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Acute Effect of High-intensity Interval and Traditional Resistance Training on Lipolysis Factors in Overweight Young Girls

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Abstract

Background: Efficient exercises for enhancing lipolysis could be implemented in the measures taken regarding obesity reduction and the related risk factors. The present study was conducted to compare the response of lipolysis inhibitory and excitatory hormones, including insulin, epinephrine, and glycerol, as index of lipolysis to high-intensity interval resistance exercise (HIIRE) and traditional resistance exercise (TRE) protocols in overweight girls.
Methods: This was a kind of acute and semi experimental study, which was performed during the winter of 2019. Eleven overweight young girls with a mean weight of 68.54±4.3 kg participated in this study objectively and voluntarily. The participants took part in HIIRE and TRE programs separately with at least a one-week interval. Blood samples were taken before and immediately after an exercise session in order to measure the levels of epinephrine, insulin, and glycerol. For analysis of the data, we utilized statistical method of paired t-test.
Results: Statistical analysis of the data revealed a reduction in the level of insulin (P=0.009) and an increase in that of glycerol (P=0.04) after HIIRE. There were no significant changes in epinephrine following HIIRE (P=0.75) and TRE (P=0.15). Moreover, there were no significant differences concerning the changes of epinephrine (P=0.93), insulin (P=0.15), and glycerol (P=0.13) between HIIRE and TRE protocols (P>0.05).
Conclusions: Regarding the decrease in lipolysis inhibitor (insulin) and the increase in glycerol, as an index of adipose lipolysis following HIIRE, it could be recommended as an effective exercise for reducing adiposity.

Keywords: Resistance training, Insulin, Epinephrine, Glycerol

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1. Introduction

Obesity is on an increasing trend all around the world and reducing adipose tissue through enhancing lipolysis has been the aim of several interventions. Lipolysis, namely the enzymatic splitting of triglycerides (TG) into three free fatty acids (FFA), glycerol in adipose tissue, and intramuscular triglyceride (IMTG) and their release into the bloodstream are known as a major source of ATP production using lipid substrate during physical activity (1). Taking control of lipolysis in human is primarily mediated with insulin and catecholamines (2).

Certain evidence in animals while less conclusive findings in humans has indicated the activation of lipolysis upon direct sympathetic innervation in subcutaneous or visceral fats (3). Epinephrine is the main lipolytic catecholamine released through the stimulation of sympathetic system (4).

Exercise increases blood flow to adipose tissue and mobilizes lipid stores, resulting in the delivery and subsequent oxidation of FFA in skeletal muscles. These effects last at least 10-20 hours after intense exercise, and reduce fat deposits in adipose tissue and plasma lipid profile (5, 6). The majority of studies have been conducted on aerobic exercise. However, resistance training has been found to improve the overall structure of the body and as a result, has attracted a great deal of attention. Furthermore, favorable changes in lipid metabolism has been observed through resistance exercises (7).

Possible mechanisms through which resistance training improves body composition could be similar to aerobic exercises and include increasing mobilization of FFA from TG stores and their oxidation (5, 8, 9).

The parameters of a resistance training program include the number of stations, intensity or load, and number of repetitions, intervals, and sets.

Changes in each of these parameters could lead to different hormonal responses and exert different metabolic effects (10). Although body fat reduction as a result of resistance training activities may be mainly owing to the increase in energy demand and negative energy balance as well as adaptations, such as increased muscle mass, basal energy, and higher reliance on the use of fats as fuel, these responses and adaptations appear to be different with respect to various resistance training programs (2).

The intensity of exercise training is the most important characteristic of exercise that has been found to affect the secretion of lipolysis activating hormones, including epinephrine and atrium natriuretic peptide (ANP).

Due to the lack of time, as an effective factor on non-adherence of most people to exercise programs, it seems that decreased overall training time and increased exercise intensity could be more effective on sports adaptations and weight loss to observe a more prominent effect during a shorter period of time. Reducing rest intervals of resistance exercises has been suggested to be a useful and effective strategy to increase lipolysis and oxidation (11).

