A COMPARISON OF THE EFFECTS OF RESISTANCE AND ENDURANCE TRAINING PROTOCOLS ON SERUM IRISIN LEVEL AND ALKALINE PHOSPHATASE ACTIVITY IN SEDENTARY OBESE WOMEN

FERESHTE POUTAFKAND[1], HAMID MAREFATI[2], HOSSEIN TAHERICHADORNESHIN[1]

[1]University of Bojnord, Department of Sport Sciences, Bojnord, Iran
[2]Hakim Sabzevari University, Department of Sport Sciences, Sabzevar, Iran

Mailing address: Hossein Taherichadorneshin, University of Bojnord, Department of Sport Sciences, Bojnord, North Khorasan, Iran, tel.: +00989158063957, e-mail: h.taheri@ub.ac.ir

Abstract
Introduction. Studies have revealed that the anabolic effect of irisin on bone is mediated by an increase in alkaline phosphatase. However, few studies have investigated the interactive effect of irisin on alkaline phosphatase after exercise training. Therefore, the present study aimed to compare the impact of endurance and resistance training protocols on serum irisin concentration and total alkaline phosphatase activity in sedentary obese women. ***Material and methods.*** Forty-five sedentary obese women (age: 48.96 ± 5.2 years, body mass index 32.24 ± 3.76 kg/m^2) were randomly assigned to control, endurance, and resistance groups. Endurance (45 to 75 minutes at an intensity corresponding to 50 to 80% of heart rate reserve) and resistance exercise training (3 sets, 10-15 repetitions at an intensity corresponding to 50 to 65% of one-repetition maximum) were conducted for 8 weeks, 3 days per week. Maximal oxygen consumption (VO2max) was estimated using the modified Bruce protocol treadmill test. Fasting blood samples were taken before the first and 48-hr after the last exercise training sessions. The serum concentrations of irisin and total alkaline phosphatase activity were measured using the sandwich ELISA method and photometric method, respectively. ***Results.*** Both endurance and resistance exercise training protocols caused a significant reduction in BMI and BFP of obese women. In contrast, VO_2max significantly increased after both exercise training protocols. However, neither endurance nor resistance training protocols had a significant impact on the serum concentrations of irisin and total alkaline phosphatase activity. No significant inter-group differences were observed between the subjects' BMI, BFP, VO_2max, total alkaline phosphatase, and irisin at the end of protocols. ***Conclusions.*** The finding of the current study revealed that neither of the training protocols had a significant impact on bone anabolic parameters. However, performing these types of exercise is suggested for weight management in obese women.

Key words: endurance training, resistance training, irisin, alkaline phosphatase, obese women

Introduction

Recently, the skeletal muscle has been termed an endocrine tissue. Not only does it contain important metabolic molecules, the expression of each of which alters the metabolism, but it is also related to other tissues through the secretion of hormones known as myokines [1, 2]. In a study conducted in Prof. Spiegelman's laboratory, the conversion of white adipose tissue to brown was found to increase calorific value and, ultimately, lead to weight loss [3]. The group's theory proposes a new myokine, which is induced by the peroxisome proliferator-activated receptor-gamma coactivator-1alpha (PGC-1α). PGC-1α is a highly important metabolic molecule expressed in the skeletal muscle and plays a vital role in glucose, fat, and energy homeostasis [1, 4]. This molecule regulates the expression of mitochondrial uncoupling protein 1 (UCP1). Therefore, it plays an important role in the exotherm of skeletal muscle and brown adipose tissue [1, 4].

While the irisin hormone was detected by the Bostrom Research Group and others in 2012, little research has ever since been conducted in this area. These researchers showed that the mice transgenically elevated with PGC-1α exhibited resistance to aging- and diabetes-associated obesity [3]. Recent research suggests that irisin acts directly on bone formation by regulating osteoblasts [5]. Irisin, which is released from the muscle tissue, increases cost-energy and the production of osteoblasts by affecting adipose and bone tissues, respectively [3]. The presence of a local network between fat and the bone tissue, known as the bone-fat axis, has been proved. In this paracrine cycle, fats affect the bone positively and negatively, such that brown fats underlie the evolution of osteoblasts by producing factors that may be secreted into the cycle or act directly on the surrounding bones [5].

