# Comparing the effect of high-intensity functional training with resistance training on glucose control and insulin resistance in obese men

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# مقارنة تأثير التدريب الوظيفي عالي الكثافة مع تدريبات المقاومة على التحكم في الجلوكوز ومقاومة الأنسولين لدى الرجال البدناء

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## الملخص:-

هدف البحث: تعدُ السمنة من أهم تحديات القرن الحادي والعشرين وهي من أهم أسباب انتشار الأمراض والوفيات على نطاق واسع بين المجتمعات المختلفة، لذلك هدفت هذه الدراسة إلى مقارنة تأثير تدريبات المقاومة الدائرية والتدريب الوظيفي عالي الكثافة على مؤشر مقاومة الأنسولين ومستويات التحكم في الجلوكوز لدى الرجال الذين يعانون من زيادة الوزن والسمنة .

طريقة البحث: في هذه الدراسة شبه التجريبية، بتصميم اختبار ما قبل الاختبار وبعده، تم اختيار ٣٦ شابًا نشطًا تتراوح أعمارهم بين ٢٥ إلى ٣٥ عامًا بشكل عشوائي وتقسيمهم إلى ثلاث مجموعات من التدريب الوظيفي المكثف وتدريبات المقاومة الدائرية والتحكم، تم إجراء أخذ عينات الدم على مرحلتين: تم إجراء اختبار ما قبل الاختبار (٢٤ ساعة قبل بدء فترة التدخل) واختبار ما بعده (٤٨ ساعة بعد انتهاء فترة التدخل)، خلال هذه المدة، شاركت مجموعة التحكم في أنشطتها اليومية ؛ بينما قامت مجموعات التدريب بأداء التمارين المطلوبة، تم تحليل البيانات المجمعة بواسطة اختبار t التابع وتحليل التباين المشترك.

النتائج: أظهرت النتائج أن نسبة الجلوكوز في الدم الصائم، والأنسولين في الدم الصائم، و HOMA-IRلدى الرجال الذين يعانون من زيادة الوزن والسمنة كانت أعلى بشكل ملحوظ بعد تدريب المقاومة الدائرية (P = 0.0001)وتدريب HIFT (P = 0.0001) وانخفضت، أظهرت النتائج أنه لدى الرجال الذين يعانون من زيادة الوزن والسمنة، انخفضت مستويات الجلوكوز والأنسولين ومقاومة الأنسولين في مجموعات التمرين بشكل ملحوظ مقارنة بمجموعة التحكم .(P <0.05) ولكن لم يتم العثور على فرق كبير بين تدريب المقاومة الدائرية وتدريب HIFT (P <0.05) .

الخلاصة: بشكل عام، أظهرت نتائج الدراسة الحالية أن تدريب المقاومة الدائرية المكثفة والوظيفية - كلاهما - قلل من مقاومة الأنسولين ومستويات الجلوكوز لدى الرجال الذين يعانون من زيادة الوزن والسمنة.


**الكلمات المفتاحية:** السمنة، التدريب الوظيفي عالي الكثافة، تدريب المقاومة، مقاومة الأنسولين.


## Abstract:-

Research Aim: Obesity is one of the most important challenges of the 21st century and is one of the most important causes of the spread of disease and widespread mortality among different societies. Therefore, the aim of this study was to compare the effect of circular resistance training and High Intensity Functional Training on insulin resistance index and glucose control levels in overweight and obese men.

Research method: In this quasi-experimental study, with a pre-test-post-test design, 36 young active men with an age range of 25 to 35 years were randomly selected and divided into three groups of intense functional training, circular resistance training and control. Blood sampling was performed in two stages: pre-test (24 hours before the start of the intervention period) and post-test (48 hours after the end of the intervention period) Was performed. During this period, the control group engaged in their daily activities; While the training groups performed the desired exercises. The collected data were analyzed by dependent t-test and ANCOVA.

Findings: The results showed that fasting blood glucose, fasting blood insulin, HOMA-IR of overweight and obese men were significantly higher after circular resistance training (P = 0.0001) and HIFT training (P = 0.0001) Decreased. The results showed that in overweight and obese men, the levels of glucose, insulin, insulin resistance in the exercise groups were significantly reduced compared to the control group (P <0.05). But no significant difference was found between circular resistance training and HIFT training (P <0.05).

Conclusion: In general, the findings of the present study showed that intense circular and functional resistance training - both - reduced insulin resistance and glucose levels in obese and overweight men.