In resistance training, a new intermittent method of exercise is used by coaches, which consists of short rest intervals between training sets. As reported by Paoli and colleagues, after evaluating energy consumption and respiratory exchange ratio, 22 hours after performing traditional resistance training (TRT) and high intensity interval resistance training (HIIRT), the amount of energy expenditure after HIIRT was greater than that in the traditional method.

Respiratory exchange ratio also decreased, which indicated that during recovery, fat utilization was dominant in HIIRT compared to that in TRT (12).

However, the related mechanisms, including hormonal changes and glycerol level were not investigated and the subjects of the mentioned study were men. In addition, regarding the metabolic differences between men and women, a similar study on women seems to be of great necessity.

In general, two major mechanisms of blood supply to tissues and lipolytic hormones appear to be directly or indirectly effective in the lipid utilization process. The intensity of exercise affects the blood supply to tissues as well as lactic acid accumulation; lactic acid is an inhibiting factor for lipid utilization (13).

Given the fact that resistance training can be performed up to the lactate threshold, two important objectives were considered for this study. Primarily, this research aimed to evaluate and compare the effect of two resistance exercise programs (Different intensities and intervals between exercise sets) on glycerol as a lipolysis index.

Secondly, we intended to evaluate and compare the effect of these two resistance exercise programs on insulin and epinephrine as mediating hormones in lipolysis process.

2. Methods

This study was a kind of acute semi experimental one performed during winter 2019 applying crossover method (for controlling the effect of previous exercise session). One group of female students participated into two exercise sessions. During every exercise session, the pre and post-exercise blood samples were taken.

According to Allman and co-workers (9), the amount of epinephrine was as the following: baseline: 23.2 ± 2.7; during exercise: 92.5 ± 16.6; post-exercise: 84.5 ± 21.4 pg/mL. According to the following formula (14), the number of the participants was estimated to be 11.

$$n = \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{ES} \right)^2$$

The participants of this research were 11 overweight female students (BMI: 25-29.9 kg/m2) from Shiraz University with an age range of 19-25 years. They took part in the study voluntarily. The inclusion criteria comprised not having participated in any regular physical activities (at least one day per week) during the last 6 months prior to the study and not having any health problems (metabolic and motor health for instance).

Our subjects signed an informed consent ahead of participation in the research study.

The study proposal and procedures were approved by Graduate and Ethic Committee of Shiraz University. The research was conducted according to the Declaration of Helsinki to research in humans.

Data collection method

The participants were provided with the necessary information about the research procedures and aims. They completed some questionnaires containing information about their daily physical activity and health and signed informed consent forms.

All the anthropometric and exercise-related measurements were performed during 8 to 9 a.m. and following 8 hours of fasting.

Because of the possible effect of estrogen in lipolysis during the exercises (15), the measurements were performed at follicular stage of menstrual cycle. The participants lived in the dormitory and had similar conditions and food types (quality) during one day prior to the two testing sessions. Two weeks before the exercises, their height, body weight, and BMI were measured. A Beurer scale (made in Germany) was used for weighing by wearing light clothing. The height of the subjects was measured in a standard position with a height meter from Seca Company (Germany).

Their BMI was calculated by dividing the weight (in kg) by the height (in meters) to the power of 2. One-repetition maximum (1-RM) for every movement of exercise was recorded as the maximum amount of weight that a person could lift for one repetition or as the maximum amount of force that could be generated in one maximal contraction.

Two resistance exercise programs were designed according to estimated 1-RM. Subsequently, the participants performed two different resistance protocols in a cross-over method randomly to control the effect of adaptation and learning for a week.

To measure 1-RM, the subjects performed general and specific warm up. The general warm-up consisted of five minutes of jogging with a 60% of maximal heart rate on top of stretching. The specific warm-up comprised one set of 10 repetitions for each exercise with the intensity of 40-50% of the perceived maximum effort.