Studies concerning the impact of physical activity on irisin have reported different results, and the type, intensity, and duration have been considered as effective factors of physical exercise on irisin [6, 7]. Some studies have measured the levels of irisin concentration at different training durations and with different exercise types (i.e., endurance, resistance, and/or a combination of both), showing that resistance training results in significant irisin responses compared to endurance and combination training types (6). One study reported that 11 weeks of endurance and resistance training did not have a significant effect on irisin promoter mRNA levels in either of the training groups, whereas differentiation of white fat cells from brown fat cells was observed [8]. Three weeks of moderate-intensity treadmill endurance training is shown to result in a 2-fold increase in UCP1 expression in the visceral adipose tissue and a 25-fold increase in the abdominal subcutaneous adipose tissue of rats. The same study showed that three weeks of swimming training resulted in a 65-fold increase in UCP1 expression of abdominal fat. The researchers also showed that 10 weeks of

Copyright © 2020 by the Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education and Health in Biała Podlaska

endurance training doubled the irisin and UCP1 promoters in human subjects [9]. According to the results of some studies, the amount of brown fat is significantly lower in obese people and a negative relationship holds between brown adipose tissue, fat percentage, and body mass index in inactive people [9]. Therefore, it can be inferred that exercise is one of the most important factors affecting the expression of genes and the associated effects on energy metabolism. In a study of mice, Colaianni et al. found that the mice that ran on wheels for three weeks not only had higher irisin expression than resting mice but also had a larger proportion of osteoblasts than the resting ones. Besides, osteoblasts increased alkaline phosphatase and increased collagen I expression in an irisin-dependent mechanism [5].

At present, there is no coherent information concerning the effect of resistance and aerobic exercise and the effect of their intensity on irisin and alkaline phosphatase simultaneously. These training methods can have different effects due to the varying intensity, length, and duration of the training period. Scientists have recently noticed the effect of irisin on bone development in mice, as well as the correlation of irisin and osteoporotic fractures in older women. One study has confirmed an inverse correlation between irisin levels and vertebral fractures but reported no significant association with BMD or body mass. Irisin may play a protective role in bone health, independently of BMD. Nonetheless, further research is required to elucidate the relationship between irisin and bone metabolism [10]. Therefore, this study aimed to investigate the effects of aerobic and resistance training in obese women on serum irisin levels as well as serum alkaline phosphatase activity as one of the ossifying markers.

Material and methods

Subjects

Forty-five sedentary obese women (age 48.96 ± 5.2 years, height 155.89 ± 4.72 cm, weight 78.40 ± 8.07 kg, body mass index: 32.24 ± 3.76 kg/m^2) were recruited in Ashkhaneh city (North Khorasan Province, Iran) to voluntarily participate in the quasi-experimental study after an advertisement was placed in public places and published on Telegram channels. The statistical samples of the present study are selected based on the background of studies conducted in this field. All subjects completed a health questionnaire and were examined by a general practitioner. Exclusion criteria comprised 1) history of any acute and chronic cardiovascular disease and metabolic disorders, 2) consumption of any medication, supplement, or treatment regimen with or without a doctor's prescription, 3) any neuromuscular and joint disease that limited physical activity, and 4) dependence on any drug, alcohol, caffeine, and smoking. The subjects completed Physical Activity Readiness Questionnaire. In addition, physical fitness level was evaluated using Baecke's physical activity questionnaire. They were considered inactive in the last 6 months if they had not 1) done heavy and intense work, 2) participated in regular physical activity more than once per week in their spare time, and 3) participated in light exercises more than 20 minutes a day and more than 3 times a week [11]. After information was given about the subject, goals, methods, possible side effects, and benefits of the study, all subjects signed a consent form to participate in the study. They were allowed to leave the study with or without any resentment. In the end, the subjects were randomly assigned to three equal groups of control, endurance training, and resistance training. During the study, 2 subjects from the endurance training group, 3 from the resistance training group, and 4 from the control group left the study. The research protocol was approved by the Institutional Review Board (University of Bojnord, Iran), and the procedures were in accordance with the 1975 Declaration of Helsinki, as revised in 1996. The demographic and anthropometric characteristics of the subjects are shown in Table 1.

