Central hemodynamic response to interval aerobic jogging in healthy male students

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Abstract

Purpose: Regular training improves maximal oxygen consumption (VO2max) and cardiovascular function. The aim of this study was to determine the central hemodynamic adaptation after interval aerobic jogging in healthy male students.

Material: Twenty untrained male students (aged 18-20 years) were volunteered and randomly divided into two groups: interval (I; n=10) and control (C; n=10). Countryside interval jogging programme 5×9 min at 70% of Maximum Heart Rate interspersed with 4 min inactive recovery, 3 days/week for 8-weeks performed. The control group remained sedentary during the period. VO2max obtained using the step-test. Standard medical method of tetrapolar chest reography (impedance cardiography) was performed for hemodynamic parameters, during resting and after workload (Step-test) conditions, before and after the training.

Results: Using t-test, after eight weeks the resting heart rate in both groups did not change significantly (P>0.05). The stroke volume increased significantly in I group after workload (P≤0.05). The cardiac output (CO) did not change significantly in both groups (P>0.05). The systolic blood pressure in I group decreased significantly at rest and after workload (P≤0.05). The diastolic blood pressure did not change significantly in both groups (P>0.05). The systemic vascular resistance in the both groups did not change significantly (P>0.05). The maximal aerobic capacity absolute and relative increased significantly in I group (P≤0.05). Significant difference between groups in stroke volume, cardiac output, VO2max absolute and relative (P≤0.05) was found.

Conclusions: Eight weeks aerobic interval jogging can influence on central hemodynamic and VO2max in male students.

Keywords: stroke volume, blood pressure, cardiac output, maximal oxygen consumption.

Introduction

Physical training, as part of cardiac rehabilitation, is effective in improving vascular function, pulmonary circulation, ventricular remodeling and functional capacity and quality of life in patients with coronary artery disease [16, 20]. However, the benefit of training on left ventricular diastolic and systolic function is controversial [11, 39, 46]. The most cases of physiological modification are heart rate and blood pressure due to physical activity [28]. The response of the heart rate and blood pressure to exercise depends on factors like active muscle mass, type of muscle fiber, intensity and the training method [23, 29].

Measures of cardiac output (CO) help to develop the information about physiological responses and mechanisms of adaptation due to the physical training, sedentary lifestyle and chronic disease. CO – the product of stroke volume (SV) and heart rate (HR) – indicates the body's ability to meet the metabolic demands of training; it may increase from 5- to 6-fold during training [44]. Coordination the function of autonomic nervous system (marked with rapid and sustained parasympathetic withdrawal coupled with sympathetic activation) is required for this to happen. The increase in HR is responsible for the majority of the enhancement the CO during training, and peak HR is a basically limiting factor of peak exercise capacity in healthy person. Maximal HR does not increase with training. In contrast, with prolonged physical training increases in SV – both at rest and during exercise – demonstrated [4].

Studies show that during physical activity increase in HR is responsible for 50 to 70 percent, contractility 15 to 25 percent and ventricular work for 15 to 25 per cent of myocardial oxygen consumption is responsible [10].

Intensive Interval training is divided into two main categories: sprint and aerobic types. Sprint-type interval training improves maximal oxygen consumption (VO_{2max}) mainly through increased oxidative capacity in peripheral muscles [14]. Aerobic-type interval training improves VO_{2max} mainly through improved cardiac function [45]. The lowest intensity for improving VO_{2max} seems to be approximately 55 - 65% of maximal heart rate [25]. Studies confirm that training programs that involve relatively high-intensity are more effective in improving VO_{2max}, cardiac function than moderate intensities, in healthy individuals [18, 26, 41]. Gibala et al. [15] have shown that interval training as compared with continuous training is more efficient in inducing rapid adaptations in skeletal muscles and exercise performance. Molmen-Hansen et al. [30] demonstrated that interval training could reduce blood pressure (BP) and improve heart function of hypertensive patients. In addition, several previous studies had reported that high intensity interval training could be used in both clinical practice and experiments, and that such exercise modality had greater beneficial effects on the heart [123, 45]. However, the sub-acute effects occur immediately after finishing the training, and involve chronic physiological adaptations that develop over the training period [9]. Information about heart function during low intensity aerobic interval training is limited and more studies have investigated the effects of intensive interval training.

Tjonna et al. [40] found that aerobic interval and

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continuous training on average three times a week on a treadmill for 16 weeks reduced systolic and diastolic blood pressure in patients with metabolic syndrome. Ciolac et al. [8] observed a decrease in mean 24-h systolic and diastolic blood pressure in long-term treated hypertensive patients. Sijie T et al. [38] showed no significant change in SBP and DBP after 15-week high intensity interval training in overweight young women. Ricardo Fontes-Carvalho et al. [12] showed 8-weeks aerobic training after myocardial infarction did not significantly improve diastolic or systolic function parameters, although it was associated with a significant improvement in VO_{2max}.