**Key words:** Obesity, High Intensity Functional Training, resistance training, Insulin Resistance.

## Introduction:-

A sedentary lifestyle is a health problem in modern human societies, leading to increased fat cell size and number, obesity, insulin resistance, and the risk of coronary artery disease. In this regard, researchers are looking for biomarkers that can better identify the effects of obesity on various physiological systems of the body. Human adipose tissue secretes several protein cytokines, which mediate various biological effects (1).

Exercise and physical activity are powerful non-pharmacological therapeutic tools for reducing obesity and preventing overweight, which are effective in modulating insulin resistance. High-intensity functional training (HIFT), which includes the CrossFit® training concept, is a training paradigm that originates from high-intensity interval training (HIIT) and well-studied strength training paradigms. HIFT involves a variety of functional movements performed at high intensity and designed to improve general health and performance parameters (2). HIFT can be adapted to a variety of fitness levels and can induce greater muscle recruitment compared with aerobic exercise and improve cardiovascular endurance and strength (3).

Functionally, while HIFT improves markers of body composition such as lean body mass and fat mass, body fat percentage, and glucose regulation (1), it has also been shown to enhance several cognitive domains. The HIIT component of HIFT has been shown to induce the secretion of proangiogenic vascular endothelial growth factor (VEGF), a growth factor that promotes angiogenesis and the formation of new blood vessels (4).

HIFT is a relatively new training paradigm that has been developed to increase parameters of cardiovascular fitness as well as parameters of skeletal muscle strength (5). Given the presence of both aerobic and strength components in HIFT training, it appears to improve skeletal muscle, cardiovascular function, reduce fat mass, and increase lean body mass (6). However, given the contradictory findings regarding the effects of high-intensity functional training on glucose and insulin control pathways, body composition, and appetite, as well as comparing the effects of this type of training with traditional circuit resistance training, the aim of the present study was to investigate the effects of eight weeks of HIFT and traditional circuit

resistance training on serum glucose, insulin, insulin resistance, and leptin levels in obese men.

**Research method**

Given that the present study was conducted on a human sample and due to the lack of control over all conditions of research on human samples, the present study method is semi-experimental and practical in terms of the application of the results. In this study, the dependent variables were conducted as a pre-test-post-test. Data collection was in the field and laboratory.

The participants of the present study were healthy overweight and obese men (BMI≥25kg/m2). Participants were invited to this study through cyberspace advertisements using WhatsApp and Instagram software. Inclusion criteria included the following: men aged 25-35, inactive (no history of resistance and functional training or any regular exercise in the last 6 months), body mass index (BMI) (kg/m2) between 25 and 40, no history of smoking and stable weight changes (less than 5% weight changes in the last 6 months). Exclusion criteria also included: diabetes or evidence of clinical depression, cognitive disorders, heart disease, cancers, liver and kidney diseases, chronic lung diseases, uncontrolled blood pressure, physical disability or any limitation that prevents physical activity or weight loss (such as osteoporosis). Finally, after screening, 40 participants were selected from 83 young obese and overweight men. Then, the participants were randomly assigned to 3 groups (HIFT training (n = 14), circuit resistance training group (n = 13), and control group (n = 13)). After a full explanation of all risks, all participants gave their informed consent before participating in this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committees and with the 1964 Declaration of Helsinki. Comparable modifications or ethical standards the control group was assessed only at the pre-test and post-test periods and did not perform any regular exercise or strenuous physical activity during the study period. The study lasted for eight weeks. The dependent variables were assessed twice - once at the beginning and once at the end of the eight-week period. One session was dedicated to explaining the experimental procedures to the participants. Participants were asked to maintain

their dietary patterns throughout the study. Dietary intake was recorded during the intervention. Dietary guidelines for weight control were not provided during the study and subjects were asked not to change their eating habits. The ingredients and calorie intake were the same on the days before blood collection. During the study, 2 participants in the HIFT training group, 1 participant in the control group, and 1 participant in the circuit resistance training group were excluded from the study process (due to medication use or absence of more than one session), and finally 36 people attended the study until the end and completed the study.

After the familiarization sessions, the subjects will be measured at the location of the desired sports club for the initial body composition test. In order to eliminate the potential effect of diet on muscle structure and body composition, the subjects were fasting for 12 hours. The subjects were fully hydrated 24 hours before the intervention and the start of the test process, but they were not allowed to use alcohol, caffeine, or intense exercise.

