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ORIGINAL ARTICLE

The Effect of Muscular Endurance interval Training on some Cardiovascular Markers in Trained runners

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ABSTRACT
The potential role of training on cardiovascular physiological markers improvement is frequently reported. Although the main mechanism involved in these changes is not understood well. This study determined the effect of one period of muscular endurance interval training on cardio-respiratory function and some physiological structures in the cardiovascular system of a group of people. To do so, 20 young men (mean age=19 & mean weight=78Kg) voluntarily participated in this study. They were randomly divided into two control and exercise (muscular endurance interval training) groups. Two-dimensional echocardiogram with Doppler was applied to measure the structural and functional variables of heart. Statistical data was analyzed using T-independent test and correlated t-test. Administering eight weeks of muscular endurance interval training significantly affected the research variables (p<0.05). That is, following variables were maximally affected: Maximal Oxygen Consumption (VO2max), Maximal Aerobic Speed (MAS), Anaerobic Threshold Speed (ATS), runners' ejection fraction percentage and record. Based on these results, it is concluded that using muscular endurance interval training is potentially important in improving cardiovascular physiological parameters.
Keywords: *Cardiorespiratory Function and Structure, Interval Training, Maximal Oxygen Consumption (VO2max)*

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INTRODUCTION

The advance of sport records, techniques, and tactics during the last century indicates the expansion of sport instructors and researchers' scientific knowledge and awareness. Sport physiological experts test several training schedules to set minimum and maximum stimulations affecting the improvement of athletes' performance; because besides hereditary factors – workout routines and methods also play a determining role in athletic performance. Yet, the desirable extent of workout for the best performance is barely known [1]. Success in sport performance is concerned with various factors. Exercise is considered a main part of it [2]. Aerobic interval training is among the most conventional training methods for improving strength performance in pre-competition season. Some physiological consistencies usually occurring after a period of aerobic interval training include blood lactate concentration decrease, pulmonary ventilation, oxygen consumption, and heart rate in a certain intensity of activity [3]. Apparently, there is a minimum intensity in these exercises. Apart from the volume of the workout, any exercises with a lower intensity will not affect strength performance so much in exercised individuals. However, continuous exercises also play an important role. According to Lavender (2002), continuous exercises may also increase Vo2max, capillary density, oxidative enzymes activity, and plasma volume in non-exercised individuals. Yet, it cannot improve exercised people' performance. These individuals respond interval exercises well [4]. On the other hand, the effect of strength training on strength performance is an issue regarded in the recent years. However, they are not usually applied for endurance runners. It seems that over %50 of Vo2max is not involved in these exercises. Yet, some evidence shows that adding strength exercises to aerobic workout plan has a positive effect on endurance

athletes' performance by changing physiological pressures decrease [5, 6, 7]. Hence, the main part of physiological differences in elite and elementary endurance athletes' performance depends on the exercise methods applied [8].
Results show that minimum physiological needs for endurance athletes' successful performance whose activity lasts more than a few minutes include high Vo2max, the ability to continue activity for a long time at Vo2max level (Tmax), high anaerobic strength and ventilatory anaerobic threshold (VAT), and motion efficiency [9]. Several studies have reported the improvement of Vo2max, vVo2max, Tmax, and Vat after various exercises [10]. Driller *et al*. (2009) studied the effect of high-intensity interval exercise on exercised sailors. They stated that four weeks of HIT further improved 2000m time trial and Vo2 Peak in race sailors. Then, it is a more effective method [11]. On the other hand, the effect of strength exercises on unexercised individuals showed that, after a training period, no significant change was seen in Vo2max. Similar results were also obtained in exercised individuals. The resulting data indicates that, probably, strength exercises did not improve cardio-respiratory parameters [7]. There is evidence indicating that heart rate must be kept at HRmax%60 for at least 20min in order for creating changes in cardio-respiratory consistencies [12]. For instance, Marsi Nick *et al*. reported Vo2max increase after 9-16 weeks of weight training by station method. It is likely resulted from the fact that individuals act with HRmax%85 [13].
On the other hand, structural and functional changes in athletes' heart are especially made in left ventricular. Nevertheless, the accurate effects of workout on the structure and function of heart depend on type, intensity, duration, basic physical preparation, heredity, and gender [14]. Austin *et al*. (2002) results show that blood circulation system undergoes further pressure during [8]circular strength training. It can lead to morphological consistencies in the left ventricular. They are probably different from correspondences induced by aerobic exercises [15]. Alkarez *et al*. (2008) also stated that heart pressure is considerably further in HRC training method. Hence, the above method can be an appropriate training approach for both increasing strength and cardiovascular correspondences [16]. Adler *et al*. (2008) studied the diastolic performance of the left ventricular in exercised male weight lifters. They concluded that high-intensity trainings lead to the improvement of left ventricular diastolic performance. It is due to the significant increases in left ventricular mass [17]. Astorinov *et al*. (2012) examined the effect of high-intensity interval training on cardiovascular performance. They state that HIT exercises effectively improved cardio-respiratory parameters in active men and women [18]. Hoseini *et al*. (2007) examined the effect of endurance, strength, and combined exercises on the structure of university girls. They found out that training schedule did not make any significant changes in the structural variables of heart [14]. A glance at the previous studies show that the useful effects of continuous aerobic exercises on the physiological parameters are frequently reported [4]. Yet, studies on cardiovascular physiological responses or correspondences are limited to muscular endurance interval exercises. Thus, the present study measures the effect of a period of muscular endurance interval exercises on these physiological factors in exercised men.

