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# Comparison of the Effects of Yoga Exercises and Moderate-Intensity Aerobic Training on Irisin and Insulin Resistance in Women with Type 2 Diabetes

Dahshti Abbas Mohammed. Al Jammoor[1], Rahman. Soori[2*], Parisa. Pournemati[3]

[1] Department of Exercise Physiology, Faculty of Sport Sciences and Health, University of Tehran, Tehran
[2] Professor, Department of Exercise Physiology, Faculty of Sport Sciences and Health, University of Tehran, Tehran, Iran
[3] Assistant Professor, Department of Exercise Physiology, Faculty of Sport Sciences and Health, University of Tehran, Tehran, Iran

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

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ABSTRACT

**Objective:** The present study examines the Comparison of the Effects of Yoga Exercises and Moderate-Intensity Aerobic Training on Irisin and Insulin Resistance in Women with Type 2 Diabetes.

**Materials and Methods:** Thirty middle-aged diabetic women with a mean age of 53.0 ± 4.31 years, height of 159.3 ± 4.54 cm, and weight of 70.8 ± 5.72 kg were randomly assigned to three groups: yoga exercise (experimental group 1), aerobic training (experimental group 2), and control. The aerobic training group performed a program consisting of three 60-minute sessions per week at an intensity of 60–70% of maximum heart rate, using light weights to simulate a combined protocol. Each session included 10 minutes of warm-up and 20 minutes of cool-down with stretching and flexibility exercises. Yoga training sessions were conducted three times a week for 60 minutes under the supervision of experienced instructors. The principle of overload was applied in the yoga protocol by increasing repetitions from 3 sets over 9 minutes in the first session to 9 sets, while rest periods were reduced, and exercise intensity was increased. Participants were advised to refrain from engaging in any other physical activity during the 12-week intervention.

**Findings:** In the interaction effect between groups and time, although weight and body fat percentage decreased in both training groups, the difference between groups was not statistically significant. No significant difference was observed in serum fasting blood sugar (FBS) levels among obese women with type 2 diabetes ($P \geq 0.05$). Changes in HOMA-IR levels across the groups ($P = 0.67$) and measurement times ($P = 0.18$) in the control, aerobic, and yoga groups were also not significant. The interaction effect of group and time on serum irisin levels in diabetic women showed no significant changes ($P = 0.67$), though serum irisin levels increased in the aerobic group. However, the time effect from

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pre- to post-test among groups (P = 0.70) and the between-group effects were not statistically significant (P ≥ 0.05).

**Conclusion:** Although the effects of the exercises were not statistically significant, considering the increased interest of patients in performing both exercises, especially yoga, these exercises can be used as complementary training for diabetic patients.

**Keywords:** *Irisin, Diabetes, Yoga, Diabetic Patients*

## 1. Introduction

Type 2 diabetes is one of the most common chronic diseases globally, posing a persistent and worldwide threat to human health and global medical care (1). Regardless of whether the prediabetes phenotype is defined by postprandial hyperglycemia (impaired glucose tolerance) and/or fasting hyperglycemia (impaired fasting glucose, HbA1c), lifestyle modification has been suggested (2). However, current evidence indicates that diabetes prevention programs based on lifestyle changes have not been successful in preventing type 2 diabetes in individuals with impaired fasting glucose. The incidence of diabetes is rapidly increasing, often resulting in significant metabolic disease and severe complications (3).

In recent years, scientists' research in the field of metabolism and energy homeostasis has led to the identification of new factors associated with homeostasis and metabolism, among which irisin is noteworthy (4). Recent studies have shown that levels of irisin, adropin, and preptin are lower in depressed individuals who participate in physical activities, and a positive correlation has been identified between quality of life and a negative association with functional disorders (5). Irisin, which is produced as a myokine in response to muscle activity and exercise, has been identified as a hormone that, by converting white fat to brown fat, leads to changes in metabolic properties, increases with exercise, and acts as a protective factor against obesity, hyperglycemia, and insulin resistance, thereby preventing diabetes (6).

