ABSTRACT

Background and objectives: Previous investigations have shown that physical activity can improve insulin sensitivity and body composition by reducing the concentration of inflammatory biomarkers. The study aimed at evaluating effects of eight weeks of resistance training and high-intensity interval training on adropin, blood glucose markers, and body composition in overweight females.

Methods: sixteen overweight females (mean age: 30 ± 4.3 years and body mass index= 29 ± 2.6 kg/m²) were randomly assigned to a resistance training group (n=8) and a high-intensity interval training group (n=8). Participants in both groups trained three times a week for eight weeks. Body composition and serum level of blood markers were determined at baseline and after the last training session.

Results: Body mass, body fat percentage, and waist-hip ratio decreased significantly in both groups (p<0.05). VO₂max significantly increased in both groups, while the changes in the resistance training group were greater than in the high-intensity interval training group (p<0.05). Insulin and HOMA-IR concentrations decreased significantly in the resistance training group (p<0.05).

Conclusion: Eight weeks of both training procedures could significantly decrease body composition markers. However, the training duration was not sufficient to alter fasting blood sugar or adropin concentrations.

Keywords: Body composition, obesity, resistance training, high-intensity interval training.
INTRODUCTION

Obesity and overweight are the major contributors to many diseases such as type 2 diabetes (T2D) and cardiovascular disease by mainly increasing risk of chronic inflammation, insulin resistance, dyslipidemia, and hypertension (1, 2). Various factors such as sedentarism, smoking, and excessive alcohol consumption can increase the severity of the mentioned diseases, especially T2D (3). Insulin resistance, an indicator of T2D, refers to a condition in which physiological concentrations of insulin are less effective in controlling blood sugar (4, 5). In this condition, cells become resistant to insulin, which is tightly linked with development of T2D (6, 7). On the other hand, adipose tissue has been shown to play a key role in insulin resistance through the irregular secretion of numerous inflammatory biomarkers including apelin, tumor necrosis factor, leptin, adiponectin, angiotensin, resistin, etc. (8-13). In addition, adropin has been recently regarded as a metabolic hormone involved in the regulation of lipid metabolism that could be reduced in obese individuals (14-17). Research shows that transgenic overexpression or systemic adropin treatment improves diet-induced obesity, insulin resistance, and glucose tolerance (18). More specifically, adropin attenuates body mass and obesity-associated metabolic disorders (16). Overall, adropin could be considered as a promising target for developing therapies against the metabolic disorders associated with obesity (18).

Previous investigations have shown that physical activity can improve insulin sensitivity and body composition by reducing the concentration of inflammatory biomarkers (19). For instance, endurance training (ET) has been shown to decrease adiposity, which negatively correlates with inflammatory biomarkers (20, 21). Particularly, the intensity of ET has been the subject of interest due to its impact on health-related outcomes of this exercise (22). High-intensity interval training (HIIT) is an effective method to stimulate several metabolic adaptations, such as decreased inflammatory markers in obese individuals, which in turn could increase insulin sensitivity while decreasing insulin resistance (9). In this regard, it has been recently reported that continuous moderate-intensity exercise for 30 minutes does not affect body fat percentage compared to HIIT (9). In one study, eight weeks of ET significantly increased serum adropin concentrations in obese adults (23). Fujie et al. (2015) also reported that eight weeks of ET at 60-70% of maximum heart rate increased adropin concentrations in healthy middle-aged and elderly individuals (24). Furthermore, Alizadeh et al. (2018) demonstrated a significant increase in adropin concentrations following ET in overweight females (25).

Given the lack of studies on the effects of resistance training (RT) and HIIT on serum concentrations of adropin in obese or overweight individuals, we aimed to compare effects of RT and HIIT on body composition, insulin, and adropin concentrations in overweight females.

MATERIALS AND METHODS

Twenty-four overweight and obese females (mean age: 30 ± 4.3 years, mean height: 164.8 ± 4.4 cm) participated in the present study. Inclusion criteria included age of between 25 and 35 years and body mass index (BMI) of 25-35. Exclusion criteria were having cardiovascular disease, diabetes, hypertension, sleep disorders, and history of regular exercise in the last six months. Written consent was obtained from all subjects before participation in the study. The study protocol was approved by the Institutional Human Subject Committee of Ferdowsi University of Mashhad and carried out in accordance with the Declaration of Helsinki.

