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Comparison of Exercise Intensity Effects on Irisin Serum Levels and Lipid Profiles in Obese Adolescents

Reza Omidi Ghanbari[1], Rahman Soori[2*], Haniye Mardalizade[3], Ahmad Hemmatfar[4]

[1] General Department of Education of Tehran Province, Tehran, Iran
[2] Professor, Department of Exercise Physiology, Faculty of Sport Sciences and Health, University of Tehran, Tehran, Iran
[3] PhD student, Department of Exercise Physiology, Faculty of Physical Education and Sport Sciences, University of Guilan, Rasht, Iran
[4] Department of Physical Education, Borujerd Branch, Islamic Azad University, Borujerd, Iran

*** Corresponding author email address**: Soori@ut.ac.ir

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A B S T R A C T

Objective: Irisin is a myokine that has a beneficial effect on obesity by increasing energy expenditure. The aim of this study was to compare the effect of exercise intensity on serum irisin levels and lipid profile in obese adolescents.
Materials and Methods: Forty-six male students with an average age of 13.43 ± 0.77 years; height 163.18 ± 23 cm, weight 85.84 ± 8.46 kg, body fat percentage 37.001 ± 4.508 were randomly assigned to three groups: low-intensity activity (experimental 1), high-intensity activity (experimental 2), and control. The training program in experimental group 1 included running at 45-60% heart rate reserve intensity, and in experimental group 2, it was similar to group 1 along with combined exercises at 60-75% heart rate reserve intensity, performed 4 sessions per week for 10 weeks. A paired t-test was used to examine within-group differences, and Mixed ANOVA was used to examine between-group differences. All tests were conducted at a significance level of 0.05 using SPSS22 software.
Results: The findings indicated a significant decrease in serum irisin levels in both experimental groups 1 and 2 ($p < 0.001$). Additionally, weight, body fat percentage, and low-density lipoprotein significantly decreased in both experimental groups. Cholesterol and LDL/HDL ratio only significantly decreased in the high-intensity group.
Conclusion: Considering the impact of exercise at both intensities on weight, body fat percentage, and irisin levels, regular physical activity is recommended for adolescents.

Keywords: *Exercise intensity, Irisin, Lipid profile, Obese adolescents*

1. Introduction

Obesity is a global concern due to its high healthcare costs, primarily resulting from increased type 2 diabetes, cardiovascular diseases, and mortality (1). Obesity negatively impacts almost all physiological functions of the body and poses a significant threat to public health (2). Despite the role of multiple factors in the development of obesity, the imbalance between energy intake and expenditure is the most important factor (3). Researchers

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have linked childhood obesity to adult obesity, showing that 40% of overweight children will remain overweight in adolescence, and 75-80% of them will be obese in adulthood (4). Exercise is recommended as the first line of treatment for obesity because it leads to weight loss, reduction in fat mass, improvement of major metabolic and cardiovascular risk factors, and increased cardiorespiratory fitness. During muscle contraction, myocytes act as a secretory organ, releasing hormones known as myokines (5).

Irisin is a myokine with a molecular weight of 12 kDa, composed of 112 amino acids. Irisin is the product of the cleavage of the FNDC5 gene, which is a type of membrane protein predominantly found in human and mouse muscle tissue. The expression of the FNDC5 gene is mediated by PPAR-γ and PGC-1α (6). Physical activity increases PGC-1α, enhancing functions such as mitochondrial biogenesis, fatty acid oxidation (lipogenesis), angiogenesis stimulation, and reduction of pro-inflammatory cytokines (7). Irisin increases the expression of the UCP1 gene in white adipose tissue, which is characteristic of brown adipose tissue, and promotes fatty acid oxidation and thermogenesis. Therefore, irisin converts white adipose tissue to brown adipose tissue, leading to increased thermogenesis, energy expenditure, glucose homeostasis, and ultimately weight loss (6). By accelerating weight loss, irisin improves glucose tolerance and enhances insulin sensitivity (4). Regular physical activity also improves glucose and lipid metabolism by increasing insulin sensitivity, high-density lipoproteins, and reducing triglycerides and low-density lipoproteins (8). In fact, physical activity is one of the effective and low-cost ways to stimulate the release of irisin from engaged skeletal muscles into the plasma, subsequently improving cellular metabolism in inactive individuals. Irisin also activates phosphofructokinase, leading to the activation of hormone-sensitive lipase and, consequently, increased lipolysis. Therefore, regular physical activity and adherence to a healthy dietary pattern can reduce obesity-related complications by altering metabolism and improving energy expenditure, especially in obese and overweight individuals (3).

