

The Comparison of the Effects of Two Types of High Intensity Interval Training (HIIT) on Body Mass and Physiological Indexes in Inactive Female Students

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Abstract: The aim of this study was to compare the effects of two types of high intensity interval training (HIIT) on body mass and physiological indexes in inactive female students. 27 inactive female students (mean age 24.81 ± 0.66 yr, height 162.09 ± 0.67 cm, weight 59.41 ± 0.33 kg) were voluntarily selected and randomly assigned to three groups (each group = 9 subjects) of high intensity interval training (type 1), high intensity interval training (type 2) and control. HIIT (type 1) (8 seconds of sprint running and 12 seconds of active recovery) was performed for 4 weeks, 3 sessions per week, 6-9 min. per session with above 90% maxHR. HIIT (type 2) (40-m shuttle run test with maximum speed) was performed with above 90% max HR while the control group did not participate in any training. Data analysis with dependent t test showed that HIIT (type 1) and HIIT (type 2) significantly increased VO_{2max} while they decreased fat percentage and BMI. The intergroup data were analyzed by one-way ANOVA at $P < 0.05$. The results showed a significant difference among HIIT (type 1), HIIT (type 2) and control groups in VO_{2max} , BMI and fat percentage.

Key words: High Intensity Interval Training (HIIT), VO_{2max} , BMI, WHR, body fat percentage.

1. Introduction

A nation improves based on different scientific researches in different fields [1]. Today's world has witnessed huge revolutions in science and technology by which humans have dominated their environment more than ever before. The reason for all these improvements can be attributed to the application of numerous researches in all scientific fields [2]. No doubt activity and liveliness have always been inseparable parts of human life and have manifested themselves in special forms during different ages. In today's industrial and modern society, human movement is being limited day by day and as a result physical education receives great importance. The industrial life keeps modern humans away from activity; this motor deficiency keeps them away from joy and liveliness and brings about risk diseases [3].

The pattern of diseases and their mortality around

the world have changed from infectious diseases such as tuberculosis to non-infectious ones such as cardiovascular diseases (CVD), cancer, chronic respiratory diseases and diabetes [4]. Today, life quality and health receive special attention [5]. One of the national priorities is to improve well-being and to prevent diseases; not only scientific society but also the public are increasingly aware of the deep consequences of lifestyle on physical and mental health and life quality [6]. The researchers concluded that lifestyle and diet had a significant relationship with cardiovascular diseases (CVD) [7]. The motto of World Health Organization is to move towards health; physical activity influences a decrease in cardiac diseases, obesity and mental disorders especially depression, anxiety and finally exhaustion through creating and maintaining a proper level of body mass and physiological indexes [8].

Physical activity as a primary intervention is economical; however, the type and amount necessary to benefit from health should be investigated [9].

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Although there are few studies of high intensity interval training (HIIT), low volume of HIIT can provoke drastic physiological stimuli compared with moderate intensity interval training [10]. In addition, few studies have been conducted about the comparison of the effects of two types of HIIT [11]. Evans et al. [11] showed that the exercises performed regularly most of the week with moderate intensity for 30 min reduced less fat than HIIT. Astoni et al. [12] showed that HIIT protocol including 8 min of sprint running and then 12 seconds of cycling with low intensity was performed for young women for 15 weeks, 3 sessions per week, 20 min each session while another group performed balance exercises. HIIT group drastically reduced their total body mass (TBM), fat mass and waist fat. Recently, a vast range of adaptations were observed after high intensity interval training. These adaptations include increased content of rest glycogen of skeletal muscle, maximum activity of glycolysis and oxidative enzymes and buffering capacity. It was reported that VO_{2max} increased or did not change after HIIT [12]. Previous studies by Berggren et al [14] showed that 6 weeks of HIIT and traditional endurance exercise in adults induced similar metabolic adaptations. Researches of Burgomaster et al. [6] showed that systolic blood pressure, VO_{2max} and BMI significantly improved after training intervention. Esmailzadeh et al. [16] indicated that HIIT for an hour had higher physiological adaptations than moderate intensity training for an hour [11]. HIIT protocol was effective for overweight women. Burgomaster et al. reported that 15 weeks of HIIT caused a significant reduction in whole-body fat percentage, subcutaneous fat and trunk and insulin resistance in the young compared with steady repetitions of physical activity [6]. Esfarjani et al. [17] reported that HIIT increased lipid oxidative capacity and mitochondrial enzyme activity.