Before baseline measurements, the participants were familiarized with the experiments and procedures. Then, they were randomly assigned into a RT group (n=8) and a HIIT group (n=8). The allocation was stratified by BMI of <25.0 or ≥25.0 kg/m², and the sequence was randomized by a computer. Measurements were made at baseline and after eight weeks of training at a specific time. The subjects were instructed not to alter their regular lifestyle and dietary habits during the study. Maximal strength testing was carried out 24 hours after the body composition measurement. For this purpose, the subjects first warmed up for 10 minutes and then performed two attempts to lift heaviest weight, and the number of repetitions was recorded. The number of repetitions to fatigue did not exceed 10. There were 3-5-minutes of resting
Subjects in the RT group completed the supervised training three times a week for eight weeks, with at least 48 hours intervals. Before the training session, the subjects started with 10 minutes of general and specific warm-up activities (slow running, stretching and light RT). The training session included four sets of lower and upper limb exercises with 70% of 1RM with 10–12 repetitions. There were 60-second and 2-minute rest intervals between the sets and exercises, respectively. To verify the principle of overload, the following formula was used to predict the 1RM and to determine the exercise load before the start of the training period, on the fourth week, and at the end of the eighth week (27): 1RM = W/ [1.0278(0.0278.r)] (26).

Subjects in the HIIT group also performed 30 minutes of supervised training three times a week for eight weeks, with at least 48 hours intervals. Each HIIT session began with a 5-minute warm-up, followed by 3 or 4 and 5 to 10 minutes short sprints, mixed conditioning, long sprints, power-short, and power long exercises. The participants were required to empty bladder within 30 minutes of arriving at the laboratory. Body mass (BM) was measured using a digital scale (Rohs, China) to the nearest 0.1 kg. Height was measured with a stadiometer (Seca, Germany) to the nearest 0.1 cm. Finally, BMI, body fat percentage (BFP), skeletal muscle mass (SMM), and waist hip ratio (WHR) were determined using a multi-frequency bioelectrical impedance device (Inbody 720, South Korea). Fasting blood samples (5 ml) were taken from the cubital vein using standard procedures. Blood sampling was performed 48 hours before the first exercise session and 48 hours after the last exercise session. Serum was separated and stored at −80 °C for later analysis. Serum concentration of adropin was measured using a commercial enzyme-linked immunosorbent assay (ELISA) kit (Eastbiopharm, sensitivity: 2.4 ng/L). Fasting blood sugar (FBS) was measured using glucose oxidase method using a commercial kit (Pars Azmun, sensitivity: 5 mg/dl). Blood insulin concentration was measured using a commercial radioimmunoassay kit (Demeditec, sensitivity: 1.76 micIU/ml). Insulin resistance was also calculated using the following equation:

\[
\text{HOMA-IR} = \frac{[\text{glucose (nmol/L)}] \times \text{insulin (\muU/mL)}}{22.5}
\]

Normality of data was confirmed by the Shapiro-Wilk test. Changes in body composition and blood parameters were compared using two-way repeated measures ANOVA [group (RT × HIIT) × time (pre × post)]. One-way ANOVA was used to evaluate changes between pre-intervention and post-intervention values where appropriate. Data analysis was carried out in SPSS Statistics (version 24, IBM, USA). Cohen’s $d$ effect size (ES) was calculated as post-training mean minus pre-training mean/pooled pre-training standard deviation means (29). In addition, ES values of 0.00-0.19, 0.20-0.49, 0.50-0.79, and ≥ 0.80 were considered trivial, small, moderate, and large, respectively. Statistical significance was set at 0.05.

