

# THE EFFECT OF AEROBIC CONTINUOUS AND INTERVAL TRAINING ON LEFT VENTRICULAR STRUCTURE AND FUNCTION IN MALE NON-ATHLETES

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**ABSTRACT:** Exercise plays an important role to improve cardiovascular performance. The aim of this study was to compare the effect of aerobic continuous and interval training on the left ventricular structure and function. Twenty untrained healthy male students (aged 18-22 years) were randomly divided into two groups: continuous (C; n=10) and interval (I; n=10). The training programme consisted of countryside jogging for 45 min during 8 weeks three times a week at 70% of maximum heart rate (MHR). In each session group C was jogging for 45 min and in group I jogging was performed in 5 nine-minute stages with a four-minute inactive rest between them. M-mode, 2-dimensional, colour and Doppler transthoracic echocardiography were performed, during resting conditions, before and after the training period. After 8-week training the end diastolic diameter, systolic blood pressure and diastolic blood pressure in groups C and I, and the posterior wall thickness and the end systolic diameter in group I showed no significant difference ( $P>0.05$ ). On the other hand, the percentage of ejection fraction and shortening fraction in groups C and I, the end systolic diameter and the posterior wall thickness in group C and the interventricular septum thickness in group I demonstrated a significant difference ( $P\leq 0.05$ ). Comparing the two groups, only the value of the interventricular septum thickness was significant ( $P\leq 0.05$ ). In general, eight-week aerobic continuous and interval training can affect left ventricular structure and function.

**KEY WORDS:** echocardiography, left ventricle, healthy male, aerobic exercise

## INTRODUCTION

Physical activities depend on the performance of the body organs, including the cardiovascular system. With regular and prolonged exercise, the heart undergoes changes. These changes constitute the cardiac adaptability in response to physical training or some physiological causes. Several studies have shown that structural and functional changes in the left ventricle during exercise are greater than in other parts of the heart [9,11,21]. These changes constitute the cardiac adaptability phenomenon following the physiological, in contrast with pathological, changes brought about by hypertension and aortic stenosis [13]. Continuous, long-term physical activities exert an overload on cardiac muscles, resulting in an exogenous hypertrophic pattern with normal ventricular walls and increased ventricular (especially left ventricular) volume [7,20]. The impact of physical training on cardiac structure and function depends on the type, intensity and duration of training, as well as previous physical fitness, genetics and gender [4,6].

Warburton et al. [22] showed that the method of intensive interval training has a health-improving effect on the cardiovascular system in patients with coronary heart disease. Sharma et al. [17] in-

vestigated the physiological limits of left ventricular hypertrophy in elite junior athletes. They demonstrated that the left ventricular posterior wall thickness in the group of athletes was significantly increased compared to the untrained subjects. Dibello et al. [3] investigated the effect of endurance exercises on the structure of the LV of marathon runners and untrained subjects. The research results showed no significant difference between the end diastolic LV sizes in both groups. However, the thickness of the interventricular septum and posterior wall of the LV in the groups showed significant differences. Pluim et al. [14] studied the hearts of 1451 athletes and concluded that the absolute average thickness of the posterior wall of the left ventricle and the interventricular septum in the control group is significantly lower than in the resistance, endurance, or concurrent training groups. Also, the thickness of the left ventricle, the interventricular septum and the posterior wall is the greatest in the power group. Wisloff et al. [25] reported that after 12 weeks of aerobic moderate continuous training and aerobic intense interval training, left ventricular ejection fraction of cardiac patients increased. Tjonna et al. [19] found that aerobic interval and 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. [1] investigated the acute effects of continuous and interval aerobic exercise on 24-h ambulatory blood pressure in long-term treated hypertensive patients. They observed a decrease in mean 24-h systolic and diastolic blood pressure.