The subjects were then asked about the maximum load or weight that they could move by 10 repetitions and 70% of that weight was selected as the initial weight. Afterwards, the resistance progressively increased until the subjects could perform only 9 or fewer repetitions of each exercise. Three minutes of rest was allowed between each specific exercise.

In the next step, the number of repetitions and the weights were recorded during each movement. Finally, the following (Brzycki) formula was used to determine 1-RM (16):

$$\mathbf{1RM} = \frac{\mathbf{weight\ (kg)}}{\mathbf{1.0278 - (0.0278 \times number\ of\ repetitions)}}$$

Exercise protocol

The exercise protocol consisted of two types of strength exercise programs that were performed in two separate sessions with at least a one-week interval. Seven movements of resistance exercises were performed in each resistance exercise protocol, including chest press, pounding, military press, forearm, triceps, leg press, and hindleg (12).

The movements and volume of resistance exercises were similar in high-intensity interval resistance exercises (HIIRE) and traditional resistance exercise (TRE) programs.

High Intensity Interval Resistance Exercise

Regarding HIIRE technique, the session included six repetitions with 80% 1RM-with 20 seconds rest, three repetitions with 80% 1RM -with 20 seconds rest followed by two repetitions with 80% 1RM - with 20 seconds rest (this protocol was performed twice) (Figure 1; 11). The duration of the entire exercise session was approximately 45 min, including the warm-up and cool-down periods.

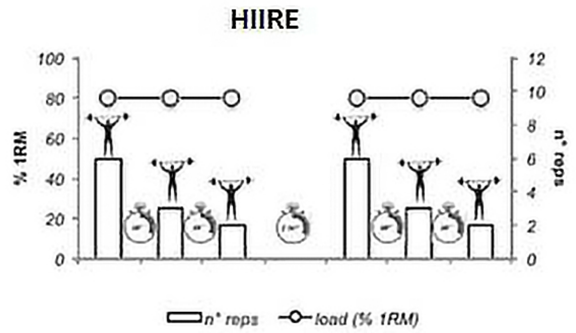

Figure 1: The figure shows the protocol of one session of HIIRE. *reps: repetitions, HIIRE: high intensity interval resistance exercise.

Traditional resistance exercise

In a TRE session, the participants performed three sets of exercises with eight repetitions at 75% of 1RM, with 2′30″ of rest between the sets (Figure 2). The duration of the training session was approximately 65 min, including the main, warm-up, and cool-down exercises (11).

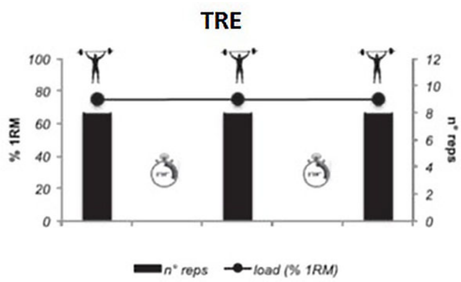

Figure 2: The figure shows the protocol of one session of TRE. *reps: repetitions, TRE: traditional resistance exercise.

Hormone measurement

10 mL of blood sample was taken from the antecubital

vein of each subject immediately before and after the implementation of the protocol in sitting position. The blood samples were immediately poured in EDTA-anticoagulated tubes and centrifuged at 3000 rpm for 4 min at 4°C. The obtained plasma was stored at -80°C for subsequent assays. Insulin level was measured using insulin kit made in Diametra Company-Italy with an internal measurement degree of 2% and sensitivity degree of 2 micIU/mL.

Glycerol was measured with glycerol assay kit (ZellBio, Germany) based on ELISA method. Epinephrine was measured utilizing the German company Nordhorn kit with a sensitivity of 11 pg / mL and a detection range of <100 pg / mL based on ELISA method.

