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The effect of mode of training on VO_2 peak in obese/overweight men

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ABSTRACT

The aim of this study was to compare three modes of training on VO_2peak in obese/overweight men. Accordingly, thirty obese/overweight men were divided into three groups, high intensity interval training (HIT; n=10), continuous training (CON; n=10) and resistance training (RES; n=10). The training was performed three time per week for 12 weeks. The HIT group performed 6-10 × 1 min intervals at 85-95% maximal heart rate, each interval separated by 1 min active recovery. The continuous group exercised continuously at 60-70% maximal heart rate. The resistance training group performed three exercises for upper body, two exercises for lower body and one exercise for trunk that performed with 70-80% 1RM. Body weight and BMI significantly decreased in all groups. After 12 weeks, peak oxygen uptake significantly increased in all groups (HIT:10%, CON: 8% and RES: 7.4%)(all $P \leq 0.001$). When the improvement of VO_2peak adjusted on basis of weight changes, the maximum and minimum net increase observed in RES and HIT groups, respectively. There was no significant difference among groups. The results showed that all three types of trainings could be effective in improvement of VO_2peak, weight loss and BMI in obese/overweight men.

Key words: Interval training, resistance training, peak oxygen uptake, obesity

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INTRODUCTION

Low peak oxygen uptake, lack of exercise and overweight are risk factors for cardiovascular, hypertension and diabetes diseases [1-2]. VO_2max is the strongest independent mortality predictor among risk factors established in healthy people and those with cardiovascular disease [3-7]. It's shown that obesity is associated with low aerobic fitness [5, 6]. Previous studies reported that for a given BMI, subcutaneous and visceral fat mass levels, individuals with high cardiorespiratory fitness have lower metabolic risk compared with individuals with low cardiorespiratory fitness [1-3]. Also, high cardiorespiratory fitness is related to lower prevalence of diseases and all-cause mortality [1, 3, 7]. It is suggested that treatment of metabolic diseases should target aerobic capacity improvement rather than weight loss [6]. Hence, VO_2max improvement is necessary to reduce cardiovascular and other chronic diseases in obese/overweight men [1]. Regular physical activity is an effective strategy for improving cardiorespiratory fitness [3]. The ACSM recommended intensities between 40 to 85% VO_2max for improving cardiorespiratory fitness [8]. Also, most of previous studies of exercise on VO_2max regarded moderate intensity continuous training as the best strategy for cardiorespiratory fitness improvement [9, 10]. Continues training caused increase of VO_2max [7-11], improvement of heart and endothelial functions [4], enhancement of capillary density [11], decrease of resting heart rate, increase of fat metabolism [10] and increase of mitochondrial biogenesis markers [10-12]. Despite these helpful effects, continuous training involved high volume which often is unpleasant and tedious as well as time consuming. Since lack of time is the most important barrier to participate in physical activities [13], low volume HIT may represent an alternative to continues training in improving aerobic fitness.

Several groups have recently used HIT to develop cardiorespiratory fitness. The HIT alternates periods of high with periods at low intensities [11]. These programs are low volume and time efficient [13]. Some of the studies showed that high intensity interval training results in cardiovascular and metabolic adaptations similar to and/or even more

than traditional continuous training. Most studies have employed all-out repeated Wingate cycling test which may not be tolerable by obese/overweight individuals [1, 12, 15]. On the other hand, some studies used training protocols with lower intensities and long duration (2 to 4 minute) [2, 6, 7] that prolonged duration of high intensity periods may intolerable by obese individuals. According to our knowledge, only limited studies investigate effect of very low volume protocols on VO_2max.

Resistance training is another type of training which naturally differs from two aforementioned trainings. This training type does not involve body weight bearing for long times. Also, it is not as high intense as interval training. Resistance training increase resting energy cost with increase of muscle mass. Schjerve et al. reported that resistance training induced numerous physiological adaptations such as improve of VO_2max, promote in vascular endothelial function and increase of mitochondrial biogenesis markers, which some of them were similar to continuous and interval training [8].