Buchan et al. [18] reported that 6 weeks of HIIT in inactive adolescent youth drastically changed body

mass and VO_{2max} . Baiati et al. [2] showed that 6 weeks of HIIT and traditional endurance training resulted in similar metabolic adaptations in adults. Ferguson et al. [19] showed that body fat percentage significantly reduced after 6 weeks of HIIT in inactive young men while weight, BMI and waist to hip ratio did not show any significant changes. Given the high capacity of HIIT to increase lipid oxidation, HIIT time efficiency and lack of similar studies, this question arises whether two types of HIIT have similar effects on body mass and physiological indexes; therefore, this study aimed at examining the effects of two types of HIIT on body mass and physiological indexes in inactive female students.

2. Methodology

The method of this study was application with regard to the aim. This semi-experimental study compared the effects of two types of HIIT on body mass index (BMI), fat percentage, waist to hip ratio and physiological index (VO_{2max}). The statistical population consisted of all female students in Fatemeh dormitory of University of Tehran (23-27 age range). These students were selected as the subjects in order to control their nutrition more efficiently. 27 female students were randomly selected from the population as the sample after they had completed physical health and physical activity questionnaire and form of consent. The subjects were randomly divided into two groups of HIIT and one control group. Experimental group 1 ($n = 9$) performed a training protocol including 8 seconds of sprint running and 12 seconds of active recovery (walking) at a specific time of the day for four weeks and three session per week [20]. A pilot study was performed for this protocol before the study. At the same time, experimental group 2 ($n = 9$) performed a training protocol including 40-m running with maximum speed derived from shuttle run test with maximum speed for four weeks and three session per week [21].

2.1 Statistical Procedures

Descriptive statistics were used to classify data and to draw tables and figures. K-S test was applied to assure data normality and then ANOVA was used to determine the differences of parameters among the groups. SPSS was used to analyze the data at $P \leq 0.05$.

3. Findings

Findings showed that both types of HIIT protocols had significant effects on weight. The general characteristics of the subjects and the studied variables are presented on Table 1.

The findings showed that four weeks of HIIT (type 1) (8 seconds of sprint running and 12 seconds of active recover) and HIIT (type 2) (40-m run with

maximum speed in 40-m shuttle run test with maximum speed) with over 90% max HR intensity significantly increased VO_{2max} , significantly decreased body fat percentage and BMI and finally did not change WHR (waist to hip ratio).

Table 2 showed that the obtained F was bigger than F in the table ($F = 5.503$) at $\alpha = 0.001$; therefore, there was a significant difference in VO_{2max} among the three groups. Scheffe test was applied to determine the source of difference.

Table 3 showed that the obtained F was bigger than F in the table ($F = 5.166$) at $\alpha = 0.002$; therefore, there was a significant difference in fat percentage among the three groups. Scheffe test was applied to determine the source of difference.

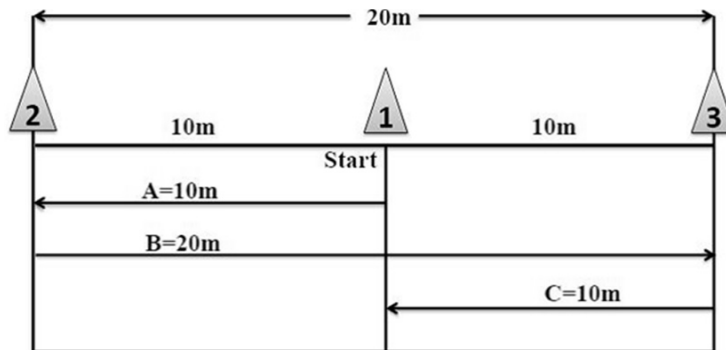


Fig. 1 Schematic design of HIIT protocol: beginning point (cone 1) to cone 2 (A pathway), return pathway (cone 3) (B pathway), final return pathway (cone 1) (C pathway).

Table 1 Individual characteristics of subjects before and after four weeks of training.

Group Variable	HIIT (type 1)		HIIT (type 2)		Control	
	pretest	posttest	pretest	posttest	pretest	posttest
Age (yr)	24.9 ± 2.1	-	24.3 ± 7.78	-	25.25 ± 6.3	-
Height (cm)	161.14 ± 6.06	-	161.12 ± 5.27	-	163.02 ± 6.3	-
Weight (kg)	59.81 ± 6.88	59.02 ± 6.59	58.98 ± 8.33	58.32 ± 7.17	59.45 ± 19.65	59.50 ± 10.24

Table 2 Results of one-way ANOVA VO_{2max} in all groups after four weeks of training.