All the laboratory tests were performed by a laboratory technologist who was unaware of the project and the protocols performed by the subjects.

Statistical analysis

After making sure of the normality of dependent variables via Kolmogorov-Smirnov test, paired t-test was used for comparing the variables in the measurements in two sessions.

All the statistical calculations were performed using SPSS software version 21 and the diagrams were plotted employing EXCEL software. The significant level was set at 0.05.

3. Results

The participants of this research were 11 overweight female students (BMI: 25-29.9 kg/m2) from Shiraz University with an age range of 19-25 years. The inclusion criteria comprised not having participated in any regular physical activities (at least one day per week) during the last 6 months prior to the study and not having any health problems (metabolic and motor health for instance).

Descriptive data of the participants, including age, height, weight, and BMI were shown in Table 1.

Table 1: Anthropometric characteristics of the participants (n=11)

Variable	BMI	Weight (kg)	Height (cm)	Age (years)
Mean ±SD	26.90±1.61	68.91±4.80	162.82±5.02	23.40±3.81

BMI: body mass index; SD: standard deviation

After confirming the absence of any significant differences between resting state of insulin in the two resistance training protocols using paired t-test (t=1.75, P=0.11), insulin changes (pre- and post-exercise difference) in the two protocols were compared to those obtained through the paired t-test.

Accordingly, the insulin changes were not found to differ significantly between HIIRE and TRE protocols (t=1.55, P=0.15).

Intra-group comparisons using paired t-test showed that insulin levels decreased significantly in the post-test samples compared to the pre-test ones (21.64±13.07 vs. 11.51±7.41) (t=3.23, P=0.009) in HIIRE. In TRE session, the insulin levels decreased non-significantly in the post-test samples compared to the pre-test ones (12.88±9.26 vs. 9.09±5.36) (t=1.59, P=0.15) (Figure 3, Table 2).

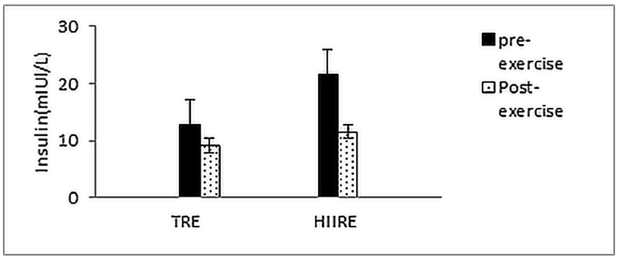

Figure 3: The figure shows Insulin levels in two resistance protocols at different times. *HIIRE: High intensity interval resistance exercise; TRE: Traditional resistance exercise.

Regarding epinephrine, after ensuring that there were no significant differences between resting state of epinephrine in the two sessions, using paired t-test (t=-0.79, P=0.93), epinephrine changes (pre- and post-exercise difference) were compared; no significant differences were observed concerning epinephrine changes between the two resistance training protocols (t=-0.79, P=0.93).

Intragroup changes were also compared with paired t-test. It was observed that in HIIRE, although epinephrine increased compared to the pre-test (11.93±3.22 vs. 16.45±8.14), the difference was not statistically significant (t=-1.1.98, P=0.75). Additionally, in TRE, epinephrine increased non-significantly in the post-test samples compared to the pre-test ones (12.23±2.90 vs. 16.87±8.63) (t=-1.51, P=0.15) (Figure 4, Table 2).

Figure 4: The figure shows Epinephrine levels in the two resistance protocols at different times. *HIIRE: High intensity interval resistance exercise; TRE: traditional resistance exercise.