Table 1. Demographic and anthropometric characteristics of study subjects

Group	Number (N)	Age (years)	Weight (kg)	Height (cm)
Control	11	48.36 ± 4.5	79 ± 9.7	156.3 ± 3.5
Endurance	13	49.53 ± 5.9	76.7 ± 6.6	154.5 ± 5.4
Resistance	12	49.01 ± 5.4	79.6 ± 8.3	156.9 ± 4.7

Anthropometric measurements

Anthropometric measurements were taken one week before the first training and 48 hours after the last training sessions in Hejab Sports Complex (Ashkhaneh, Iran). The subjects' height was measured by a wall-mounted stadiometer (Sahand CO. Tabriz, Iran) and their weight was measured using a digital scale (Sahand CO. Tabriz, Iran) with an accuracy of 0.1 kg and 1 cm, respectively. The subjects' height and weight were measured in standing position, with bare feet and empty bladders. Body mass index (BMI) is calculated as weight in kilograms divided by the square of height in meters. To calculate body density, the Jackson-Pollock three-spot formula (triceps, supraspinatus, and thigh) was employed using a slim guide caliper. Finally, body fat percentage (BFP) was calculated using the Siri equation formula [12].

Determination of the maximal oxygen consumption

One week before the first training session and 48 hours after the last training session, the subjects' maximal oxygen consumption (VO_2max) was assessed in Hejab Sports Complex (Ashkhaneh, Iran). The modified Bruce treadmill test is population-specific for active and sedentary adults with and without cardiac conditions. Therefore, the modified Bruce test was conducted on a calibrated motorized treadmill (Horizon Fitness HTM 3000 model) to assess VO2max. This test was performed under supervision of a physician at 15:00 to 17:00 p.m. The first two stages of the modified Bruce test are performed at a 1.7 mph and 0% grade and 1.7 mph and 5% grade. Then, speed and incline gradually increased every 3 minutes according to instruction until the participant voluntarily terminated the test due to fatigue, despite verbal encouragement. Heart rate (HR) and rating of perceived exertion (RPE) were continuously measured and recorded at the end of each stage (every three minutes) using a polar H10 cardio-frequency metre belt and Borg 20-point scale, respectively. The subject's effort was considered maximal if physical signs suggestive of exhaustion were apparent and two following criteria were met: (a) maximal HR no less than 15 beats below age-predicted maximal HR, (b) RPE more than 17 [13]. The VO_2max for each participant was determined by the following equation: VO2max (ml/kg/min) = 2.94 × running time + 3.74. Subjects performed stretching movements before the VO_2max test. They were asked to refrain from any acute exercise for 48 hours before the test. Besides, they were asked to load glycogen during this period.

Assessment of one-repetition maximum

One-repetition maximum (1-RM) of the subjects was determined one week before the first and 72 hours after the last training session under the direct supervision of certified strength and conditioning specialist in Koshesh Sports Complex (Ashkhaneh, Iran). All tests were assessed in two stages on the same devices, in the same positions, and by one same evaluator. Subjects ran on a treadmill for 7 minutes before the 1-RM test. After 3 minutes of rest, the 1-RM assessment process began. Based on the estimation of the subjects' strength experimentally, a weight was selected that the subject could lift at least once and at most 10 times completely and correctly. By inserting the number of repetitions and the amount of weight, the 1-RM value for each movement was determined by Brzycki equation [14] as follows: 1-RM = weight × [(number of repetitions × 0.033) + 1].

Endurance and resistance training protocols

Endurance and resistance training protocols were performed for 8 weeks, 3 sessions per week, and according to the overload principle in Koshesh Sports Complex (Ashkhaneh, Iran). Both protocols were conducted under the direct supervision of certified strength and conditioning specialist and physician at 15:00 to 18:00 p.m. Outdoor running endurance-training program was performed based on the percentage of heart rate reserve (HRR) (Tab. 2). Heart rate during endurance training was controlled using a polar H10 cardio-frequency metre belt. Karvonen formula was used to calculate HRR as: [(max HR - resting HR) × % intensity] + resting HR. The subjects in the resistance exercise group performed seven movements of bench press, lat pull, barbell triceps extension, barbell arm curl, leg curl, and leg extension. They performed each movement for 3 sets of 10 to 15 repetitions. The rest time between each set was 60 seconds as well as 2 minutes between each movement (Tab. 2). The subjects were familiarized with the procedure in three sessions within one week before the protocol started. Before and after each training session, they warmed up and cooled down for 10 minutes. The subjects in the control group did not participate in any training program.