Therefore, the present study examined effect of three different training programs (traditional endurance, low volume high intensity interval and resistance training) on VO_2peak in obese/overweight men. We also compared effects of these programs to highlight the most effective and applied training method to promote cardiorespiratory health.

MATERIALS AND METHODS

Subjects

A total of 30 healthy obese/overweight men took part in the study. The subjects were randomized to HIT (n= 10), CON (n= 10) and RES (n= 10) groups. Participants in all of the groups signed a written informed consent form. They completed a medical history questionnaire. The study was approved by the Islamic Azad University Ethics Committee. Inclusion criteria were included: 1) sedentary: physical activity level less than 2 sessions per week, 2) BMI between 25 to 32 kg/m^2, 3) not having hypertension, cardiovascular and respiratory diseases, 4) lack of history of metabolic and hormonal diseases, 5) no smoking and 6) no taking any medicine. All measurements were performed before (pre) and after (48 hours after last training session) 12 weeks intervention. The subjects in all groups performed training programs 3 times per week for 12 weeks. The physical characteristics of the subjects are presented in Table 1.

Study design

Anthropometric measurements

The height and weight of each subject was measured and recorded in nearest 0.1 m and 1 cm, respectively (seca, Germany). The BMI was calculated by dividing weight (kg) by square of height (m).

Familiarization

Since subjects were inactive, should first be got familiar with training protocols. A week before begin intervention, subjects made several familiarization visits to the laboratory to accustomed with the testing procedures and training devices. During the first visit, subjects under supervision of a sport physiologist performed an incremental test to exhaustion on a treadmill. Also, the participations of each group were accustomed with your training protocols. During the second visit, VO_2peak test was performed 72 hours before start of intervention.

VO_2peak test

Because many subjects cannot get to the actual Vo_2 plateau, the term VO_2peak was used. At baseline and after 12 weeks intervention, each subject completed a progressive maximal exercise test using Mercury laboratorial treadmill (h/p/cosmos mercury med, Germany) and online gas collection system (power cube, Ganshorn, Germany) to determine VO_2peak. Subjects warmed up for 10 min with voluntary speed (3-6 km/h) and incline (0-5 percent). Then, a face mask was placed on mouth and nose of subject. After warm up, treadmill incline and speed were set on zero and 5.3 km/h (3.3 mi/h), respectively. After first minute, the incline increased 2 percent per minute until subject reach to VO_2peak criteria. During the test, heart rate continuously recorded using a heart rate monitor (Polar, RS300, Finland). A plateau of VO_2 despite increased workload, a respiratory exchange ratio >1.05, an HR greater than or equal to age-predicted maximum and volitional exhaustion were used as criteria for reaching the VO_2peak.

Training protocols

Warm-up and cool-down

Before each exercise protocol, subjects were warmed up under a similar program. The warm up period includes a 5 minutes walking or jogging on a treadmill at 50% of VO_2peak. The exercise session was terminated by a 3 min low intensity jogging as cool-down period.

High intensity intermittent training (HIT)
Exercise training in HIT group was treadmill walking or running three times per week (Saturday, Monday, and Wednesday) for 12 weeks. Each training session consisted 60 s running at 85 – 95% of maximal heart rate followed by 60 s walking or jogging at 55 – 60% maximal heart rate (HRmax) for recovery. Subjects finished six high-intensity intervals during the first week, eight intervals during the second week, 10 intervals during the third to eighth weeks and 12 intervals on the final four weeks. Each session lasted about 20-24 minutes.

Continues training
Continues training protocol comprised continues treadmill walking/running at 55 – 70 % HRmax for 30 – 45 min. subjects performed 30 min walking/running at 55 – 60 % HRmax during the first two weeks. Over the 12 weeks period, then, intensity and duration of training were increased to 70 % HRmax and 45 min, respectively.