RESULTS

Compliance with RT and HIIT conditions was 66.6 %. Four participants in both groups dropped due to unwillingness to carry out exercise procedures. The values of variables did not differ significantly at baseline (p>0.05). A significant effect of time was observed for BM (p<0.001), BFP (p<0.01), WHR (p<0.01), and VO$_{2\text{max}}$ (p<0.01), while no time × group interaction was detected for the variables overtime (p>0.05). The values of BM, BFP, and WHR decreased significantly in both groups. Interestingly, VO$_{2\text{max}}$ significantly increased in both groups and the changes in the RT group was greater than HIIT group. However, SMM, adropin and FBS did not change significantly in the study groups (p>0.05). Insulin and HOMA-IR concentrations decreased significantly in the RT group (Table 1).

DISCUSSION

The present study aimed at comparing the effects of eight weeks of RT and HIIT on adropin, blood glucose markers, and body composition in overweight females. The beneficial effects of physical activity on body composition indices are well documented (30-32). Traditional ET focuses on longer exercise for longer periods, while HIIT consists of high-intensity, short-term training, and active recovery periods, which has significant advantage over traditional ET in terms of time efficiency (33).
Adropin is effective in increasing TSC2 protein concentrations after aerobic exercise has been demonstrated (23). Adropin is effective in preventing obesity, insulin resistance, and impaired glucose tolerance (18). It seems that improved body composition through physical activity might affect adopin concentrations. Fujie et al. found that serum adropin concentrations are increased by approximately 75% after eight weeks of regular aerobic exercise (24). Alizadeh et al. insulin resistance but not FBS and adropin concentrations in overweight women (25). In our study, insulin and HOMA-IR decreased

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM (kg)</td>
<td>HIIT</td>
<td>77.3 ± 7.8</td>
<td>73.5 ± 7.0*</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>79.4 ± 8.7</td>
<td>77.3 ± 7.8*</td>
<td>0.001</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>HIIT</td>
<td>28.8 ± 2.3</td>
<td>27 ± 1.7</td>
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</tr>
<tr>
<td></td>
<td>RT</td>
<td>29.2 ± 3.1</td>
<td>28.3 ± 3.2</td>
<td>0.003</td>
</tr>
<tr>
<td>FBF (%)</td>
<td>HIIT</td>
<td>38 ± 6.4</td>
<td>36.1 ± 5.9*</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>39.3 ± 5</td>
<td>38.3 ± 5.2</td>
<td>0.521</td>
</tr>
<tr>
<td>SMM (kg)</td>
<td>HIIT</td>
<td>26.2 ± 2.4</td>
<td>25.6 ± 2.1</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>26.4 ± 2.9</td>
<td>26.1 ± 2.5</td>
<td>0.001</td>
</tr>
<tr>
<td>WHR (m)</td>
<td>HIIT</td>
<td>0.89 ± 0.02</td>
<td>0.86 ± 0.01*</td>
<td>0.989</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>0.89 ± 0.05</td>
<td>0.86 ± 0.05*</td>
<td>0.589</td>
</tr>
<tr>
<td>VO₂max (L/min)</td>
<td>HIIT</td>
<td>1.7 ± 0.3</td>
<td>2.2 ± 0.3*</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>RT</td>
<td>1.6 ± 0.4</td>
<td>2.4 ± 0.7*</td>
<td>0.784</td>
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<tr>
<td>Adropin (ng/L)</td>
<td>HIIT</td>
<td>51.8 ± 19.4</td>
<td>54.8 ± 11.7</td>
<td>0.470</td>
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<tr>
<td></td>
<td>RT</td>
<td>51.2 ± 25.6</td>
<td>57.9 ± 16.2</td>
<td>0.989</td>
</tr>
<tr>
<td>FBS (ml/dL)</td>
<td>HIIT</td>
<td>81.5 ± 9.8</td>
<td>75.8 ± 5.8</td>
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<td>RT</td>
<td>84.5 ± 8</td>
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<td>Insulin (micIU/mL)</td>
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<tr>
<td>HOMA-IR</td>
<td>HIIT</td>
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<td>2.6 ± 1.4</td>
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<tr>
<td></td>
<td>RT</td>
<td>3.7 ± 1.2</td>
<td>2.8 ± 1.1*</td>
<td>0.176</td>
</tr>
</tbody>
</table>

There is robust evidence that HIIT may pose superior benefits compared to traditional endurance exercise on health markers (34, 35). In our study, HIIT was more effective than RT in decreasing BM and BFP, which seems not surprising. It is hypothesized that elevated excess post-exercise oxygen consumption compared to traditional endurance exercised or RT may account for the decrease in BM and BFP in the HIIT group (36-39).