Table 2. Endurance and resistance training protocols

		Endurance training	Resistance training
Week	Session	Length, intensity of running	Set, repetition, intensity
1	1	45 minutes, 50% HRR	3 sets, 10-15 repetitions, 50% 1-RM
	2	46 minutes, 50% HRR	3 sets, 10-15 repetitions, 50% 1-RM
	3	47 minutes, 50% HRR	3 sets, 10-15 repetitions, 50% 1-RM
2	4	48 minutes, 55% HRR	3 sets, 10-15 repetitions, 50% 1-RM
	5	49 minutes, 55% HRR	3 sets, 10-15 repetitions, 50% 1-RM
	6	51 minutes, 55% HRR	3 sets, 10-15 repetitions, 50% 1-RM
3	7	52 minutes, 60% HRR	3 sets, 10-15 repetitions, 55% 1-RM
	8	53 minutes, 60% HRR	3 sets, 10-15 repetitions, 55% 1-RM
	9	55 minutes, 60% HRR	3 sets, 10-15 repetitions, 55% 1-RM
4	10	56 minutes, 65% HRR	3 sets, 10-15 repetitions, 55% 1-RM
	11	57 minutes, 65% HRR	3 sets, 10-15 repetitions, 55% 1-RM
	12	59 minutes, 65% HRR	3 sets, 10-15 repetitions, 55% 1-RM
5	13	60 minutes, 65% HRR	3 sets, 10-15 repetitions, 60% 1-RM
	14	61 minutes, 65% HRR	3 sets, 10-15 repetitions, 60% 1-RM
	15	63 minutes, 65% HRR	3 sets, 10-15 repetitions, 60% 1-RM
6	16	64 minutes, 70% HRR	3 sets, 10-15 repetitions, 60% 1-RM
	17	65 minutes, 70% HRR	3 sets, 10-15 repetitions, 60% 1-RM
	18	67 minutes, 70% HRR	3 sets, 10-15 repetitions, 60% 1-RM
7	19	68 minutes, 75% HRR	3 sets, 10-15 repetitions, 65% 1-RM
	20	69 minutes, 75% HRR	3 sets, 10-15 repetitions, 65% 1-RM
	21	71 minutes, 75% HRR	3 sets, 10-15 repetitions, 65% 1-RM
8	22	72 minutes, 80% HRR	3 sets, 10-15 repetitions, 65% 1-RM
	23	73 minutes, 80% HRR	3 sets, 10-15 repetitions, 65% 1-RM
	24	75 minutes, 80% HRR	3 sets, 10-15 repetitions, 65% 1-RM

1-RM: One-Repetition Maximum, HRR: Heart Rate Reserve.

Dietary intake control

Dietary habits were assessed using a 3-day dietary record questionnaire filled out one week before the protocol initiated. The participants were asked to record all the drinks and food they had consumed. Nutritional analysis by a qualified dietician demonstrated that the calorie intakes from carbohydrate, protein and fat were 55%, 17%, and 28%, respectively. The subjects were asked to maintain their normal eating habits. In addition, they were instructed not to consume lipid-lowering drugs or supplements during the training protocol.

Blood sampling and biochemical evaluation

10 cc of fasting blood was taken from the brachial vein of the subjects before the first session and 48 hours after the completion of the protocol in the Farhangian Medical Laboratory (Ashkhaneh, Iran). To separate the serum, blood samples were centrifuged at 15°C for 15 minutes at 3000 rpm. Serum samples were stored for biochemical evaluation at -80°C. Serum irisin concentration was measured by the ELISA sandwich method using the ZellBio commercial kit (Germany). Also, the total serum alkaline phosphatase activity was measured through the photometric method using the Pars Azmoun commercial kit (Iran). The sensitivity values of irisin and alkaline phosphatase kits were 0.1 ng/ml and 4 IU/l, respectively.

Statistical analysis

Version 23 of the Statistical Package for Social Sciences (SPSS Institute, Chicago, USA) was used to analyze the data. The significance level was set at $p < 0.05$. The normal distribution of data was evaluated with the Shapiro-Wilk test. Dependent t-test and Wilcoxon test were used to evaluate within-group changes. To evaluate the between-group differences, analysis of covariance and Kruskal-Wallis test were used. Results are displayed as mean ± standard deviation.