Research Method

The statistical population of the study consisted of all active runners in Tehran Track and Field Board. They attended endurance running exercises for at least three and at last six months. Twenty candidates were qualified. They were randomly placed in two endurance interval (n=9) and control (n=9) groups. The placement was done based on [10]one mile record; given that all strong, medium, and weak groups exist in each group.
Workout Protocol: Before pretest, the participants referred to laboratory for getting familiar with the laboratory, how to work with [11]analyzer gas, running on treadmill, [12]echocardiography, and [13]electrocardiography. They also learned how to work with weight and how to do interval circular strength exercise. They were asked to avoid intensive physical activity at least two days before the test. The participants were also asked to record their diet on diet recall forms so as to be repeated at the time of posttest.
Respiratory measurements: All measurements were done in the Physical Capabilities Evaluation and Measurement Base of Olympic National Academy. Vo2max was measured as follows: In a maximal test with 3min stages, the participant started moving on a treadmill. The basic device speed was 8km/h. Speed increased 1km/h in each stage. Vo2max was directly measured by the analyzer gas. Vat was determined as follows: ventilary break point time was computed based on two variables including time (intensity) and oxygen consumption. Then, treadmill speed was set based on the time of the point incidence. It was regarded to be the speed during which a person reached anaerobic threshold (Vat) [19]. To evaluate Tmax, the participants first did warm-up exercises for 15min. This stage included 5min

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treadmill activity with vVo2max%50, 5min stretching exercises, and again 5min treadmill activity with vVo2max%60. The speed was increased to vVo2max%80. It was increase as vVo2max in 15 seconds. From this moment until the end of the activity, time was measured by a chronometer [20]. The performance time of one mile (1609m) running was also recorded in a special track and field piste in a competitive form.

The measurements of one-repetition maximum (1RM): In strength exercises, a percentage of 1RM and performance speed was taken activity intensity. Performance duration was considered activity volume. Athletes attended eight weeks of exercises (three sessions a week). Based on the researcher's report, all participants (interval group (14260 ± 321.12) and control group (14000 ± 298.91)) weekly performed meter in their running plan. The following formula was used for determining 1RM (one-repetition maximum) individually and separately for each muscular group [21].

Clinical measurements: [19]General Electric (GE) Doppler 2D echocardiogram (VIVID3 made in U.S.A) was applied to measure the structural and functional variables of heart [22]. Resting heart rate was measured by General Electric electrocardiogram (MAC 500 made in U.S.A). Resting heart output was also obtained by the product of two factors including strike volume and resting heart rate [23]. At the end of the training period, the participants were asked to be in the laboratory and the place of recording after the last exercise session while meeting the pretest diet. All measurements were exactly repeated in the posttest stage.