Furthermore, it seems that post-exercise fat oxidation following HIIT is due to hormonal response (40). Although the hormonal responses were not evaluated in the present study, the lipolytic effects of epinephrine in response to HIIT are well-described (41), which would be expected to stimulate fat loss (42). Another main effect of HIIT is the suppression of appetite (43), which might contribute to the decrease in nutrients intake and the subsequent fat and BM loss. In the present study, SMM did not change significantly following both procedures. It seems that the duration of our RT procedure was not long enough, which could explain the lack of significant effect on SMM after eight weeks. Despite the beneficial effects of HIIT on fat loss, this type of exercise may not be advantageous to RT in augmenting SMM gains due to increased energy expenditure after exercise (44), which increases TSC2 protein may be in results of energy deficiency. The experienced energy deficiency inhibits the mechanistic target of rapamycin complex 1, which is the most important signaling pathway in boosting muscle protein synthesis and increased SMM gains (45). The higher increase of VO₂max in the RT group compared to the HIIT group was an interesting finding of our study. However, research has shown increases in SMM in exercising muscle and blood flow to active musculature as well as cardiac output (SV max and maximal heart rate) and arteriovenous oxygen difference (capillary density and myoglobin concentration) contribute to the RT-induced increase of VO₂max (46). Both RT and HIIT protocols failed to alter adropin or FBS concentrations. However, insulin and HOMA-IR concentrations significantly decreased in the RT group. Adropin regulates nitric oxide synthesis through vascular endothelial growth factor receptor 2. Although research on Adropin is very limited, the elevation of adopin concentrations after aerobic exercise has been demonstrated (23). Adropin is effective in preventing obesity, insulin resistance, and impaired glucose tolerance (18). Thus, it seems that improved body composition through physical activity might affect adopin concentrations. Fujie et al. found that serum adropin concentrations are increased by approximately 75% after eight weeks of regular aerobic exercise (24). Alizadeh et al. insulin resistance but not FBS and adropin concentrations in overweight women (25). In our study, insulin and HOMA-IR decreased
assessed reported that 30 minutes of aerobic exercise could improve insulin levels and significantly in the RT group. This may be due to the appropriate training period and the involvement of large muscle groups in the training protocol that require higher cellular energy compared to small muscle groups \(^{(47)}\). The limitations of our study include the small sample size and utilization of bioelectrical impedance to measure body composition, which is not as accurate as dual-energy x-ray absorptiometry (the gold standard technique for body composition measurement); however, previous studies have shown that it is a valid and reliable method \(^{(48, 49)}\).

CONCLUSION
Despite application of a proper volume and intensity of both RT and HIIT procedures, only the concentrations of insulin and HOMA-IR changed significantly after eight weeks of RT. However, both exercises similarly affected body composition indices. In addition, RT was not capable of affecting SMM overtime maybe due to short period of study. Conducting future studies with a larger sample size for longer periods could verify our findings.

ACKNOWLEDGMENTS
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DECLARATIONS
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This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics approvals and consent to participate
Written consent was obtained from all subjects before participation in the study. The study protocol was approved by the Institutional Human Subject Committee of Ferdowsi University of Mashhad and carried out in accordance with the Declaration of Helsinki.

Conflict of interest
The authors declare that there is no conflict of interest regarding publication of this article.

REFERENCES


38. Hazell TJ, Olver TD, Hamilton CD, Lemon PW. Two minutes of sprint-interval exercise elicits 24-hr oxygen consumption similar to that of 30 min of continuous endurance exercise. International journal of sport nutrition and exercise metabolism. 2012; 22(4): 276-83. [PubMed] [Google Scholar]

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