In the study low intensity training was used (60–80% of MHR), because this training method is much easier for untrained persons to carry out than a high intensity training programme and can help improve the quality of life of patients with heart failure. In addition, such a training method is more often used for endurance development in people who do not identify themselves as professional athletes and use physical activity to achieve or maintain an adequate level of physical fitness. Low intensity training is the most appropriate and the least dangerous type of physical load to maintain an optimal state of health of an individual. Considering the limitations in studying continuous and interval training with low intensity, the present study was designed to assess their effects on the left ventricular structure and function of untrained healthy males.

## MATERIALS AND METHODS

**Subjects.** Twenty non-athletic male students of the Azad Islamic University of Birjand (Iran) took part in the study. The study protocol was approved by the research ethics committee of Payame Noor University of Tehran and each participant gave informed consent before enrolment. The students were 18 to 22 years old, were not professional athletes and did not have any sports category. The criterion for cardiovascular health was the data obtained from the questionnaire devised by the researcher. Subsequently, the subjects' ECGs were studied to confirm their cardiac health. 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. Then they were randomly assigned to 2 training groups: continuous and interval.

### Training programmes

Eight-week training programmes were designed for each group including countryside jogging. The heart rate (HR) was 70% of the maximum heart rate (MHR).

The group engaged in the continuous training programme at each session carried out 45 minutes of jogging without a break. The group engaged in the interval training programme carried out jogging in 5 stages, 9 minutes each, 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.

### Measuring cardiac structural and functional variables

The echocardiography method was used in order to determine the morphometric parameters of the left ventricle in subjects under study. Ultrasound examination was carried out before and after con-

tinuous and interval training at rest. In the examination, the subjects were asked to assume the left lateral decubitus position and the optimal images of heart chambers were chosen to measure left ventricular end diastolic diameter (LVEDD mm), left ventricular end systolic diameter (LVESD mm), interventricular septum thickness (IVST mm) and posterior wall thickness (LVPWT mm). The thickness of walls was measured in the diastolic phase of the cardiac cycle.

Myocardial contractility was assessed according to the following criteria: ejection fraction (%) and shortening fraction (%).

These variables were measured at the echocardiography ward in the Birjand Vali-asr Hospital by a cardiologist. Echocardiographic examination was carried out on an Esaote Biomedica unit (Italy) with application of M-modal, two-dimensional colour and Doppler trans-thoracic echocardiography [6,10].

The heart beat while resting was measured by 60-s count and blood pressure was measured with mercury blood pressure devices of Richter model no more than 2 times with 2–3-minute intervals on the right hand with the subject in the sitting position. In addition, the subjects under examination were warned not to drink coffee three hours before the test, and to avoid strenuous exercises one hour prior to it. Systolic blood pressure (SBP, mm Hg) and diastolic blood pressure (DBP, mm Hg) were recorded.

In the study the students' anthropometric data were taken into consideration (height, cm; weight, kg). The subjects were not significantly different in terms of weight and height before the study. Maximum heart rate was determined by the formula:  
 $HR_{max} = 220 \text{ beats/min} - \text{age}$ .

### Statistical method

For the analysis of research findings, we used SPSS-11.5 software and appropriate descriptive statistical methods such as Kolmogorov–Smirnov test for the identification of similarity and normality of information related to subjects, and after making sure of normality of data, we used the dependent t-test for statistical analysis; a P value equal to or less than 0.05 was considered as the significance level.

## RESULTS

General features and demographic characteristics of the participants are summarized in Table 1. Absolute values of left ventricular structure and function features of the participants are summarized in Table 2. The left ventricular end diastolic diameter of the continuous and interval groups did not change significantly after training ( $P > 0.05$ ). The end systolic diameter decreased significantly in the continuous group ( $P \leq 0.05$ ). The interventricular septum thickness decreased significantly in the interval group ( $P \leq 0.05$ ).