Results

In terms of anthropometric variables, the within-group evaluation showed that both endurance training ($t = 2.60$, $p = 0.023$) and resistance training ($t = 3.25$, $p = 0.008$) caused a significant reduction in BMI. In addition, the within-group evaluation showed that both endurance training ($t = 8.15$, $p = 0.001$) and resistance training ($t = 5.52$, $p = 0.001$) significantly reduced BFP. However, no significant within-group change in the control group was observed in terms of BMI ($t = 1.48$, $p = 0.173$) and BFP ($t = 1.87$, $p = 0.201$). Also, between-group evaluation showed that there was no significant difference between BFP ($F = 2.885$, $p = 0.076$) and BMI ($F = 1.064$, $p = 0.357$) of the three groups at the end of the protocol (Tab. 3).

Regarding the physiological variable VO_2max, within-group evaluations showed that both endurance training ($t = 2.39$, $p = 0.038$) and resistance training ($t = 2.55$, $p = 0.029$)

Table 3. The effect of endurance and resistance training on anthropometric and physiological parameters in obese women

Parameter	Group	Before	After
BMI (kg/m^2)	Control	32.3 ± 32.7	32.3 ± 11.55
	Endurance	32.4 ± 27.2	31.4 ± 70.16*
	Resistance	32.3 ± 13.6	31.3 ± 66.46*
BFP (%)	Control	38.2 ± 33.88	35.1 ± 61.50
	Endurance	37.4 ± 52.2	31.3 ± 91.52*
	Resistance	36.4 ± 67.81	31.3 ± 98.49*
VO_2max (ml/ kg/min)	Control	40.4 ± 1.19	40.5 ± 32.59
	Endurance	33.4 ± 17.68	37.6 ± 16.26*
	Resistance	31.8 ± 24.24	34.9 ± 88.66*

* – indicates a significant difference with the before. BMI: Body Mass Index, BFP: Body Fat Percentage, VO_2max: Maximal Oxygen Consumption.

Table 4. The effect of endurance and resistance training on ossifying markers in obese women

Parameter	Group	Before	After
Alkaline phosphatase (U/L)	Control	239.13 ± 81.13	218.75 ± 54.13
	Endurance	187.59 ± 23.57	202.63 ± 15.54
	Resistance	193.37 ± 25.42	192.42 ± 41.98
Irisin (ng/ml)	Control	14.12 ± 93.38	15.11 ± 18.51
	Endurance	14.8 ± 49.83	15.9 ± 13.11
	Resistance	8.3 ± 79.88	9.5 ± 67.24

caused a significant increase in VO_2max. However, no significant within-group change was observed in the control group ($t = 0.132$, $p = 0.907$). Moreover, the between-group evaluations showed that there was no significant difference in VO_2max of the three groups at the end of study ($F = 0.420$, $p = 0.663$) (Tab. 3).

Concerning biochemical variables, within-group results showed that there was no significant difference in total alkaline phosphatase activity before and after the training course in the endurance training ($t = 1.708$, $p = 0.113$), resistance training ($t = 0.093$, $p = 0.927$), and control ($t = 0.938$, $p = 0.370$) groups. Besides, within-group results showed no significant difference in irisin levels before and after the training course in the three groups of endurance training ($z = 0.510$, $p = 0.917$), resistance training ($z = 999$, $p = 1.01$), and control ($z = 0.356$, $p = 0.722$). In addition, between-group results did not show a significant difference in alkaline phosphatase ($F = 0.610$, $p = 0.550$) and irisin ($F = 3.43$, $p = 0.180$,) in the three groups at the end of the study (Tab. 4).

Discussion and Conclusion

Obesity is a chronic disease that occurs due to an imbalance between the energy received and the energy consumed in our body. In fact, obesity is a condition in which excess adipose tissue accumulates in the body. Excessive accumulation of the adipose tissue can cause a decline in health indicators, including a reduction in life expectancy or a decrease in life quality. In other words, the appetite and desire for food and the metabolism in the body of obese people are uncoordinated. Obesity is a multifactorial phenomenon that arises from the interaction of several complex factors, including genetics and behavioral components, especially physical activity and diet, and is influenced by the socio-cultural and environmental contexts [15, 16]. Findings showed a significant difference in anthropometric factors including subcutaneous fat in the two training groups compared to baseline, although the effect of resistance training and aerobic training was not significantly different. Also, the results of aerobic and resistance training protocols on serum irisin and total alkaline phosphatase before and after the training period were not significantly different. Moreover, no difference was observed between the effects of aerobic and resistance training on physiological factors of serum irisin and total alkaline phosphatase.