Statistical analysis: Parametric tests were applied for statistical analyses. The normality of population distribution and data was examined by Kolmogorov-Smirnov test. Two groups' means were compared using independent and paired t-tests. The level of significance ($p<0.05$) was considered for all statistical analyses.

RESULTS

Eight weeks of muscular endurance interval exercises had a significant effect on the research variables. Yet, they did not have a significant effect on interventricular septum and Tmax. In sum, research results showed that strength interval exercises led to significant increases and changes in Vo2max ($F=5.71$, $P=0.009$), vVo2max ($F=13.87$, $P=0.000$), Vat ($F=3.93$, $P=0.033$), ejection fraction percentage ($F=11.32$, $P=0.000$), and 1mile record ($F=13.96$, $P=0.000$) variables in the exercised runners. Yet, there was no significant difference between the research groups regarding interventricular septum ($F=0.110$, $P=0.896$) and Tmax ($F=0.700$, $P=0.506$). Some of these results can be seen in Diagrams 1 to 5.

Table 1: Mean and standard deviation of anthropometrical markers of two groups

Anthropometrical index	Interval group	Control group
Age (year)	20 ± 3.76	19.5 ± 0.92
Height (cm)	186 ± 7.4	184 ± 3.01
Weight (kg)	78.5 ± 8.32	73 ± 9.99
Body fat (%)	12.9 ± 4.77	11.5 ± 4.44
BMI (kg/m2)	22.9 ± 1.88	21.14 ± 3.48

Table 2: The protocol of muscular-endurance interval training

Exercise stages	**Exercise stage**			**Active rest stage**			
Training weeks	**Intensity**	**speed**	**Time** (second)	**Intensity**	**speed**	**Time** (second)	**Time of each set** (min)
1	1RM %30	2V	10	1RM %30	½ V	20	3
2	1RM%30	2V	10	1RM%30	½ V	20	3
3	1RM%35	2V	10	1RM%35	½ V	20	3
4	1RM%35	2V	10	1RM%35	½ V	20	3
5	1RM%40	2V	10	1RM%40	½ V	20	3
6	1RM%40	2V	10	1RM%40	½ V	20	3
7	1RM%50	2V	10	1RM%50	½ V	20	3
8	1RM%50	2V	10	1RM%50	½ V	20	3

Table 3: Mean and Standard deviation of physiological markers in pre and post training of two groups

Variable	Interval group		Control group	
	Pre-training	Post-training	Pre-training	Post-training
HR rest (bpm)	68 ± 1	60 ± 2	68 ± 2	67 ± 1
VO2max (ml/kg/min)	51.2 ± 7.2	58.1 ± 8.4	49 ± 5.1	49.8 ± 4.6
vVO2max (km/h)	12.8 ± 0.87	14.7 ± 0.66	12.8 ± 0.94	13.1 ± 1.1
V at (km/h)	10.3 ± 1.22	14.6 ± 1.13	11.2 ± 1.8	13.2 ± 0.67
T max (s)	507 ± 212	547 ± 162	507 ± 117	510 ± 112
Stroke volume (ml)	69.4 ± 1.67	75.6 ± 2.01	69.2 ± 1.48	70.89 ± 1.45
Cardiac output (Lit/min)	4.75 ± 0.16	4.55 ± 0.11	4.73 ± 0.03	4.73 ± 0.05
Inter-ventricular septum (mm)	11.18 ± 1.82	12.08 ± 1.7	11.14 ± 1.83	12.44 ± 2.03
Left ventricular ejection fraction (%)	0.67 ± 0.05	0.76 ± 0.04	0.68 ± 0.05	0.67 ± 0.03
1 mile running (S)	405 ± 37	343 ± 36	414 ± 35	396 ± 27