**TABLE 1. GENERAL CHARACTERISTICS OF THE SUBJECTS**

Groups	Number	Age (years)	Height (cm)	Weight (kg)
Continuous	10	20.5 ± 1.58	174.2 ± 6.40	72.65 ± 9.19
Interval	10	20.7 ± 1.05	173.8 ± 5.57	72.48 ± 7.51

**TABLE 2.** ABSOLUTE VALUES OF LEFT VENTRICLE STRUCTURAL AND FUNCTIONAL FEATURES IN THE CONTINUOUS AND INTERVAL GROUPS

Variables	Continuous		Interval	
	Before	After	Before	After
LVEDD (mm)	48.76 ± 4.7	49.4 ± 3.95	46.36 ± 3.97	46.28 ± 5.75
LVESD (mm)	32.37 ± 2.82	29.21 ± 4.52 **	31.87 ± 3.33	28.54 ± 4.54
IVST (mm)	9.86 ± 1.84	10.12 ± 1.89	10.11 ± 0.9	8.14 ± 1.52 **
PWT (mm)	7.08 ± 1.16	8.0 ± 1.42 *	7.18 ± 0.6	7.0 ± 1.13
FS (%)	33.5 ± 5.1	40.2 ± 5.8 ***	31.3 ± 4.5	37.5 ± 3.2 **
EF (%)	61.6 ± 6.8	70.1 ± 7.0 ***	59.5 ± 5.2	67.3 ± 4.2 **
SBP (mmHg)	120 ± 11.8	116 ± 11.7	112 ± 10.1	112.5 ± 11.4
DBP (mmHg)	74 ± 8.2	71.5 ± 9.9	70 ± 9.7	71 ± 9.4

Note: Significantly different than before training at statistical level: \* – P≤0.05, \*\*\* – P≤0.01, \*\*\*\* – P≤0.001

The posterior wall thickness increased significantly in the continuous group (P≤0.05). Increase in the percentage of ejection fraction and shortening fraction was significant in both groups (P≤0.05). Changes in the systolic blood pressure and diastolic blood pressure were not significant in both groups (P>0.05). A significant difference was observed only in the interventricular septum thickness among the groups (P≤0.05). There was no significant difference among the groups in other parameters (P>0.05).

## DISCUSSION

In the present study, the left ventricular end diastolic diameter did not change significantly following continuous and interval training. Plum et al. [14] did not observe significant differences in the end diastolic diameter between athletic and control groups. The end systolic diameter decreased in groups, but was significant only in the continuous group (P≤0.05). Decrease of left ventricular systolic diameter after aerobic training may indicate a decrease in residual blood volume in the left ventricle after systole and a volume overload in the left ventricle [12].

Thus the effect of continuous and interval training programmes of jogging on the heart is expressed in the overload of its chambers by the flowing blood resulting in the same increase in the diameter of the cavities, especially of the left ventricle, and in the increase of the relative wall thickness [15,21]. Hence the significant increase in posterior wall thickness and no significant change in interventricular septum thickness in the continuous group is probably due to an increase in the left ventricular mass index, which can be regarded as an adverse precursor of left ventricular hypertrophy. After 8 weeks of interval training, there was a significant decrease in the thickness of the interventricular septum without a significant decrease in the left ventricular contractility function and in the thickness of its posterior wall. Perhaps this is due to the rapid filling of the left ventricle during the diastole phase and delayed diastolic decrease. D'Andrea et al. [2] and Somauroo et al. [18] reported a significant difference in the thickness of cardiac walls between athletes and control groups. The short duration of the training programme im-

peded the development of obvious structural modifications. Wernstedt et al. [23] and Somauroo et al. [18] observed significant differences between athletes and control groups. On the other hand, Sanjay [16] did not report significant structural changes in the heart. These differences may be due to longer duration of training, type of training, history of training in subjects, different statistical populations, and the psychological stress level of subjects.

As a result of the continuous and interval training programmes of jogging, the following left ventricular indices of myocardial contractility underwent significant changes: percentage of shortening fraction (FS%) and percentage of ejection fraction (EF%). An increase in both parameters was noted. Foster et al. [5] observed a significant increase in percentage of shortening fraction. Wisloff et al. [25] observed a significant increase in percentage of ejection fraction.