It has been shown that muscle mass is the most critical factor for circulating irisin levels, and weight loss and reduced muscle mass lead to lower irisin levels (7). In a study by Bonfante et al. (2022) involving 34 overweight and type 2 diabetic patients, it was found that combined training increased the thermogenic activity of brown fat in areas such as the cervical and supraclavicular regions. They also reported a positive correlation between changes in brown fat and levels of irisin and adiponectin (8). Additionally, it has been shown that the production of irisin by organs other than muscle tissue may significantly influence serum irisin levels. Researchers have observed a decrease in skeletal muscle ATP concentrations when circulating irisin levels increase, leading to the hypothesis that irisin has short-term effects on restoring glucose homeostasis (9).

The effects of various physical activities on irisin levels and metabolic markers have generally been reported following endurance and resistance training (10-12). However, there has been limited research on new effective methods for weight loss and diabetes management, such as yoga exercises. Our review did not find any studies that examined yoga practices on the factors discussed within a diabetic population. However, in a study by Kumar Singh et al. (2019) involving prediabetic women undergoing a diabetic yoga protocol, significant reductions in HbA1c and glucose levels were observed (13). Aydin et al. (2023) conducted research on the effects of irisin induction and physical activities in rats with metabolic syndrome and higher uric acid levels, demonstrating that the combination of irisin injections and exercise had a significant impact on improving the metabolic profile of subjects (14).

Given the increased use of yoga exercises in recent years, which have fewer injury risks and provide physical and psychological benefits, this study was designed to investigate the impact of yoga and combined aerobic exercise on serum irisin levels and insulin resistance (5, 14). Moreover, diabetic patients, often suffering from complications such as diabetic foot ulcers or various neuropathies, may be more inclined to engage in low-impact exercises like yoga. Consequently, this research aimed to explore the effectiveness of yoga and combined aerobic training on serum irisin levels and insulin resistance.

## 2. Methods and Materials

### *2.1 Study Design and Participants*

The present study is a quasi-experimental design using a pre-test and post-test approach. The ethical code for this study is IR.UT.PSYEDU.REC.1403.078. The statistical sample included 30 overweight women with type 2 diabetes, randomly divided into three groups: the first group (yoga exercises, n = 10), the second group (moderate-intensity aerobic physical activity, n = 10), and the third group (control, n = 10). Blood samples and related analyses were collected from all participants before and after 12 weeks of training.

Prior to the intervention, fasting blood samples were collected in the morning from the antecubital vein using 5 cc syringes and placed in tubes containing antiprotease. Serum was separated using a centrifuge at room temperature and then stored at -80°C for biochemical measurements. Irisin levels were measured using a sandwich ELISA method with research kits from ZellBio, Germany. Insulin resistance was calculated using the following formula:

HOMA-IR = (insulin × glucose) / 405

At the end of the 12-week intervention, blood samples were collected from the research and control groups 48 hours after the last training session, similar to the first phase. It should be noted that blood sampling in both phases was conducted under identical conditions in terms of the environment and time for all subjects.

## 2.2 Training Protocols

1) The aerobic training group performed sessions three times a week, starting at 60 minutes per session with an intensity of 60% of maximum heart rate, which was gradually increased to 70% by the end of the training period. Light weights were also used to better simulate the combined protocol. The intensity of the training was monitored using a Polar heart rate monitor. Each session included a 10-minute warm-up and a 20-minute cool-down with stretching and flexibility exercises.

2) The yoga sessions were also conducted three times a week for 60 minutes each, under the supervision of experienced instructors. The principle of overload in the yoga training protocol was applied by increasing the number of repetitions, starting from 3 repetitions over 9 minutes in the first session, gradually reducing rest time and increasing the intensity of the exercises. Participants were instructed to refrain from engaging in any other physical activities during the 12-week training program.

## 2.3 Data Analysis

Data were analyzed using the Shapiro-Wilk test (to check for normal distribution), paired t-test (for within-group changes), and two-way repeated measures ANOVA (for between-group changes). All tests were conducted with a 0.05 error level, and data analysis was performed using SPSS version 20, while graphs were generated with Excel.

# 3. Results

The mean and standard deviation of pre-test and post-test variables, including weight, height, age, waist-to-hip ratio (WHR), body mass index (BMI), insulin resistance index, and serum irisin levels, are presented in Table 1.