Table 2: The comparison of insulin, epinephrine, and glycerol levels in different times and between different resistance exercise protocols

Variable	Training type	Measurement time	Mean±SD	Intragroup comparison (P)	Intergroup comparison (P)
Insulin(mIU/L)	TRE	Pre- exercise	12.88±9.26	0.14	0.15
		Post- exercise	9.09±5.36		
	HIIRE	Pre- exercise	21.64±13.07	0.009*	
		Post- exercise	11.51±7.41		
Epinephrine (pg/mL)	TRE	Pre- exercise	12.23±2.90	0.15	0.93
		Post- exercise	16.87±8.63		
	HIIRE	Pre- exercise	11.93±3.22	0.75	
		Post- exercise	16.45±8.14		
Glycerol(Ɱmol/L)	TRE	Pre- exercise	45.66±24.19	0.37	0.13
		Post- exercise	53.11±23.52		
	HIIRE	Pre- exercise	55.93±28.87	0.04*	
		Post- exercise	91.67±35.41		

HIIT: High intensity interval exercise; TRE: traditional resistance exercise; *significant difference (P<0.05)

Considering blood glycerol, after confirming the absence of any significant differences between resting state glycerol in the resistance training protocols, using paired t-test (t=-1.53, P=0.15), blood glycerol changes of the tests (pre- and post-exercise difference) were compared, which illustrated no significant differences between the glycerol changes between the two resistance training protocols (t=1.62, P=0.13).

It was also observed that in TRE protocol, the glycerol increased following the exercised (45.66±24.19 vs. 53.11±23.52) and the difference was not statistically significant (t=-9.24, P=0.37). In HIIRE, glycerol increased significantly in the post-test samples compared to the pre-test ones (55.93±28.87 vs. 91.67±35.41) (t=-2.33, P=0.04) (Figure 5, Table 2).

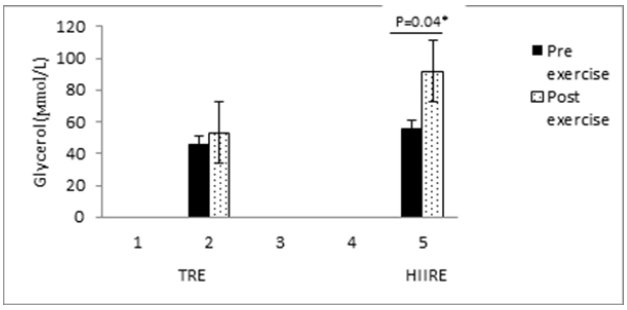

Figure 5: The figure shows Glycerol levels in the two resistance protocols at different times. *HIIRE: High intensity interval resistance exercise; TRE: traditional resistance exercise.

4. Discussion

The most important finding of the present study was that immediately following the resistance exercise programs, plasma insulin reduced and epinephrine and glycerol increased. However, the decrease in insulin and increase in glycerol were not statistically significant in the TRE protocol while they were significant in the HIIRE protocol. This was the first available research, which investigated the effect of HIIRE on lipolysis-related hormones. The main cause of the greater decrease in insulin hormone in HIIRE protocol may be the higher intensity of this training protocol.

Considering the decrease in insulin level immediately after HIIRE, higher intensity may be accompanied by further metabolic pressure in this type of exercise, which could account for the decrease in lipolysis inhibitory hormone. Paoli and colleagues (2012) compared energy consumption and respiratory exchange ratio 22 hours after the TRT and HIIRT; they reported that energy consumption was higher whereas respiratory exchange ratio was lower following the HIIRT exercises, indicating that fat utilization was dominant during HIIRT and recovery period compared to that during TRT.

According to the increased lactate level in HIIRT, higher intensity of exercise could result in the predominance of fat utilization up to 22 hours after resistance training (12). It seems that in the present study, the amount of fat utilization was higher in HIIRE than that in the traditional protocol during the recovery period in view of lower insulin and higher glycerol levels.