DISCUSSION AND CONCLUSION

In the present study, eight weeks of muscular endurance interval exercises had a significant effect on Vo2max, vVo2max, and Vat. Regarding Vo2max, results of this study did not correlate with the results reported by researchers [24, 25]. Perhaps, this conflict was concerned with athletes' basic preparation level, the lower intensity of the exercises, and short duration and exercises volume (training protocol). Resulting data indicated that strength exercises with conventional methods used do not stimulate VO2max improvement on their own [7]. Rather, results reported a VO2max increase after 9-16 weeks of weight exercises by station method [13]. Results correlate with the findings of Many observers [3, 11, 13, 26, 27]. Probably, the reason behind this correlation goes back to Lavendfer's idea. He states that continuous exercises are effective for unexercised people. Yet, they cannot improve performance and increase VO2max in the exercised individuals. Thus, these athletes need higher intensity exercises to improve VO2max [3]. Driller [11] examined High Intensity Interval Training (HIIT) in exercised sailors for 4 weeks. Esfarjani [26] studied partial exercised men performed three different HIT protocols. They stated that performing these types of exercises improved VO2max further. Then, this is a more effective training method. It seems that the potential increase of VO2max is due to plasma volume increase or arterial-venous blood oxygen difference increase, motion efficiency improvement, and lactate threshold increase [5, 7]. Regarding vVo2max, results do not correlate with the results of Garsin *et al*. (2003) and Gharedaghi [25]. Garsin examines the effect of HIIT on the variables involved in the endurance performance of eight semi-endurance elite runners. No change was observed in vVO2max after interval exercises. These results may be due to runners' high preparation level and (or) the low intensity of the interval exercises [25].

Yet, in the present study, training protocol did not lead to any significant changes in Tmax. It did not correlate with the results reported [13, 24, 29]. As shown in Garsin [25], no changes were seen in Tmax after the interval exercises. Similarly, a study concerning the effect of six-week strength exercises on anaerobic capacity and Tmax indicated no significant changes in Tmax [28]. Researchers state that the results may be due to the low intensity of the interval exercises [25]. Some studies reported the priority of aerobic interval-strength interval exercises in creating significant Tmax changes in exercised runners. These researchers administered athletes' aerobic schedule in terms of HIIT. It likely states the importance of the influence of high intensity aerobic exercises on Tmax index [27].

Results of the present study showed that no significant changes were seen in interventricular septum after eight weeks of the exercises. It does not correlate with the results reported by Berland [29], and Barona *et al*. [30] [29, 30]. It was found out that strength exercise can increase the thickness of the left ventricular walls. Yet, it is not necessarily resulted from all strength training protocols. Rather, other factors such as athlete's talent, enduring or not enduring training turns up to concentric contraction disability threshold, and muscular mass size involved in the exercises can play a role in their success or failure [12]. On the other hand, the results of the present study correlate with the findings reported by James [16] and Hoseini 3[5]. James *et al*. [31] state that the intensity of strength exercises does not increase the thickness of the left ventricular wall.

Again, in the present research, it was demonstrated that administering eight weeks of interval exercises significantly increased the participants' ejection fraction percentage and strike volume. It corresponds and correlates with the results obtained by Adler *et al*. [19] and Fallah Mohammadi [36]. Adler *et al*. [17] state that high intensity strength exercises improved the ejection fraction percentage and diastolic performance of the left ventricle both in resting and training states. Injection fraction is almost used clinically as an index of heart pumping ability [32]. Studies have shown that the usual indices of systolic function (i.e. truncation fraction percentage and ejection fraction percentage) are not affected by strength exercises. Yet, it is reported that the truncation fraction percentage is significantly further in the exercised strength athletes as compared to normal participants [12]. Totally, it can be said that strength interval exercises created the ability to increase and make significant changes in the critical heart function index (i.e. the injection fraction of the left ventricle). It is probably due to the further influence of HIIT on the exercised individuals. Based on the results of this study, resting heart rate considerably decreased in both continuous and interval exercises groups. This influence was further in the continuance group as compared to the interval group. Based on scientific evidence and the existing resources, heart rate considerably decreased due to physical exercises [32].

Finally, it can be said that muscular endurance interval exercises had different effects on cardio-respiratory characteristics. Since the participants of this study were exercised non-elite people, the effect of the interval exercises on many variables is important. Hence, regarding the potential effect of the interval exercises on the improvement of cardiorespiratory characteristics and record, athletes and especially runners are recommended to place these exercises in their training and preparation schedules with respect to their own physical qualities and field.

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