Resistance training
The resistance training program was designed on the basis of baseline 1RM in each exercise. The training included exercises to load major muscle groups performed at 70 – 80 % 1RM three times per week for 45-50 min per session. Subjects performed six multi joint exercises comprised three exercises for upper body (bench press, lateral pull, military press); two exercise for lower body (knee extension, leg press) and one exercise for trunk (crunch). In the first two week, training intensity was corresponding to 70% of 1RM. Then, resistance was increased by 5% in every 4 weeks. Finally, the intensity reached 80% of 1RM in last 4 weeks. Subjects performed four sets of 8-12 repetitions. The rest interval between sets was 60 seconds.

Statistical analysis
All data is presented as mean $\pm$ SD. Before using parametric tests, the assumption of normality was verified using the Shapiro – Wilk test. The two – way ANOVA was used to assess group-time interaction (3×2) with one between group factor (HIT, RES, CON) and one within group factor (pre vs. post-test). The Bonferroni post-hoc test was used to determine differences between groups. Significance level was set at $P \leq 0.05$. Data were analyzed by SPSS 16 software.

RESULTS

Subject characteristics
The data presented in Table1 is indicated that three groups did not differ significantly in any of parameters at baseline. No significant differences between three groups were indicated homogeneity of groups. No significant group – time interaction was observed in weight. Body weight was decreased by 7.9% ($p < 0.01$), 4.9% ($p < 0.02$) and 2.9% ($p < 0.05$) in HIT, CON, and RES groups, respectively (Figure 1), but no significant differences between three groups were observed. BMI was decreased by 2.4, 1.4 and 1 kg/m^2 in HIT, CON, and RES groups, respectively, But no significant differences between the groups was observed.

Table 1 Baseline characteristics of groups
Values are means ±SD.

Characteristics	Group				
	HIT	CON	RES	F	P
Age	30.8 ± 8.9	30 ± 6.1	29 ± 10	1.43	0.25
Height	176.2 ± 7.5	179.4 ± 5.1	175.8 ± 6.2	1.31	0.28
Body mass	92.5 ± 11	95.4 ± 18.3	90.2 ± 13.8	0.70	0.55
BMI	29.7 ± 1.5	29.5 ± 4.3	29 ± 2.7	0.42	0.73
VO_2peak (L.min^{-1})	3.2 ± 0.6	3.3 ± 0.7	3.0 ± 0.4	0.77	0.51
VO_2peak (ml. kg^{-1}. Min^{-1})	33.9 ± 3.8	35.8 ± 11	33.7 ± 4.5	1.57	0.21

VO_2peak
VO_2peak (L.min^{-1}) was significantly increased in CON ($p < 0.003$) and RES ($p < 0.029$) groups with no significant differences between groups (Table 2). In HIT group, however, VO_2peak (L.min^{-1}) remain unchanged. There was no significant group – time interaction for VO_2peak.

Relative Vo_2peak (ml. kg^{-1}. min^{-1}) was significantly increased in three training groups (all $p < 0.001$) (Figure 1). There was no significant group – time interaction in relative VO_2peak. No significant differences were found between groups. When VO_2peak changes corrected base on weight loss, net increase of VO_2peak in RES group (4.8 %) was higher than two other groups (1.8 and 3.2 % in HIT and CON groups, respectively).

Table 2 data for three groups before and after training
Values are means ± SD.