Moro and co-workers (11) reported no significant differences in the effects of the two exercise programs on body composition, strength, anabolic hormones, and blood lipid levels in the elderly by comparing the impact of HIIRT and TRT protocols. Their TRT protocol consisted of three sets of eight repetitions with 75% of maximum repetition and 90 seconds of the interval between each exercise set. Their HIIRT protocol comprised two sets with six repetitions and very high intensity (nearly 90% of maximum repetition), but rest intervals of <20 seconds. They reported lower insulin levels, greater reductions in blood lipids, and improvement of body composition in HIIRT compared to the TRT, which was significantly associated with higher intensity and could further improve the cardiovascular risk factors.

In addition, decreased plasma insulin levels as anti-regulatory hormone as well as the growing release of leptin and adiponectin from adipose tissue have been implicated in FFA mobilization and intra muscular triglyceride (IMGT) lipolysis at resistance exercise (17). This effect is partly owing to the activation of these cytokines by 5' adenosine monophosphate-activated protein kinase (AMPK) and somewhat sympathetic activation. Another cytokine is IL-6, which is produced by active muscles and stimulates hepatic glucose production, PI3K glucose uptake, lipolysis of adipose tissue, and lipid oxidation through cytokine receptors, signal transducer, and activator of transcription 3 (STAT3) signaling (18).

The present study also indicated that epinephrine response to the two resistance training protocols was not significantly different. Epinephrine increased immediately after the exercises, however, and it may be argued that the intensity or duration of the exercises was less than the amount that could cause a significant intergroup difference on all or the majority of variables.

Another reason for the absence of significant differences could be the intensity of protocols and the fact that there was not great differences between the two intensities to induce significant changes in some hormones. Pre-exercise insulin was different between the study groups, which could also be effective on our findings. Even though the type of meals was similar before the two exercise sessions, it was possible that the previous quantity of the meals was different and eating snacks was not accurately reported.

Furthermore, the release of epinephrine during the exercises in fat people may decrease due to low sympathetic activity (19). In addition to the low epinephrine release during intense exercises in overweight people, lipolysis (especially from visceral fat reserves) has been shown to decrease after adrenergic stimulation. The low fitness level of the subjects and their excess weight could also result in similar responses in the same subjects even with different training protocols (20).

Another important finding of this study was the increase in blood glycerol levels as a result of HIIRE, which indicated the overall increase in lipolysis in account of this type of exercises. The decrease in insulin levels observed in HIIRE of the present study might justify the increase in glycerol as an index of lipolysis. In low- to moderate-intensity exercises, lipolysis increases up to 400-fold compared to the basal levels because of higher concentrations of catecholamine and ANP as well as decreased plasma insulin. Growth hormone (GH) could also stimulate lipolysis, which was not measured in the present study. Increasing secretion of GH, as a result of exercise, leads to increased post-exercise lipolysis in subcutaneous adipose tissue.

Increased lipolysis as a result of GH reaches its peak levels approximately two hours after 20 minutes of exercise with the intensity of 70% of VO2max (21). According to recent studies, many of the proteins involved in adipocyte lipolysis are multifunctional enzymes and various metabolic signals control adipose lipolysis (22, 23), which may contribute to greater response of lipolysis to HIIRE.

In the present study, higher intensities and lower rest periods in HIIRE protocol led to lower insulin, and thereby increasing lipolysis. One of the important limitations of this work was the small number of participants. Thus, although the findings confirmed our hypothesis, the generalization of the findings is not recommended. Considering the fact that lipolysis could be controlled by various factors, it is recommended to take into account lipolysis mediators in future studies.

5. Conclusion

One of the limitations of the current study was the limited number of participants, which could be effective on the statistical significance of our findings. However, HIIRE with higher intensity and shorter resting times resulted in higher metabolic pressure and hence, promoted lipolysis. This seems to be achieved by decreasing lipolysis inhibitors (insulin) rather than stimulating factors, such as epinephrine. Hence, it could be recommended as an effective exercise for reducing adiposity through enhancing lipolysis.

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Ethical approval: The Ethics and graduate Board of Shiraz University approved the present study with the code of 2555565.

Conflict of interest: None declared.

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