The significant increase in the percentage of shortening fraction and percentage of ejection fraction could be due to the decreased left ventricular end systolic diameter after training and as a response to the increase in stroke volume. Thus, increase in the percentage of shortening fraction of the left ventricular muscle fibres indicated an increase in the volume of blood pumped by the left ventricle at each left ventricular contraction. This indicates the superiority of left ventricular function after exercise.

A decrease in systolic and diastolic blood pressure in the continuous group was seen, and at the same time an increase in systolic and diastolic blood pressure in the interval group was observed, but none of these changes were significant. Tjonna et al. [19] and Ciolac et al. [1] noted a decrease in systolic and diastolic blood pressure after training. The lack of change in systolic and diastolic blood pressure variables in this study may be due to insufficient long training.

In this study, apart from the interventricular septum thickness, the changes in structural parameters of the left ventricle were not significant among the groups. On the other hand, the changes in left ventricular function parameters were not significant among the groups.

An 8-week training programme with the above-mentioned intensities does not provide sufficient stimulus for such modification of

left ventricular structure, but it is a stimulus for improving the function of the left ventricle (particularly the LV myocardial contractility). However, the change in LV structure and function could be connected with increased preload, decreased afterload and unchanged or slightly increased contractility of LV myocardium. Overall, these contradictory results are probably due to differences in training duration, methods, subjects, experience, ethnicity, and gender.

It may be suggested that athletes who do resistance activities should do more aerobic training to prevent abnormal function of the left ventricle. Athletic trainers can also prevent excessive fatigue in continuous training by using interval training for their athletes.

Since the study is quasi-experimental and the subjects were not available full time for the researcher, the results could be affected by external factors. Therefore, it is recommended to avoid interference of external factors during the whole experimental study. For greater effectiveness, the training programme could be conducted for a longer duration.

## CONCLUSIONS

The results of this study indicate that the heart (particularly the left ventricle) enlarges following aerobic training. It seems that this enlargement not only hinders cardiac function, but also enhances it. Changes in the thickness of the myocardium interventricular septum in the interval training group and in the posterior wall thickness in the continuous training group represent heart adaptations to excessive stress caused by application of these training programmes. Significant increase in the parameters of cardiac contractile function suggests that jogging in accordance with continuous and interval training programmes favours cardiac muscle strengthening. Both training programmes have similar effects on myocardial contractility.