Variables	groups					
	HIT		CONTIN		RESIS	
.	Before	after	before	after	Before	after
Body mass(kg)	92.5 ± 11	85.2 ± 11.3**	95.4 ± 18.3	90.7 ± 15.1**	90.2 ± 13.8	87.4 ± 12.2*
BMI(kg/m^2)	29.7 ± 1.5	27.3 ± 1.9**	29.5 ± 4.3	28 ± 3.4**	29 ± 2.7	28.1 ± 2.1*
VO_2peak (L.min^{-1})	3.2 ± 0.6	3.2 ± 0.6	3.3 ± 0.7	3.5 ± 0.8*	3.0 ± 0.4	3.1 ± 0.3*
VO_2peak (ml. kg^{-1}. Min^{-1})	33.9 ± 3.8	37.2 ± 3.7**	35.8 ± 11	38.8 ± 10.9**	33.7 ± 4.5	36.3 ± 4.6**

Significantly differences between before and after training within groups ($P \leq 0.05$, ** $P \leq 0.002$)*

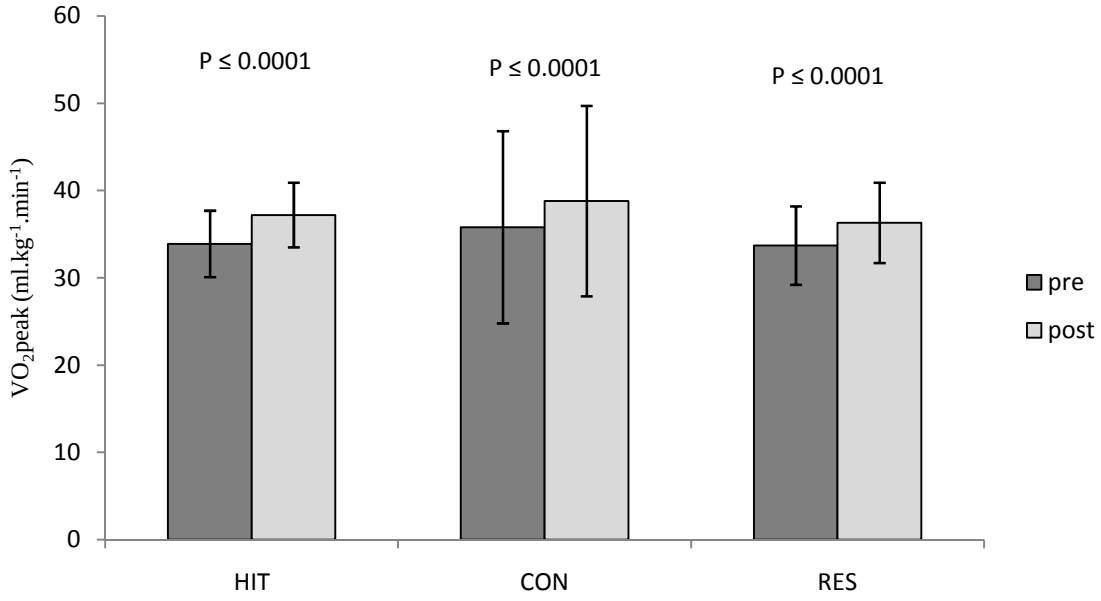

Figure 1 VO_2peak (ml.kg^{-1}. min^{-1}) before and after HIT, CONTI and RESIS. No significant differences between groups

DISCUSSION

The main findings of Present study are that both the Continuous endurance training and the resistance training improved VO_2peak. Additionally, 12 weeks training in three groups significantly reduced weight and BMI.

Since aerobic capacity reflects a continuum between health and cardiovascular-induced mortality [7], it is important to design effective training programs for improving VO_2peak in obese/overweight people. Studies showed that intensity and duration of exercise affected cardiovascular effects of training [4]. Our study is one of the few studies that investigate effects of three types of different training on VO_2peak in obese/ overweight subjects.

