indices among the 3 analysed programmes is presented in Figure 2.

Blood lipid profile. No significant group-time interaction was noted for blood lipid variables. Only for the triglycerides (TG) was the main effect for time significant (P<0.01). *Post hoc* analyses of TG indicated that the CME and CON groups improved significantly (p<0.05 and p<0.05), but the AIT group did not. Values of TC, LDL-C and HDL-C were not affected by any of the training programmes, and remained unchanged in all of the groups.

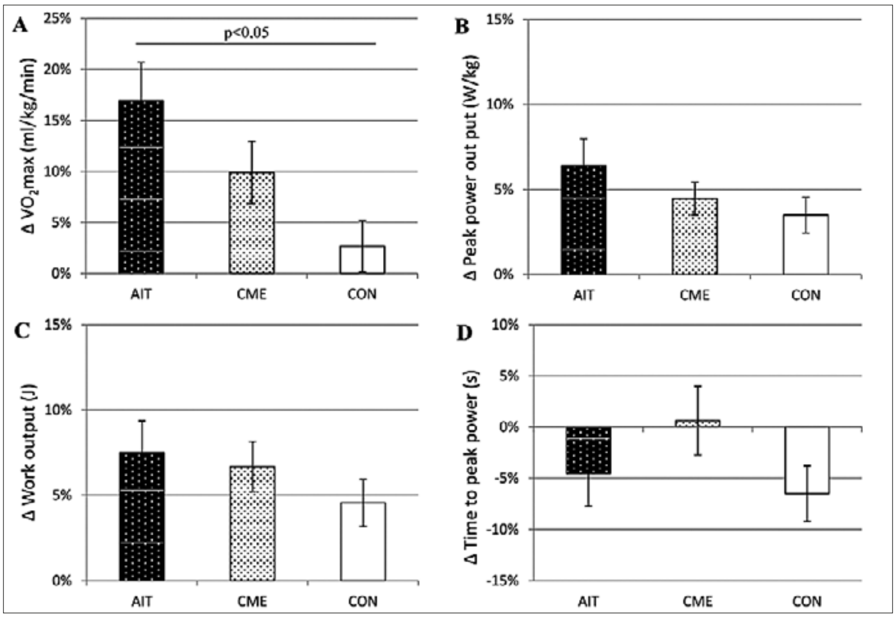

Figure 2 a-d. Changes (mean±SEM) in VO_2 peak (a), anaerobic work output (b) anaerobic peak power (c) and time to peak power (d) among subjects from AIT (black bars), CME (grey bar) and control (white bar) groups after 8 weeks of training

DISCUSSION

Most of the results from current studies aimed at comparing the physiological effects of interval training and training based on moderate intensity exercises have shown that exercising with high intensity can provide similar or superior effects to continuous exercise training, but in a shorter duration because it is more time-efficient [10, 17]. The literature on aerobic exercises reports that interval training could increase VO_2max, maximal power and speed, and capacity for intensive exercise, as well as reducing common risk factors of cardiovascular diseases including overweight and glucose tolerance disorders. It was established that for significant improvements in somatic features, physical fitness and lipid profile, the aerobic interval training should be continued for at least 8 weeks or last optimally for 12 weeks.

Somatic indices. Normalising body mass and fat mass reduction could be important benefits for physically active subjects [18]. Overweight as a result of excess fat mass and its complications followed by diabetes and metabolic syndrome are common causes of mortality in developed countries [19]. In young females, in contrast to the elderly, physical activity energy expenditure significantly determines body mass and body fat, which stresses the preventive role of regular physical activity in limiting overweight and associated health problems [20].

In the presented study, females participating in organised physical activities gained beneficial changes regardless of type and intensity of physical exercise in the somatic indices: waist circumference, WHR and sum of skinfolds. Improvements in waist circumference were greater in AIT than in CME or CON. Similarly, WHR and sum of skinfolds were more significantly reduced in AIT than in CON. The other somatic variables – body mass, hip circumference and BMI – were also reduced after 8 weeks, but changes were not related to type of training.

Other authors suggest that in young subjects with normal body mass and composition, a 6-week, or even 8–16-week physical exercise programme based on repeated sprints or interval high-intensity exercises combined with aerobic exercises could not result in improving somatic features [21]. Nevertheless, aerobic interval training in the obese lasting at least 12–16 weeks seems to improve health-related anthropometric indices.

Aerobic and anaerobic capacity. It was revealed that a stronger relationship occurs between aerobic fitness and risk of CVD than volume of physical activity (expressed in time) and CVD [22]. Results of other studies established an association between cardiovascular mortality and maximal oxygen consumption [23]. In the presented study, the collected data confirmed the beneficial effect of physical exercise on aerobic capacity. AIT resulted in a significantly greater improvement in absolute VO_2max and VO_2max related to body mass than in CON. Improvement in VO_2max in CME compared to CON did not reach statistical significance.

Other authors have presented results confirming that the effect of AIT on increasing VO_2max is similar or greater than CME [21, 24]. Moreover, the AIT session duration could be shorter than CME because including high intensity exercise increased physical activity energy expenditure. Usually, similar improvements in VO_2max were noted when the AIT session duration was shorter by about 15–20%, when compared to CME. After equality of energy expenditure in AIT and CME, superior improvements in VO_2max were noted in the AIT programmes [21, 24]. An intermediate burst of vigorous physical activity interspersed by periods of rest or low-intensity exercise can induce endurance-like adaptations, e.g. increased capacity for whole-body and skeletal muscle lipid oxidation, enhanced peripheral vascular structure and function, and improved exercise performance, even within several weeks [17]. Comparable improvements can be expected in much longer traditional endurance training [17]. AIT or sprint interval training results show significantly greater increase in both aerobic capacity and selected indices of anaerobic capacity [25, 26]. Analysis of collected data from the presented study revealed beneficial effects of participating in organized physical activity exercises, but the effects were independent of the type of training. Increase in total work performed in the anaerobic test and maximal power output was significant, but similar in AIT, CME and CON.

Blood lipid profile. A review of 14 papers concerning the effects of AIT on blood lipid profile shows that only HDL-cholesterol improved after training lasting approximately 8 weeks. It should be stressed that improving indices of blood lipid profile is limited among healthy subjects with normal values of lipid indices, as in the subjects investigated in this study. A significant reduction of body mass or improving body composition could enhance beneficial changes in blood lipid profile [27]. In this study, participation in organized physical activities was effective only in reducing concentration of triglycerides in CME and CON groups, but the rate of change was not related to the type of exercise training programme.

The primary hypothesis of superiority of AIT over CME or CON has not been fully supported by the results of the presented study. It was found that participation in organized physical activities is beneficial for selected health indices, but AIT provides greater improvement than CME or CON only in waist circumference, WHR, sum of skinfolds and VO_2max. Results of current investigation suggesting enhanced VO_2max are congruent with the latest studies of short periods of AIT training and support findings that AIT induces rapid adaptations in exercise performance after a relatively low time commitment [11, 17, 25]. However, based on current results, a relatively higher improvement could be expected in aerobic capacity, rather than anaerobic capacity in response to aerobic interval training.

CONCLUSIONS

Eight weeks of aerobic interval training is more effective in improving body composition and cardiorespiratory fitness than continuous moderate exercise and regular physical education programmes in collegiate women. The results of this study confer that aerobic interval training could be recommend as a means for improving the efficiency of physical education lesson in gaining health effects in collegiate women.

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