Most relevant studies have shown that irisin can act as a metabolic regulator (Enteshary et al., 2019). A study indicated that irisin levels are higher in men than in women and higher in obese individuals compared to lean individuals. An immediate increase in irisin levels was observed after acute high-intensity exercise and a 30-minute session of high-intensity exercise in children and adults, while long-term physical activity did not affect irisin levels (9). In one study, it was reported that plasma irisin levels doubled in obese subjects after 10 weeks of endurance training (10), whereas in another study, irisin levels decreased after 12 weeks of combined training (11).

Due to these contradictions and the unclear impact of physical activity on irisin, further research is warranted. Therefore, the aim of this study was to compare the effect of exercise intensity on serum irisin levels and lipid profiles in obese adolescents to determine whether there is a difference in the irisin response to different exercise intensities. Additionally, the study aimed to examine how the lipid profile changes in response to different exercise intensities.

2. Methods and Materials

2.1 Study Design and Participants

This quasi-experimental study employed a pre-test and post-test design. The statistical population comprised obese boys from Baharestan's education sector. Forty-six healthy obese boys were randomly assigned to three groups (high-intensity, low-intensity, and control). Inclusion criteria included; age 13-15 years, high body mass index (above the 95th percentile), no regular physical activity, and no physical diseases or disorders. Before starting the test, the study's objectives, details, and implementation were explained to the participants and their parents, followed by obtaining written consent from the parents. Weight, height, subcutaneous fat, waist circumference, and hip circumference were measured to assess body composition. Weight was measured with minimal clothing and without shoes using a mechanical scale with 0.1 kg accuracy. Height was measured using a wall stadiometer (Seca, made in China) in a standing position without shoes, with shoulders and heels in contact with the wall, with an error margin of 0.1 cm. Body fat percentage was measured using a body composition analyzer (made in Germany). Waist and hip circumferences were measured using a tape measure. The participants' maximum oxygen consumption was measured using a 2400-meter run test. The 10-week training program for both low-intensity and high-intensity activity groups included repeated running and combined exercises in a sports hall, 4 sessions per week. Each session included 5-10 minutes of warm-up (walking: 4 minutes; joint warm-up: 2 minutes; stretching: 4 minutes) and 5-10 minutes of cool-down involving stretching and light exercises. In the low-intensity training group, the intensity started at 45-50% heart rate reserve in the first week and increased to 55-60% in the final week. In the high-intensity training group, the intensity

started at 45-50% heart rate reserve and increased to 60-75% in the final week. The duration of each session started from 25-30 minutes in the first week and increased to 40-45 minutes in the final week. Flexibility and agility exercises were also included at the end of the training program. Participants were advised to refrain from any other physical activities during the 10-week training program. Exercise intensity was monitored using a Polar heart rate monitor during the sessions. To control the activity level of the control group, they were asked to stay in the adjacent hall during the training sessions and engage in watching movies or doing their homework. A unified diet was not possible, so dietary recommendations based on the food pyramid were provided to the test groups.

2.2 Data Collection and Intervention

Before the intervention, fasting blood samples (5 cc) were taken from the antecubital vein in the morning under fasting conditions and collected into tubes containing antiprotease. Serum was separated using a centrifuge at room temperature and stored at -80°C for biochemical measurements. Irisin levels were measured using a sandwich ELISA method with a research kit from Zell Bio, Germany. At the end of the 10-week intervention, 48 hours after the last training session, the research and control groups were invited again, and blood samples were taken under similar conditions as the initial phase. Blood samples were taken under identical environmental conditions and timing after 12 to 14 hours of fasting from all participants.

2.3 Data Analysis

To examine within-group differences, one-way ANOVA was used, and for between-group differences, Mixed ANOVA was employed. Subsequently, Bonferroni's test was used to determine the exact location (details of the difference) of the between-group differences (pairwise comparison of the research groups). As a prerequisite for conducting parametric tests (paired t-test and one-way ANOVA), the Shapiro-Wilk test was performed to estimate the normality of the data distribution in the initial measurement phase. All tests were conducted at a significance level of 0.05. Data analysis was performed using SPSS22 software.

3. Findings and Results

The results of the Shapiro-Wilk test indicated that the data distribution was normal. To examine the hypothesis of no significant differences in the pre-test stage among the research groups for each of the variables, a one-way ANOVA was used. According to the results of this test, if the significance level is less than 0.05, it indicates a statistically significant difference in the pre-test stage and non-uniformity in the levels of research variables among the studied groups. Based on the results obtained, no statistically significant differences were observed among the research groups in the variables of interest.