**Table 1.** Descriptive Statistics of Variables Across Research Groups

| Variable | Group | Pre-Test Mean ± Standard Deviation | Post-Test Mean ± Standard Deviation |
|---|---|---|---|
| Weight (kg) | Yoga | 70.59 ± 6.72 | 69.92 ± 6.60 |
| | Aerobic | 70.92 ± 5.09 | 68.47 ± 5.01 |
| | Control | 70.98 ± 5.89 | 71.83 ± 7.61 |
| Body Fat (%) | Yoga | 39.88 ± 3.59 | 39.67 ± 3.80 |
| | Aerobic | 41.04 ± 3.71 | 39.91 ± 3.78 |
| | Control | 41.63 ± 2.01 | 42.14 ± 3.13 |
| WHR | Yoga | 0.91 ± 0.04 | 0.90 ± 0.04 |
| | Aerobic | 0.91 ± 0.04 | 0.91 ± 0.04 |
| | Control | 0.92 ± 0.05 | 0.92 ± 0.05 |
| BMI ($W/H^2$) | Yoga | 27.75 ± 2.71 | 27.46 ± 2.73 |
| | Aerobic | 28.08 ± 2.43 | 27.10 ± 2.44 |
| | Control | 28.05 ± 2.62 | 28.41 ± 3.47 |
| FBS (mg/dL) | Yoga | 150.20 ± 51.06 | 140.30 ± 36.47 |
| | Aerobic | 182.50 ± 45.92 | 145.40 ± 34.59 |
| | Control | 130.25 ± 34.91 | 133.50 ± 34.87 |
| HOMA-IR | Yoga | 4.57 ± 2.32 | 5.55 ± 2.65 |
| | Aerobic | 7.66 ± 6.90 | 4.53 ± 2.94 |
| | Control | 3.06 ± 1.74 | 5.05 ± 4.53 |
| Irisin (µg/mL) | Yoga | 10.09 ± 2.34 | 9.40 ± 2.14 |
| | Aerobic | 9.37 ± 1.21 | 9.54 ± 1.84 |
| | Control | 10.28 ± 0.79 | 9.59 ± 1.21 |

The interaction effect of group and time showed that although weight and body fat percentage decreased in both exercise groups, the differences between groups were not statistically significant. Additionally, there was no significant change in fasting blood sugar (FBS) levels among obese women with type 2 diabetes ($P \geq 0.05$) (Figure 1). Changes in HOMA-IR levels within groups ($P = 0.67$) and across measurement times ($P = 0.18$) for the control, aerobic, and yoga groups were also not statistically significant (Figure 2).

Examining the interaction effect of group and time on serum irisin levels in diabetic women across the research groups showed no significant differences ($P = 0.67$), although an increase in serum irisin levels was observed in the aerobic group (Figure 3). However, the effect of measurement times from pre-test to post-test within groups ($P = 0.70$) and the between-group effects were not statistically significant ($P = 0.39$).