In the present study, VO_2peak (L.min^{-1}) significantly increased in both the continuous and resistance training groups, without any significant differences between groups. However, VO_2peak (L.min^{-1}) did not significantly changed in HIT group. Since body weight significantly decreased in all groups, therefore absolute VO_2peak (L.min^{-1}) could not reflect real variation of aerobic fitness. Therefore, relative VO_2peak (ml.kg^{-1}.min^{-1}) was used to show variations. Relative VO_2Peak significantly increased in all groups, but no significant difference was found between groups. When VO_2Peak changes corrected based on weight changes, yet there were no significant differences between groups. Net increase of VO_2peak in RES group was more than that in two other groups. The results of present study confirm results of previous studies [1,2,6,10,16,18], reporting significant improvements in VO_2peak after a variety of continuous, interval, resistance and combined (resistance and interval) trainings with no significant difference between trainings. Although all three training modes increased VO_2peak, mechanisms increasing VO_2peak may different in each training group. Traditional continuous training is the training which performed with moderate intensity and long duration. It has been suggested that improving VO_2max in response to continuous training is due to peripheral adaptations (muscle capability to oxygen uptake), while interval training increases VO_2max with both central and peripheral (hemodynamic) adaptations. It is suggested that continuous training mainly improved VO_2max by peripheral adaptations (capillary density and arteriovenous oxygen difference) [11]. Several studies showed that continuous training improves muscle oxidative capacity through increasing activity of oxidative enzymes such as cytochrome C oxidase and its subunits [10,12] as well as mitochondrial biogenesis factors such as

PGC-lα [10]. Since muscle oxidative capacity is one of the determinants of VO_2max, so the increase of VO_2peak in CON group could contribute to increase of muscle oxidative capacity.

It has been reported that intermittent training by increases of cardiac output, capillary density and arteriovenous oxygen difference improves VO_2max [11]. Also, the intensity of intermittent training could be another possible mechanism for improvement of VO_2peak in HIT group. High intensity interval training stresses type II muscle fibers [20, 21] leading to increase of activity of oxidative enzymes [20, 21], mitochondrial biogenesis factors especially PGC-1α [12], oxidative capacity [1, 12] and cross sectional area [22] of them. Since these fibers approximately constitute fifty percent of fibers within muscles in most people, this could be regarded as a mechanism to improve VO_2peak in response to interval training. Some evidence suggests that capacity of heart pumping (stroke volume) is the main limiting factor of VO_2max [14]. It has been shown that interval training increase stroke volume and improves vascular flow mediated dilatation [22].

Resistance training used in the present study includes large multi joint exercises. Because of involving large muscle mass, these exercises exert remarkable stress to cardiorespiratory system that in part explains increase of VO_2peak of RES group in the present study. Although underlying mechanisms of this adaptive response are not completely understood, some possible mechanisms could be presented for increases of VO_2peak in response to resistance training. Some of studies reported that resistance training increases lean body mass [24], muscle mass and capillary density [18] that all of which could help increases in VO_2peak. It is reported that resistance training improved endothelial function [24], which also probably increase blood delivering to muscles that could lead to improve VO_2peak. Local ischemia during resistance training is a considerable stimulus for improve aerobic metabolism. Resistance training, with restriction of blood flow, induces local hypoxia in active muscles [8]. Therefore, local Ischemia can also be considered as a possible mechanism for increase of VO_2peak after resistance training.

Another finding of present study was significant reduction of body weight and BMI in three groups. Although no significant difference was found between groups, reduction in weighs and BMI in HIT group was more than other two groups. This finding is consistent with the findings by Trapp et al. [25], who reported that high intensity interval training decreased body weight substantially. Remarkable effect of high intensity intermittent training on weight loss and body composition could be contributes to the following factors. It has been demonstrated that high intensity intermittent training does exert great load on trunk and leg musculature that increases fat consumption [25].

CONCLUSION

Present study showed that high intensity intermittent, traditional continuous and resistance training improve cardiorespiratory fitness in obese/overweight men. However, Resistance training compared to interval and traditional continues training created more improvement in VO_2peak in obese/overweight men. In addition, all training modes decreased body weight and BMI. However, high intensity intermittent training results in greater weight loss in obese/overweight men than continues and resistance training.

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