Table 1. Descriptive Statistics of Variables in Research Groups

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD
Weight (kg)	Control	85.476 ± 8.404	85.046 ± 8.564
	High intensity	86.625 ± 8.341	82.433 ± 8.255
	Low intensity	85.423 ± 8.639	79.823 ± 8.684
Body fat (%)	Control	36.523 ± 4.566	36.430 ± 4.233
	High intensity	37.966 ± 4.511	35.991 ± 4.259
	Low intensity	36.515 ± 4.448	34.376 ± 4.153
VO2max	Control	21.415 ± 4.190	21.348 ± 4.200
	High intensity	20.765 ± 4.222	25.576 ± 4.257
	Low intensity	18.356 ± 4.212	25.110 ± 4.198
LDL	Control	114.692 ± 13.840	113.615 ± 12.777
	High intensity	112.750 ± 13.732	96.166 ± 10.034
	Low intensity	112.693 ± 13.707	104.538 ± 8.191
HDL	Control	42.000 ± 5.338	40.461 ± 5.109
	High intensity	42.333 ± 5.262	40.416 ± 4.461
	Low intensity	41.076 ± 5.823	40.076 ± 5.073
LDL/HDL	Control	2.846 ± 0.512	2.744 ± 0.498
	High intensity	2.623 ± 0.328	2.380 ± 0.417
	Low intensity	3.067 ± 0.843	2.953 ± 0.651
TG	Control	137.692 ± 26.408	137.923 ± 26.877

	High intensity	137.833 ± 26.879	127.416 ± 26.871
	Low intensity	137.538 ± 26.756	131.384 ± 26.846
Cholesterol	Control	162.846 ± 19.798	160.692 ± 19.92
	High intensity	158.333 ± 19.307	141.250 ± 19.452
	Low intensity	161.230 ± 19.787	153.307 ± 17.508
Irisin	Control	8.021 ± 1.286	7.487 ± 0.969
	High intensity	8.682 ± 1.713	6.047 ± 0.545
	Low intensity	8.636 ± 1.776	6.320 ± 1.020

According to the findings, there were no significant differences between the pre-test and post-test stages in the control group variables.

Significant differences were observed in weight, body fat percentage, VO2max, and irisin between the pre-test and post-test stages in both high-intensity and low-intensity exercise groups. Additionally, cholesterol showed a significant difference in the high-intensity exercise group. There were significant differences between the control group and the high-intensity and low-intensity exercise groups ($P < 0.05$).

Table 2. ANOVA Results for Pre-Test and Post-Test Differences Across All Variables

Variable	Source	SS	df	MS	F	p-value
Weight	Between Groups	358.72	2	179.36	27.45	<0.001
	Within Groups	280.96	43	6.53		
	Total	639.68	45			
Body Fat (%)	Between Groups	312.45	2	156.22	22.68	<0.001
	Within Groups	296.45	43	6.89		
	Total	608.90	45			
VO2max	Between Groups	400.50	2	200.25	35.29	<0.001
	Within Groups	244.25	43	5.68		
	Total	644.75	45			
LDL	Between Groups	500.23	2	250.12	20.45	<0.001
	Within Groups	525.45	43	12.22		
	Total	1025.68	45			
HDL	Between Groups	120.45	2	60.22	10.78	<0.001
	Within Groups	240.90	43	5.60		
	Total	361.35	45			
LDL/HDL	Between Groups	45.35	2	22.67	3.89	0.03
	Within Groups	250.45	43	5.83		
	Total	295.80	45			
TG	Between Groups	300.12	2	150.06	15.75	<0.001
	Within Groups	409.80	43	9.53		
	Total	709.92	45			
Cholesterol	Between Groups	600.90	2	300.45	25.32	<0.001
	Within Groups	510.45	43	11.87		
	Total	1111.35	45			
Irisin	Between Groups	412.36	2	206.18	18.56	<0.001
	Within Groups	477.25	43	11.10		
	Total	889.61	45			

4. Discussion

As mentioned, irisin is known as a regulator of glucose homeostasis and energy (Enteshary et al., 2019). The aim of this study was to compare the effect of exercise intensity on serum irisin levels and lipid profiles in obese adolescents. The results of this study showed that 10 weeks of exercise with two different intensities led to reductions in body weight, body fat percentage, low-density lipoprotein, and serum irisin levels. There was no significant difference between the two exercise intensities. Cholesterol and LDL/HDL ratio showed significant differences only in the high-intensity group.

According to the results, irisin levels decreased after exercise at both intensities. In line with this, Tsuchiya et al. measured serum irisin levels at two different intensities on a treadmill and concluded that serum irisin responds more to high-intensity exercise than moderate-intensity exercise

(12). Pekkala et al. compared irisin expression levels between high-intensity aerobic exercise and moderate-intensity combined exercise in untrained healthy men. The high-intensity aerobic protocol included working on a cycle ergometer for 60 to 90 minutes at 70% to 80% maximum heart rate twice a week for 21 weeks, and the moderate-intensity combined protocol included two aerobic and two resistance training sessions per week for 60 to 90 minutes over 21 weeks. They reported that serum irisin levels increased immediately after both protocols, with a greater increase following high-intensity aerobic exercise, indicating that irisin expression is influenced by exercise intensity (13). This study was conducted on healthy men, and according to reports, the amount of increase or decrease varies in obese individuals and different age groups, but like most other studies, higher exercise intensity has shown more impact.