Despite much research, still cannot be said with certainty that aerobic interval training have a significant impact on the function of cardiovascular system. Therefore, in this study the effect of aerobic interval jogging on central hemodynamic parameters of heart in male students investigated.

Material and methods

Participants. The study was performed on 20 non-athletic male students of the Belarusian state University of physical culture (Belarus) aged from 18-20 years (interval training group IG; n=10 and control group CG; n=10), who took part in the study. Each participant gave informed consent before enrolment. The students did not have any sports category. The criterion for cardiovascular health was the data obtained from the questionnaire devised by the researcher. Before the initiation to participate in the study, the subjects were informed of the process and filled out the medical sport questionnaire and the consent form.

Training programme. Training programme was designed including a 45-minutes countryside interval jogging with 70% of the maximum heart rate (MHR), three times a week for eight weeks, 5_x9 minutes with 4-minute inactive rest intervals between them. The subjects warmed up for 10 min before starting the main programme, and cooled down for 10 min after the main programme. All the training sessions were supervised by the researcher. The control group remained sedentary during the period.

Complex «Impecard-M TU RB14563250. 017-96. made in Belarus» was used to study central hemodynamics (HR, SV, CO, SVR) with application of standard medical method of tetrapolar chest reography (impedance cardiography).

Blood pressure (BP) was measured manually using mechanical aneroid sphygmomanometer and a quality stethoscope (MDF ® Calibra Professional Aneroid Sphygmomanometer and Stethoscope). Resting blood pressure (BP) was measured 3 times in the seated position. The average of the 3 readings was used for the representative examination value. The measurement was performed under controlled conditions in a quiet room. The cuff of the blood pressure monitor was placed around the upper right arm.

The heart beat while resting was measured by 60-s count, maximum heart rate was determined by the formula:

HR_{max} = 220 beats/min − age.

It is a simple step-test that uses a step bench that is 40 cm high for males. Subjects exercise with a step frequency of 22.5 steps per minute under the metronome for 6 minutes. Aerobic capacity was expressed as estimated maximal oxygen consumption (VO_{2max}), obtained using the step-test and the Astrand-Ryhming nomogram from the steady state heart rate (HR) and workload [1].

Statistical analysis. Descriptive statistics, a t-test for paired data was used to assess differences between pre- and post-tests in groups and independent t-test to assess differences between groups, P equal to or less than 0.05 was considered as the significance level. Data normality was checked with Kolmogorov – Smirnov test.

Results

General features and demographic characteristics of the participants are summarized in Table 1. Absolute values of central hemodynamic features of the participants are summarized in Table 2. After eight weeks the resting heart rate (HR) in the interval and control groups did not change significantly (P>0.05).The stroke volume (SV) increased significantly in the interval group after workload (P≤0.05). The cardiac output (CO) did not change significantly in both groups (P>0.05). The systolic blood pressure (SBP) in the interval group decreased significantly at rest and after workload (P≤0.05). The diastolic blood pressure did not change significantly in both groups (P>0.05). The systemic vascular resistance (SVR) in the interval and control groups did not change significantly (P>0.05). The maximal oxygen consumption absolute and relative (VO_{2max} absolute, VO_{2max} relative) increased significantly in the interval group (P≤0.05). Significant difference were observed between groups in SV, CO, VO_{2max} absolute and VO_{2max} relative (P≤0.05).

Discussion

In the present study, HR decreased no significantly in the interval group after 8-weeks training in rest and after workload. Meyer et al. [26] observed increase in the HR, on the other hand, Rodrigues et al. [36] showed decrease in HR after aerobic training. SV increased in rest and workload but was significantly in workload. Aerobic

Table 1. General characteristics of the subjects

Variables	Interval training	Control group
Age (year)	18,5±0,5	18,2±0,2
Height (cm)	175,9±5,1	176,2±4,5
Weight (kg)	69,2±6,1	71,8±3,84

Table 2. Absolute values of central hemodynamic features in the interval and control groups

Variables	Groups	Interval		**Control**	
	Status	Before training	After 8-weeks training	Before training	After 8-weeks
HR, beats.min^{-1}	Rest	68,2±6,5	66,2±3,7	71,3±7,5	68,3±5,4
	Step-test	135,2±11,2	124,0±8,5	132,2±20,7	127,0±24,2
SV, ml	Rest	81,2±19,2	89,1±22,1**	78,3±22,3	80,5±21,7
	Step-test	70,3±18,1	84,1±14,9*	72,4±14,3	77,5±16,2
CO, l.min^{-1}	Rest	5,6±0,7	5,8±0,8	5,7±1,4	5,5±0,9
	Step-test	9,3±1,8	10,5±1,4	9,8±1,9	9,8±1,6
SBP, mmHg	Rest	128,7±6,2	115,3±4,2*	121,6±2,8	120,0±5,7
	Step-test	158,5±14,0	140,3±5,9*	150,0±10,0	140,0±17,3
DBP, mmHg	Rest	78,7±2,18	75,0±5,0	78,5±7,4	76,6±2,8
	Step-test	76,8±8,9	69,8±8,1**	81,6±2,9	77,1±9,5
SVR, dynes·sec·cm^5	Rest	1056,2±109,3	1007,8±107,8	1107,8±114,9	1061,7±120,2
	Step-test	1026,8±126,1	927,0±104,5	1065,9±120,3	1032,5±127,8
VO_{2max} absolute, l.min^{-1}	Step-test	4,1±0,6	4,7±0,5*,**	3,6±1,1	3,7±0,7
VO_{2max} relative, ml.kg^{-1}.min^{-1}	Step-test	52,6±8,8	62,9±6,3*,**	48,1±10,9	51,4±11,5