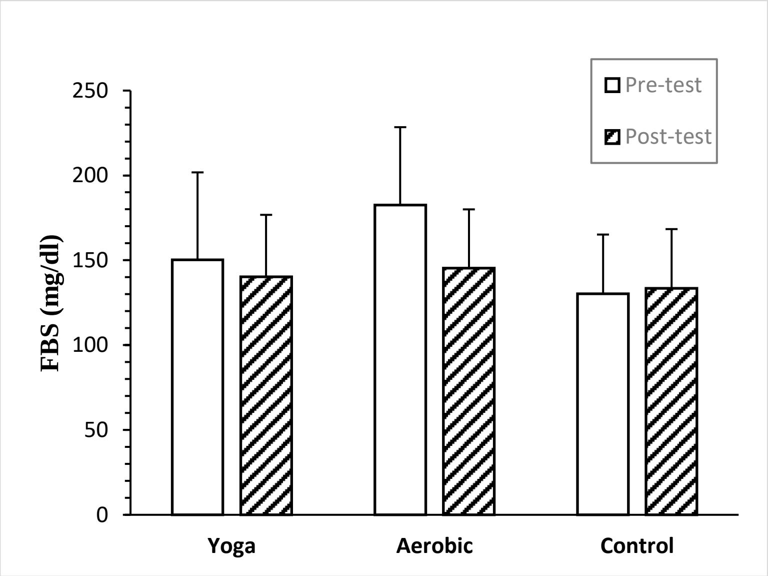


**Figure 1.** Comparison of Changes in Blood Sugar Levels Across Research Groups

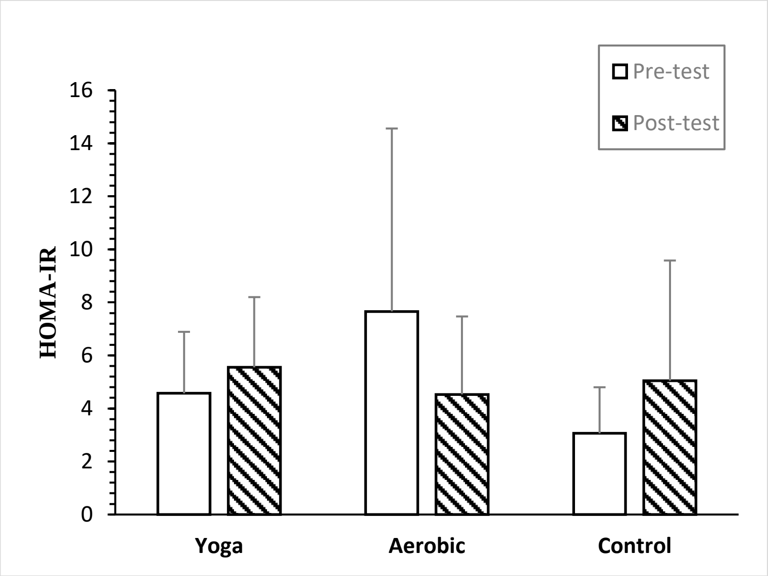


**Figure 2.** Comparison of Changes in Insulin Resistance Across Research Groups

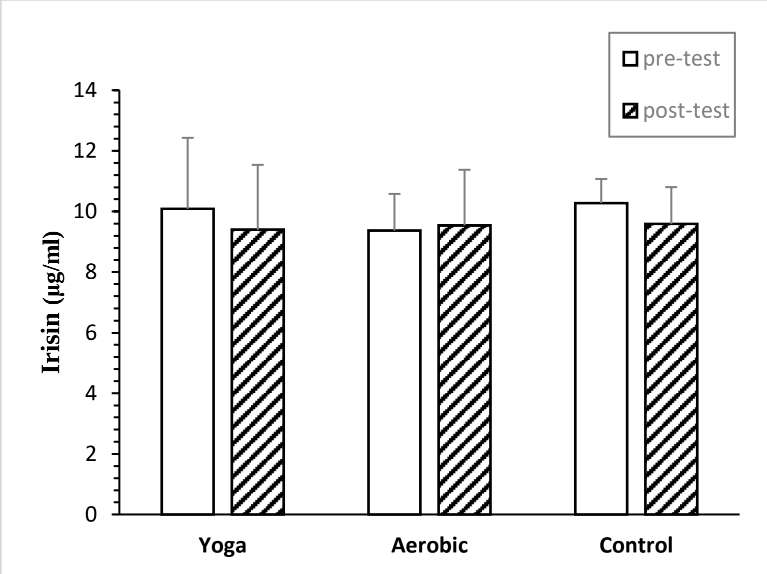


**Figure 3.** Comparison of Changes in Serum Irisin Levels Across Research Groups

## 4. Discussion and Conclusion

In recent years, the role of irisin in regulating glucose homeostasis, basal metabolism, and energy has become evident (15). Furthermore, a recent study in this area revealed that irisin, adropin, and preptin levels are lower in depressed individuals who participate in physical activities, with a positive relationship between quality of life and a negative association with functional disorders (5). Generally, irisin levels in adults are influenced by age, gender, obesity, and muscle mass, and with an increase in any of these factors, serum irisin levels may decrease (9).