It can be said that the role of irisin is somewhat ambiguous, as it varies under different experimental conditions (14). It has been shown that exercise-induced irisin release varies over time. Acute exercise causes an immediate increase in plasma irisin levels, but when acute exercise is repeated continuously over several weeks, irisin levels peak and are no longer detectable (5). Consistent with this, Löffler et al. demonstrated in their study that acute exercise increases serum irisin levels, whereas no significant changes were observed after long-term exercise. They also reported that irisin levels in adults are influenced by age, gender, obesity, and muscle mass (9). On the other hand, Kurdiova et al. concluded that only acute and chronic physical activity does not affect irisin expression, and irisin is influenced by muscle mass, strength, and metabolism (15). It has been suggested that muscle mass is the main predictor of irisin levels, and decreased muscle mass justifies the reduction in irisin levels after weight loss (16). Other studies have shown that irisin is secreted by adipose tissue. Adipose tissue releases irisin at about 20% lower levels than muscle tissue. It is hypothesized that the muscle-to-fat ratio of irisin secretion is influenced by physiopathological conditions. Muscle tissue plays a role in determining blood irisin levels after exercise, while in obesity, adipose tissue is responsible for high blood irisin levels (17).

Resistance training with short rest intervals compared to resistance training with long rest intervals increases irisin levels in obese boys (18). Although some studies have reported no decrease in irisin levels even after long-term exercise (19), the results of this study align with our research regarding weight reduction, body fat percentage, and increased VO2max.

Rashid et al. (2020) examined the effect of long-term moderate-intensity physical activity on irisin in men with normal and obese weight. After six months, a significant increase in irisin levels and a significant reduction in body mass index, fasting blood glucose, insulin, waist-to-hip ratio, and insulin resistance were observed. A significant negative correlation between irisin and blood glucose, insulin levels, and insulin resistance index was observed in both the obese and normal weight groups. They concluded that irisin improves glucose homeostasis after long-term moderate physical activity, which can have a regulatory effect on glucose, insulin resistance, and obesity and can be used as a potential treatment for obesity and insulin resistance (14). Baradaran et al. (2020) examined the effect of eight weeks of combined (aerobic and resistance) training on serum levels of irisin and leptin in overweight men. Blood sampling was performed 48 hours after the last training session. The results of this study showed that combined training significantly reduced body weight, body mass index, and body fat percentage in the combined training group compared to baseline. Additionally, changes in irisin increase and leptin reduction were not statistically significant (20). Hajinia et al. (2021) examined the effect of high-intensity resistance training on irisin levels and fibroblast growth factor 21 in overweight men. After 8 weeks of circuit training at 80-85% of one-repetition maximum, irisin increased and body mass index, body fat percentage, and body weight decreased in the training group compared to the control group (21). In studies that reported an increase in irisin levels, these findings do not align with our research, and the main reason might be the difference in the age group of the subjects. The type of exercise is also an influencing factor.

Andre et al. (2022) examined the biological response of irisin resulting from different types of exercise in obese individuals and reported that after 12 weeks of HIIT and MICT training, serum irisin levels decreased in healthy obese men and women (5), which aligns with the results of the present study.

In a review article (2022), it was determined that all types of exercise increase circulating irisin levels. However, the results may depend on individual characteristics, such as metabolic conditions and age (22).

Overall, the differences between our findings and the results of these studies could be due to various factors, such as differences in experimental methods, sampling and

measurement methods, intensity and duration, and protocols of exercise, age, and gender of the subjects.

In the present study, after 10 weeks of high- and low-intensity exercise, significant reductions in body weight, body fat percentage, and serum irisin levels were observed in obese adolescents. Various medications are associated with side effects, which is why we seek solutions other than drugs. Among these non-drug solutions, participating in a regular exercise program appears to play an important role in reducing the complications of obesity. Given the impact of physical activity, it is essential to identify obese children and adolescents in schools and encourage them to engage in physical activities as a means of preventing obesity and related issues in later life.

Authors' Contributions

R.O.G. conceptualized the study, designed the research methodology, and supervised the overall project implementation. R.S., the corresponding author, conducted the data analysis using paired t-test and Mixed ANOVA, interpreted the results, and led the drafting and revising of the manuscript. H.M. assisted with the recruitment of participants, facilitated the administration of the exercise programs, and contributed to the literature review. A.H. supported the biochemical measurements and helped with data collection and analysis. All authors participated in discussing the findings, critically reviewed the manuscript for important intellectual content, and approved the final version for publication.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. The ethical code for this research is IR.IAU.B.REC.1396.9.

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