	Sum of squares	df	Mean of squares	F	Sig.
Inter-groups	105.374	4	93.526	5.503	0.001
Intra-group	853.679	40	16.996		
Total	958.1053	44			

Table 3 Results of one-way ANOVA for fat percentage in all groups after four weeks of training.

	Sum of squares	df	Mean of squares	F	Sig.
Inter-groups	65.148	4	16.287	5.166	0.002
Intra-group	126.111	40	3.153		
Total	191.259	44			

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Table 4 Results of one-way ANOVA for WHR in all groups after four weeks of training.

	Sum of squares	df	Mean of squares	F	Sig.
Inter-groups	0.004	4	0.001	5.166	0.480
Intra-group	0.049	40	0.001	0.888	
Total	0.053	44			

Table 5 Results of one-way ANOVA for BMI in all groups after four weeks of training.

	Sum of squares	df	Mean of squares	F	Sig.
Inter-groups	15.178	4	3.795	1.299	0.285
Intra-group	128.481	40	2.920		
Total	143.659	44			

Table 4 showed that the obtained F was bigger than F in the table ($F = 5.166$) at $\alpha = 0.480$; therefore, there was a significant difference in WHR among the three groups. Scheffe test was applied to determine the source of difference.

Table 5 showed that the obtained F was bigger than F in the table ($F = 1.299$) at $\alpha = 0.285$; therefore, there was a significant difference in BMI among the three groups. Scheffe test was applied to determine the source of difference.

4. Discussion and Conclusion

The present study aimed at comparing the effects of two types of HIIT on body mass and physiological indexes in inactive female students. The comparisons showed that four weeks of HIIT (type 1) including 8 seconds of sprint running and 12 seconds of active recovery for 6 to 9 min and HIIT (type 2) including 40-m run with maximum speed in 40-m shuttle run test with maximum speed) with over 90% max HR intensity significantly increased VO_{2max} while no significant differences were observed in control group. The ability to work in a higher percentage of VO_{2max} is a sign of high lactate. When lactate threshold is expressed as a percentage of VO_{2max} , it is one of the best indexes to determine athletes' motor rhythm in endurance activities such as cycling and endurance running [10, 22]. The findings of the present study were in line with some researches [5, 14, 18, 23], while they were contrary to other findings which reported no changes in VO_{2max} [7, 10, 11, 19]. The reason for the contradiction between the findings of

this study and those of Burgomaster et al. [6] may be the short duration of training (6 sessions, 2 weeks) and primary VO_{2max} of the subjects. In addition, the contradiction between this study and Dorado et al. [26] may be due to the insufficient volume of exercises, age and gender of the subjects (men aged between 35 and 46).

The present findings showed that four weeks of HIIT (type 1 and 2) with over 90% max HR intensity significantly decreased BMI while no significant differences were observed in control group. These BMI findings after four weeks of HIIT were in line with some studies [7, 18, 24], while they were contrary to other findings which reported no changes in BMI (30, 17). The reason for the contradiction between the findings of this study and those of Burgomaster et al. [6] may be the short duration of training (6 sessions, 2 weeks) and gender (young men). The reason for the contradiction between the findings of this study and those of Ferguson et al. [19] may be the insufficient volume of exercises and changes in lean body mass percentage (equal ratio of body mass increase to fat percentage decrease). As height is constant in this age range, researchers suggested different factors influencing BMI changes such as body weight, fat percentage or body mass changes [9, 19].

The present findings showed that four weeks of HIIT (type 1 and 2) with over 90% max HR intensity significantly decreased fat percentage while no significant differences were observed in control group. These fat percentage findings after four weeks of HIIT

were in line with some studies [6, 18, 24], while they were contrary to another study which reported no changes in fat percentage [22]. The reason for the contradiction may be a difference in pre-training fat percentage and gender (young men) of the subjects.