The results of this study showed that performing a course of aerobic and resistance training was not associated with a significant change in serum levels of irisin, as similarly confirmed by Raschke et al. and Hakimi and Attarzade [8, 17]. One study reported that 11 weeks of endurance and resistance training did not have a significant effect on fibronectin type III domain-containing protein 5 (FNDC5) levels, the precursor of irisin, in either of the training groups, whereas differentiation of white fat cells to brown fat cells was observed [8]. Since no muscle tissue biopsy was performed in the present study, the conversion of white adipose tissue to brown adipose tissue may have occurred, while the circulating irisin may not have changed. Norheim et al. also observed a decrease in irisin in overweight men at 12 weeks of combined resistance and endurance training. They reported that irisin increased after intense acute training, although it decreased after 12 weeks. According to them, a 12-week exercise program has an impact on selected brown genes in the subcutaneous adipose tissue, whereas UCP1 mRNA is not associated with FNDC5 expression in the subcutaneous adipose tissue or skeletal muscle or plasma irisin levels [18], because irisin is a product of FNDC5 expression in the skeletal muscle. On the other hand, plasma irisin levels are associated with body mass index, cell mass, and free fat mass. Insufficiency of muscle mass in participants in these studies and their overweight could be the reason for the difference in irisin levels.

The results of this study showed that performing a course of endurance and resistance training has no significant effect on total alkaline phosphatase levels. The results agree with the findings from Bijeh et al. and Moazami et al.'s studies. Nevertheless, it does not agree with the results reported by Rudberg et al. in terms of exercise on an ergometer cycle, and Karabulut et al. concerning high-intensity and low-intensity resistance training [19, 20]. In Bijeh et al.'s study, which was conducted on middle-aged women, aerobic exercise was performed with 55-65% of HRR for 6 months; no significant change was found in total alkaline phosphatase, however [19]. Moazami et al. performed aerobic exercise on inactive obese women for 6 months. They reported that BMI and BFP decreased, while total alkaline phosphatase did not change significantly [20]. The low intensity of the exercise in our study may justify why it had little effect on total alkaline phosphatase. Upon a 9-week intense aerobic exercise with an intensity of 70-80% of maximum heart rate, Tartibian reported an increase in total alkaline phosphatase activity in young women, suggesting that the significant increase in total alkaline phosphatase relied on strain and pressure to the musculoskeletal system [21].

The results of this study showed the significant effect of aerobic and resistance training on body composition indices (subcutaneous fat, BMI). BMI decreased significantly in both aerobic and resistance exercise groups. Among studies with similar findings is Sadeghi et al.'s. In their research, 12 weeks of endurance training with 40-80% intensity significantly increased VO2max and significantly decreased weight, BMI, and BF% in women with high body mass index [22]. Moreover, most previous research concerning the effect of resistance training in inactive and obese girls as well as in overweight women has revealed a significant decrease in BMI and BFP [23, 24]. The results of this study, however, do not correspond with the findings of some other researchers. Poehlman et al. performed aerobic and endurance training on young non-obese women for 6 months. The results showed that in all the three groups of endurance, resistance and control, body weight and BMI did not change. Moreover, while fat mass did not change in all the three groups, free-fat mass increased only in the resistance training group compared to the control group [12]. Khorramjah et al.'s study was conducted on 24 obese and overweight postmenopausal women. The experimental groups participated in an aerobic exercise program (with an intensity of 65 to 75% of maximum heart rate) or resistance (with an intensity of 55 to 65% of 1-RM) for 10 weeks. The study found no significant difference in weight, BMI, waist circumference, and BFP between the two groups [25].

The present study showed that aerobic and resistance training for eight weeks increased VO_2max. These results are consistent with the findings of Motamedi et al. [26]. Motamedi et al. examined the effect of a diet with or without aerobic exercise on anthropometric indices and cardiorespiratory fitness of men aged 25 to 50 years, concluding that eight weeks of aerobic exercise, three sessions per week, with an intensity of 55 to 60 % HRR, comprising brisk walking, jogging, and a combination of simple aerobic steps, increased VO_2max levels at the end of the period. Aerobic exercise increases the number of capillaries in the muscle fibers and the cross-section area of the muscle, which can lead to better blood flow to the muscle. It also increases the number and size of skeletal muscle mitochondria and improves the possibility of muscle oxidative metabolism, which results in increased muscle aerobic capacity [26]. In general, the findings of the present study showed that neither the endurance nor the resistance exercise has a significant impact on the anabolic parameters of bone. However, these two types of exercise are recommended for weight management in obese women.