Note: Significantly different than before training at statistical level: * in groups, ** between groups – P≤0.05

exercise for a long time can affect the parasympathetic nerve, thus increasing SV and reducing the resting HR [3, 5, 35]. Increase in SV due to increases in ventricular end-diastolic volume and due to reductions in end-systolic volume [31]. CO increased in rest and workload but did not significantly. Regular training is associated with central and peripheral cardiovascular adaptations that help the generation of a large and sustained cardiac output and a large stroke volume [2, 33]. Increase in SV at workload demonstrates adaptation of cardiovascular system participants after 8-weeks interval training and increase efficiency heart function alongside a decrease in HR and stronger heart contractions leads to increase CO. After 8-weeks SV interval group was significantly higher than control group.

After 8-weeks interval training SBP significantly decreased, DBP decreased no significantly in rest and workload. Kelley GA et al. [22] reported reductions in resting systolic and diastolic blood pressure 3.3 mm Hg in normotensive, 5.4 mm Hg in borderline hypertensive, and 10,8 mm Hg in hypertensive individuals after aerobic training. Tjonna et al. [41] investigated that the intensity aerobic interval training reduces SBP and DBP in healthy men. Park et al. [32] showed significantly decrease in systolic blood pressure after aerobic exercise. On the other hand, some researchers noted no significant changes in blood pressure after aerobic exercise [17, 37]. After 8-weeks DBP interval group was significantly less than control group.

Mean arterial blood pressure increases in result of dynamic exercise, largely owing to an increase in systolic blood pressure, because diastolic blood pressure remains at near-resting levels. Increase in mean arterial pressure results from an increase in cardiac output and decrease in total peripheral resistance [9, 34]. The mechanism in which exercises have effect on blood pressure is different depending on exercise intensity, time, and exercise types, but it is known that blood pressure is decreased due to decreased activity of sympathetic nervous system and decreased peripheral resistance [7]. That confirmed with decrease in SVP at rest and after workload.

After 8-weeks interval training VO_{2max} (absolute and relative) increased significantly in rest and workload. Gormley SE et al. [17] in study on sixty-one healthy young adult were randomly assigned to (moderate, vigorous , near-maximal-intensity) aerobic training groups, showed increase the VO_{2max} significantly in all exercising groups by 7.2, 4.8, and 3.4 ml.min^{-1}.kg^{-1}. Mazurek K et al. [24] reported aerobic interval training resulted in a significantly greater improvement in VO_{2max} absolute and VO_{2max} related than in continuous aerobic training in college females. Tjonna et al. [41] showed the intensive endurance training significantly improves VO_{2max} after 10-week of training in healthy men.

During exercise in untrained subjects oxygen consumption reach maximal values of 30–50 ml·kg^{-1}·min^{-1}. The variability of VO_{2max} is due to the body composition, level of training, blood volume, hemoglobin mass, stroke volume and genetic factors. With intense aerobic training, healthy men can get a VO_{2max} near 60 ml·kg^{-1}·min^{-1}. In elite male endurance athletes, a VO_{2max} in the 70–85 ml·kg^{-1}·min^{-1} range reported [20, 43]. Previous studies indicated that aerobic interval training improves VO_{2max} by improving cardiac function [45]. Improvements in VO_{2max} in interval training resulted by the improvements in cardiac output and more specifically stroke volume [6, 19]. Trilk et al. [42] demonstrated that interval training improved cardiac function by reducing HR and increasing SV. The initial level of aerobic fitness has a significant influence on the magnitude of improvement, since sedentary individuals achieve greater positive changes compared to athletes. In our study after 8-weeks interval training VO_{2max} increased significantly alongside a reduction in HR and elevated SV. After 8-weeks VO_{2max} in interval group was significantly higher than control group.

Conclusion

The present study demonstrated that eight weeks aerobic interval jogging increases VO_{2max} and stroke volume and reduces blood pressure and systemic peripheral resistance. The author recommends comparing the effects of low-intensity and high-intensity Interval training in project to obtain more accurate results. For people with a low level of fitness, low-intensity interval training as a procedure to increase the performance of the cardiovascular system is recommended. In general, eight weeks aerobic interval jogging can cause central hemodynamics adaptation in healthy male students at rest and workload.

Conflict of interests

The author declares that there is no conflict of interests.

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