Researchers have suggested different factors influencing fat metabolism such as mitochondrial density increase, mitochondrial enzyme activity increase, an increase in oxygen administration to electron transfer system, FABPc (Fatty acid binding protein), FABPpm (Fatty acid binding protein memberani), FAT/CD36 (Fatty acid Translocase) and FATP (Fatty acid transport protein) increase, malonyl-CoA decrease, phosphorylation of ACC (Acetylcoa carboxilas) enzyme, CPT1 (Carnitin palmitoyltransferaz I) activity increase, reduction of CPT1 sensitivity to malonyl-CoA and AMPK activity increase. LCFA (long chain fatty acid) plays an important role in fat metabolism. LCFA endothelial transfer from blood plasma to tissue interstice is the first stage of transfer from plasma section to intracellular fluid of muscular cell. Some studies expressed the reason for LCFA oxidation increase as follows: muscle contraction increases protein kinase activity which is activated by AMP (AMPK). AMPK plays a key role in adjusting LCFA oxidation increase resulted from contraction. These studies also reported that HIIT increased those proteins involved in sarcolemmal transport (LCFAFABPc, FABPpm, FAT/CD36 and FATP) and reduced fat percentage [13].

Muscle lipolysis triglyceride (intermuscular fat uptake) is only stimulated in higher intensity physical activities [2, 25]. In comparison with moderate to low intensity physical activity, HIIT induces metabolic adaptations in skeletal muscle which is beneficial to fat oxidation (fat burning) and the energy consumption level is beneficial to negative energy and fat balance in high intensity physical activity more than moderate to low intensity physical activities [15].

To stimulate fatty acid oxidation, HIIT is more

effective than regular submaximal training. Using similar output, HIIT increases RQ compared with regular low intensity physical activity and shows energy consumption of more than 24 hours [12]. Linke et al. [22] showed that two months of HIIT significantly reduced fat percentage in obese adults (30-45 years old). It was reported that high body fat percentage decreases cardiovascular system function of oxygen administration to various parts and therefore decreases cardiovascular endurance capacity. An increase in body fat percentage to whole body weight decreases absolute body power [13].

The present findings showed that four weeks of HIIT type 1 and 2 with over 90% max HR intensity did not significantly change WHR (waist to hip ratio) while no significant differences were observed in the control group. The WHR findings after four weeks of HIIT were in line with some researches [3, 9] and were contrary to other researches which reported WHR significant decrease. This contradiction can be attributed to long period of training (8 weeks) and subjects (obese) [6, 24]. In a consecutive study of obese women for two years, the results showed that HIIT decreased WHR. The researchers reported that the reason was visceral fat decrease of the subjects and that WHR decrease followed an increase in visceral fat oxidation [14]. WHR decrease in obese women is higher than obese men in similar conditions and women show more sensitivity to visceral fat decrease than men in similar training intensity and duration. The reason for this difference is related to their visceral fat burning structure, that is to say women have higher and more intense mitochondrial activity in their visceral part. Women's CAPT1 (Carnitin Palmitoyltransferaz I) sensitivity to malonyl-CoA in mitochondrial membrane is lower than men which can be a reason for their higher fat burning and WHR decrease in visceral part. Women have higher and more active FABP protein in response to physical activity in their visceral part [26, 27]. Researchers have suggested different factors

influencing WHR changes such as malonyl-CoA decarboxylase (MCD) changes. MCD decarboxylates malonyl-CoA (physical activity increases MCD activity) and increases visceral fat burning which increases visceral fat burning and decreases WHR along with acyl-CoA carboxylase (ACC) activation. ACC and MCD are adjusted with AMPK activity. In a study, AMPK activity increased, ACC activity and malonyl-CoA decreased and intramuscular LCFA oxidation increased in injected and actively isolated muscles of wistar rats which ran on a treadmill with moderate intensity. It can be concluded that AMPK changes is a WHR control factor during physical activity. With regard to the present findings, it can be noted that one of the reasons for a lack of WHR change after four weeks of HIIT can be the subjects (they were not obese). Ferranti [9] in a study on 15 men (30-35 years old) reported a significant relationship between WHR decrease and cardiovascular risk factors decrease [26, 28]. So WHR control can prevent cardiovascular diseases.

Overall, the findings of this study showed that HIIT (type 1) (8 seconds of sprint running and 12 seconds of active recovery) and HIIT (type 2) (40-m shuttle run test with maximum speed) was performed with above 90% max HR intensity increased VO_{2max} while they decreased fat percentage and BMI in inactive female students. HIIT (type 1) showed more obvious effects than HIIT (type 2) but the direction of these effects was similar. As these two HIIT protocols were conducted in a similar condition, HIIT (type 1) can be introduced as the more effective protocol. In addition, it can be concluded that different HIIT protocols with similar intensities can have different effects (different intensities) in different indexes. HIIT can be introduced as an effective activity which decreases fat percentage and BMI while it increases VO_{2max} . These effects can improve quality of life and health. It is suggested that this study should be duplicated for a male population in order to reach a more

comprehensive conclusion.

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