The findings of the present study show a significant decrease in BMI and weight, which is probably due to increased energy consumption, and progress in the oxidation of skeletal fat due to aerobic and resistance training. It is argued that during aerobic activities, fatty acids are used as the main fuel by the muscle, leading to reduced body fat [27]. Aerobic exercise reduces visceral fat and total abdominal fat. In general, the results of the present study showed that resistance and aerobic exercise did not have a significant effect on serum irisin levels and bone-building markers in obese women. Nevertheless, the significant weight loss, BMI, BFP, and increased VO_2max in both aerobic and resistance training groups, as well as an increase in 1-RM in the resistance training group, can be attributed to the favorable effects of aerobic and resistance training programs as effective non-pharmacological methods in weight control and regulation of body energy balance. However, given the conflicting findings and limited information, the effects of these types of exercise in obese people are not definitive, and it is necessary to do more research in this regard with larger sample size and wider age range. One of the main limitations of the present study was the lack of a controlled diet. The subjects were asked to maintain their nutrient type, caloric intake and normal eating habits; however, there is no documentation that these subjects kept the same dietary habits. In fact, the type of nutrition and amount of consumed calories can affect the body composition. Future research should include a detailed record of food intake throughout the study.

References

1. Polyzos S.A., Kountouras J., Shields K., Mantzoros C.S. (2013). Irisin: a renaissance in metabolism? *Metabolism: Clinical and Experimental* 62(8), 1037-44. DOI: 10.1016/j.metabol.2013.04.008
2. Pedersen B.K. (2012). A muscular twist on the fate of fat. *New England Journal of Medicine* 366(16), 1544-5. DOI: 10.1056/NEJMcibr1201024
3. Boström P., Wu J., Jedrychowski M.P., Korde A., Ye L., Lo J.C., et al. (2012). A PGC1-α-dependent myokine that drives brown-fat-like development of white fat and thermogenesis. *Nature* 481(7382), 463. DOI: 10.1038/nature10777
4. Puigserver P., Wu Z., Park C.W., Graves R., Wright M., Spiegelman B.M. (1998). A cold-inducible coactivator of nuclear receptors linked to adaptive thermogenesis. *Cell* 92(6), 829-39. DOI: 10.1016/s0092-8674(00)81410-5
5. Colaianni G., Cuscito C., Mongelli T., Oranger A., Mori G., Brunetti G., et al. (2014). Irisin enhances osteoblast differentiation in vitro. *International Journal of Endocrinology*, ID 902186. DOI: 10.1155/2014/902186
6. Tsuchiya Y., Ando D., Takamatsu K., Goto K. (2015). Resistance exercise induces a greater irisin response than endurance exercise. *Metabolism* 64(9), 1042-50. DOI: 10.1016/j.metabol.2015.05.010
7. Huh J.Y., Panagiotou G., Mougios V., Brinkoetter M., Vamvini M.T., Schneider B.E., et al. (2012). FNDC5 and irisin in humans: I. Predictors of circulating concentrations in serum and plasma and II. mRNA expression and circulating concentrations in response to weight loss and exercise. *Metabolism* 61(12), 1725-38. DOI: 10.1016/j.metabol.2012.09.002
8. Raschke S., Elsen M., Gassenhuber H., Sommerfeld M., Schwahn U., Brockmann B., et al. (2013). Evidence against a beneficial effect of irisin in humans. *PloS ONE* 8(9), e73680. DOI: 10.1371/journal.pone.0073680
9. Khosravianfar M., Sharifi G. (2018). Comparison of the effect of period of resistance, aerobic and concurrent training on irisin, CRP serum levels in obese women. *Journal of Shahrekord University of Medical Sciences* 20(2), 13-23.
10. Palermo A., Strollo R., Maddaloni E., Tuccinardi D., D'Onofrio L., Briganti S.I., et al. (2015). Irisin is associated with osteoporotic fractures independently of bone mineral density, body composition or daily physical activity. *Clinical Endocrinology* 82(4), 615-9. DOI: 10.1111/cen.12672
11. Martins C., Kazakova I., Ludviksen M., Mehus I., Wisloff U., Kulseng B., et al. (2016). High-intensity interval training and isocaloric moderate-intensity continuous training result in similar improvements in body composition and fitness in obese individuals. *International Journal of Sport Nutrition and Exercise Metabolism* 26(3), 197-204. DOI: 10.1123/ijsnem.2015-0078
12. Mogharnasi M., Taherichadorneshin H., Abbasi-Deloei N. (2019). Effect of exercise training type on plasma levels of vaspin, nesfatin-1, and high-sensitivity C-reactive protein in overweight and obese women. *Obesity Medicine* 13, 34-8. DOI: 10.1016/j.obmed.2018.12.006
13. Midgley A.W., McNaughton L.R., Polman R., Marchant D. (2007). Criteria for determination of maximal oxygen uptake. *Sports Medicine* 37(12), 1019-28. DOI: 10.2165/00007256-200737120-00002