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## REFERENCES

- Ciolac E.G., Guimaraes G.V., D'Avila V.M., Bortolotto L. A., Doria E. L., Bocchi E. A. Acute effects of continuous and interval aerobic exercise on 24-h ambulatory blood pressure in long-term treated hypertensive patients. *Int. J. Cardiol.* 2009;133: 381-387.
- D'Andrea A., Limongelli G., Caso P., Sarubbi B., Pietra A.D., Brancaccio P. et al. Association between left ventricular structure and cardiac performance during effort in two morphological forms of athlete's heart. *Int. J. Cardiol.* 2002;86:177-184.
- Dibello V., Lattanzi F., Lunardi L. LV performance and ultrasonic myocardial quantitative reflector in endurance senior athletes. *Eur. Heart. J.* 1993;14:358-363.
- Dumanoir G.R., Haykowsky M.J., Syrotuik D.G., Taylor D.A., Bell G.J. The effect of high intensity rowing and combined strength and endurance training on left ventricular systolic function and morphology. *Int. J. Sports Med.* 2007;28:488-494.
- Foster C., Meyer K., Georgakopoulos N., Ellestad A.J., Fitzgerald D.J., Tilman K., et al. Left ventricular function during interval and steady state exercise. *Med. Sci. Sports Exerc.* 1999;31:1157-1162.
- Gates P.E., Tanakaa H., Graves J., Seals D.R. Left ventricular structure and diastolic function with human ageing. Relation to habitual exercise and arterial stiffness. *Eur. Heart. J.* 2003;24:2213-20.
- Goodman J.M., Liu P.P., Green H.J. Left ventricular adaptations following short term endurance training. *J. Appl. Physiol.* 2005;98:454-460.
- Hildick-Smith D.J., Shapiro L.M. Echocardiographic differentiation of pathological and physiological left ventricular hypertrophy. *Heart* 2001;85:615-619.
- Hosseini M., Piri M., Agha-Alinejad H., Haj-Sadeghi Sh. The effect of endurance, resistance and concurrent training on the heart structure of female students. *Biol. Sport* 2012;29:17-21.
- Luthra A. *Echo made easy.* Dehli Press, New Dehli 2005.
- Middleton N., Shave R., George K., Whyte G., Hart E., Atkinson G. Left ventricular function immediately following prolonged exercise: A meta-analysis. *Med. Sci. Sports Exerc.* 2006;38:681-687.
- Oakley D. *The athlete's heart.* BMJ Publishing Group Ltd & British Cardiovascular Society 2001;86:722-726.
- Pelliccia A., Maron B.J., Culasso F., Spataro A., Caselli G. Athlete's heart in women: echocardiographic characterization of highly trained elite female athletes. *JAMA* 1996;276:211-215.
- Pluim B.M., Zwiderman A.H., Van der Laarse L.A., Van der Aar V., Wall E.E. The athlete's heart a meta-analysis of cardiac structure and function. *Circulation* 2000;101:336-344.
- Rawlins J., Bhan A., Sharma S. Left ventricular hypertrophy in athletes. *Eur. J. Echocardiogr.* 2009;10:350-356.
- Sharma S. The athlete's heart; effect of age, sex, ethnicity and sporting discipline. *Exp. Physiol.* 2003;88:665-669.
- Sharma S., Maron B.J., Whyte G., Firoozi S., Elliott P.M., McKenna W. J. Physiologic limits of left ventricular hypertrophy in elite junior athletes: Relevance to differential diagnosis of athlete's heart and hypertrophic cardiomyopathy. *Am. J. Coll. Cardiol.* 2002;40:1431-1436.
- Somauro J.D., Pyatt J.R., Jackson M., Perry R.A., Ramsdale D.R. An echocardiographic assessment of cardiac morphology and common ECG finding in teenage professional soccer players. *Heart* 2001;85:649-654.
- Tjonna A.E., Lee S.J., Rognmo O., Stølen T.O., Bye A., Haram P.M., et al. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome. *Circulation* 2008;118:346-354.
- Vencunans T., Raugaliene R., Jankauskiene E., Tomas V., Rasa R.A., Edita J. Structure and function of distance runners' heart. *Medicina (Kaunas)* 2005;41:685-692.
- Vitartaite A., Vainoras A., Sedekerskiene V and Poderys J. The influence of aerobics exercise to cardiovascular functional parameters of 30-40 year old women. *Medicina (Kaunas)* 2004;40:451-458.
- Warburton D.E., McKenzie D.C., Haykowsky M.J., Taylor A., Shoemaker P., Ignaszewski A. P. et al. Effectiveness of high-intensity interval training for the rehabilitation of patients with coronary artery disease. *Am. J. Cardiol.* 2005;95:1080-1084.
- Wernstedt P., Sjostedt C., Ekman I., Du H., Thuomas K.A., Areskog N.H. et al. Adaptation of cardiac morphology and function to endurance and strength training. A comparative study using MR imaging and echocardiography in males and females. *Scand. J. Med. Sci. Sport.* 2002;12:17-25.
- Whyte G.P., George K.P., Nevill A.M., Shave R., Sharma S., McKenna W.J. Left ventricular morphology and function in female athletes: A meta-analysis. *Int. J. Sports Med.* 2004;25:380-383.

25. Wisloff U., Stoylen A., Loennechen J.P., Bruvold M., Rognmo O., Haram P. M. et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: A randomized study. *Circulation* 2007; 115:3086-3094.