According to the results of this study, weight and body fat percentage decreased in both the aerobic and yoga exercise groups, but the differences between groups were not statistically significant. Additionally, there was no significant change in fasting blood sugar (FBS) levels among obese women with type 2 diabetes ($P \geq 0.05$). Changes in insulin resistance levels among groups ($P = 0.67$) and measurement times ($P = 0.18$) for the control, aerobic, and yoga groups were also not significant. After 12 weeks of yoga and aerobic training, changes in serum irisin levels were not significant, although an increase was observed in the aerobic group ($P \geq 0.05$). Kurdiova and colleagues found that both acute and chronic physical activity do not affect irisin expression, and irisin is influenced by muscle mass, strength, and metabolism (11). Some studies have also reported no decrease in irisin levels even after prolonged physical activity (10). Muscle mass is the primary predictor of irisin levels, and a reduction in muscle mass explains the decrease in irisin levels following weight loss. Overall, the role of irisin remains somewhat unclear, as it varies under different experimental conditions (7).

It has been shown that the release of exercise-induced irisin varies over time. Short, intense training sessions lead to a rapid increase in plasma irisin levels, but when acute exercise is consistently repeated over several weeks, irisin levels peak and are no longer detectable (9). Some research has indicated that serum irisin responds more strongly to high-intensity exercise compared to moderate-intensity exercise (16). A rapid increase in serum irisin levels as a result of intense exercise has been reported in some studies. Reports suggest that the extent of increase or decrease varies among obese individuals and across different age groups. However, as in most studies, higher intensity exercises have shown greater effects (12).

While the primary role of physical activity in increasing irisin levels is undeniable, irisin injection may also be effective when combined with physical exercise. Aydin and colleagues (2023) demonstrated in a study on rats with metabolic syndrome and higher uric acid levels that irisin injection, combined with physical activity, had a significant impact on improving the metabolic profile (14). However, some studies have observed no significant increase in irisin despite improved insulin resistance. Baradaran and colleagues (2020) reported significant decreases in body weight, BMI, and body fat percentage in overweight men after eight weeks of combined aerobic and resistance training, though changes in irisin and leptin were not significant (17). In this study, blood sugar levels decreased in both exercise groups, and insulin resistance improved in the aerobic group. Although these changes were relatively strong, they were not statistically significant, possibly due to increased standard deviation values resulting from diabetic participants with substantial variations in these factors, likely caused by insulin injections or anti-hyperglycemic medications. Additionally, muscle tissue changes in diabetic participants may have been less pronounced than in the aerobic group, confirming that muscle tissue plays a role in determining post-exercise irisin levels, while in obesity, adipose tissue is responsible for higher irisin levels (7, 18).

Other studies have also shown that irisin is secreted by adipose tissue. Adipose tissue releases irisin at approximately 20% less than muscle tissue. It is hypothesized that the muscle-to-fat ratio of irisin secretion is influenced by pathophysiological conditions. D'Amuri and colleagues (2022) investigated irisin levels induced by various 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. This finding aligns with the results in the yoga and control groups (19). In recent years, reviews have indicated that all types of exercise can increase circulating irisin levels. However, results may depend on individual characteristics, such as metabolic conditions and age (20).

Considering the reduced use of medications in this study and participants' interest in yoga and aerobic training, it is recommended that these exercises be included in the training programs for patients with diabetes.

This study had several limitations, including a small sample size, which may have affected the statistical power and the generalizability of the results. Additionally, variations in participants' adherence to the training protocol and potential external factors such as diet and medication use were not fully controlled, which could have influenced the findings. Future research should consider larger, more diverse populations and explore the long-term effects of different types and intensities of exercise on irisin levels and metabolic outcomes. It would also be beneficial to investigate the mechanisms underlying the differential responses to exercise in various demographic and clinical subgroups, such as age and metabolic status. From a practical standpoint, implementing yoga and aerobic training programs tailored for individuals with type 2 diabetes in clinical and community settings could improve overall metabolic health and reduce reliance on medication, enhancing patients' quality of life.

## Authors' Contributions

D.A.M. contributed to the conceptualization and design of the study, as well as the data collection and analysis. R.S. was responsible for overseeing the methodology, statistical analysis, and interpretation of the results. P.P. played a key role in drafting the manuscript, reviewing the literature, and refining the discussion section. All authors contributed to revising the manuscript critically 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.

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