14. Brzycki M. (1993). Strength testing-predicting a one--rep max from reps-to-fatigue. *Journal of Physical Education, Recreation & Dance* 64(1), 88-90. DOI: 10.1080/07303084.1993.10606684
15. Ekelund U.L., Neovius M., Linné Y., Brage S., Wareham N.J., Rössner S. (2005). Associations between physical activity and fat mass in adolescents: the Stockholm Weight Development Study. *The American Journal of Clinical Nutrition* 81(2), 355-60. DOI: 10.1093/ajcn.81.2.355
16. Daniels S.R., Arnett D.K., Eckel R.H., Gidding S.S., Hayman L.L., Kumanyika S., et al. (2005). Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment. *Circulation* 111(15), 1999-2012. DOI: 10.1161/01.CIR.0000161369.71722.10
17. Hakimi M., Attarzade H.S. (2016). The changes of irisin serum levels and lipid profile of overweight male students after eight weeks of aerobic training. *Journal of Shahid Sadoughi University of Medical Sciences and Health Services* 23(12), 1233-1245.
18. Norheim F., Langleite T.M., Hjorth M., Holen T., Kielland A., Stadheim H.K., et al. (2014). The effects of acute and chronic exercise on PGC1α, irisin and browning of subcutaneous adipose tissue in humans. *The FEBS Journal* 281(3), 739-49. DOI: 10.1111/febs.12619
19. Bijeh N., Moazami M., Mansouri J., Nematpour F., Ejtehadi M.M. (2011). Effect of aerobic exercises on markers of bone metabolism in middle-aged women. *Kowsar Medical Journal* 16(2), 129-35.
20. Moazemi M., Jamali F.S. (2014). The effect of 6-months aerobic exercises on bone-specific alkaline phosphatase and parathyroid hormone in obese inactive woman. *Journal of Sport in Biomotor Sciences* 5(2), 71-9.
21. Tartibian B., Moutab S.N. (2009). Effects of 9-weeks high intensity aerobic exercises on parathyroid hormone and marker of metabolism of bone formation in young women. *Olympic* 16(4), 79-88.
22. Sadeghi S. (2017). The effect of twelve weeks endurance training on liver enzymes levels in Iranian obese women. *Scientific Journals Management System* 15(13), 49-60.
23. Khalili S., Nouri R. (2013). The effect of eight weeks resistance training on leptin and insulin resistance in obese female. *Avicenna Journal of Clinical Medicine* 20(1), 59-65.
24. Ghanbari-Niaki A., Saghebjoo M., Soltani R., Kirwan J.P. (2010). Plasma visfatin is increased after high-intensity exercise. *Annals of Nutrition and Metabolism* 57(1), 3-8. DOI: 10.1159/000313936
25. Khoramjah M., Khorshidi D., Karimi M. (2019). Effect of moderate-intensity aerobic training on some hormonal and metabolic factors associated with breast cancer in overweight postmenopausal women. *Iranian Journal of Ageing* 14(1), 74-83.
26. Motamedi P., Nikroo H., Hejazi K. (2017). The effects of eight-weeks aerobic training on serum leptin levels, anthropometric indices and VO2max in sedentary obese men. *Iranian Journal of Ergonomics* 5(1), 36-42.
27. Hoseinikakhk S.A., Khaleghzadeh H., Nematy M., Hamedinia M. (2015). The effect of combined aerobic- resistance training on lipid profile and liver enzymes in patients with non-alcoholic fatty liver under nutrition diet. *Sport Physiology* 7(27), 65-84.

Submitted: September 26, 2020
Accepted: October 31, 2020