After the necessary coordination with the gym officials and trainers, the main protocol began for 8 weeks. All participants were also asked to maintain their normal diet throughout the study and, depending on the group they were in, not to change their physical activity or participate in other sports activities. High-intensity functional training (HIFT) was performed according to the study by Feito et al. (2019), the total training period of the subjects was 24 sessions (8 weeks) and each session was about 60 minutes of activity. CrossFit was used as the HIFT program in this study (1). All HIFT sessions were supervised and led by a level 2 instructor, and the first and second sessions used common HIFT movements (squats, deadlifts, presses, barbells, dumbbells, medicine ball exercises, pull-ups, kettlebell swings, etc.); no additional exercises were performed on these two days. Beginning on the third day, each HIFT class consisted of 10–15 min of stretching and warm-up, 10–20 min of training and instructional movements and techniques, and 5–30 min of a work-of-the-day (WOD) performed at a very high intensity and relative to the individual's ability. The main components of the training included aerobic activities (running, jumping rope), bodyweight activities (pull-ups, squats), and weightlifting (front squats, kettlebell swings), always performed in the form of CrossFit

exercises in single, double, and triple sets for time, reps, or weight. Each weight and movement performed was recorded according to the individual's understanding and ability in each training session. Based on the WOD characteristics, the time to complete the WOD, the repetitions and rounds completed in the WOD, the weights used, and any equipment needed to perform a training program, the daily training volume was recorded.

Circuit Resistance Training (CRT) Protocol

All participants attended the gym before the start of the eight-week intervention. Participants attended the gym for one session to familiarize themselves with the exercise equipment and the correct technique for all exercises. The CRT consisted of an eight-week training program that participants had to complete three times.

All participants had low levels of physical activity according to the International Physical Activity Questionnaire (IPAQ), except for one in the control group and two in the HIFT group who had moderate levels of physical activity. Participants were instructed to maintain their lifestyle (abstain from any additional physical activity) and dietary habits throughout the study. Physical activity levels (outside the exercise program in the experimental groups) were confirmed for all participants after the study with the IPAQ.

Perceived activity intensity was recorded as a way to monitor exercise load using the OMNI-RES (0 = very easy to 10 = very hard) (7). Participants were given instructions before each session. In addition, participants were instructed to rate their overall perception of exercise difficulty at the end of each exercise set.

BMI was calculated as weight in kilograms divided by height in meters squared. Waist-to-hip ratio (WHR) was calculated as waist circumference divided by hip circumference.

To measure biochemical variables in all 3 study groups, blood sampling was performed in two stages: pre-test (24 hours before the start of the intervention period) and post-test (48 hours after the end of the intervention period). To measure fasting blood glucose, fasting insulin, and serum leptin levels in the subjects, after at least 12 hours of overnight fasting, 7 ml of blood was taken from the brachial vein of each individual and the blood sample was immediately poured into

EDTA-containing tubes. The samples were centrifuged at 4°C, at a speed of 3000 rpm, for 20 minutes. Then, plasma and serum were poured separately into labeled tubes and stored in a freezer at -30°C for future measurement of blood variables. At this temperature, the samples can be stored for a maximum of one year. To minimize the effects of exercise on blood samples, subjects did not do any exercise for 72 hours before. Blood sampling was performed between 8-10 am to observe the circadian rhythm of protein secretion. Sample collection in the laboratory and the measurement steps were performed at room temperature (18-25 °C).

A Pars Azmoun Company kit made in Iran was used to assess blood glucose, and a Crystal D Company kit made in China was used to assess insulin (internal precision (CV) less than 10% and external precision less than 12% with a wavelength of 450 nm). Insulin resistance was also calculated and evaluated using the homeostasis model assessment of insulin resistance and based on the following equation (8):

HOMA-IR = (FBS (mmol/L) × FBI (IU per ml) ÷ 22.5)

Where HOMA is the homeostasis model of insulin resistance, FBS is fasting blood glucose values, and FBI is fasting blood insulin values.

After data collection, SPSS version 22 statistical software was used to analyze them; in a way that the values of central tendency and mean dispersion and standard deviation were used to estimate descriptive statistics of the research. The Shapiro-Wilks statistical test was used to examine the distribution of data and the t-test was used to compare means within groups and the analysis of covariance (ANCOVA) test was used to compare between groups. The significance level was considered to be P<%5. All data analysis was performed using SPSS22 software.

Result

The results of the univariate analysis of covariance test show that there is a significant difference in glucose levels between circuit resistance training and HIFT with a significance of 0.007 and an effect size of 0.265. The results of the Bonferroni post hoc test showed that in overweight men, the glucose levels of the training

groups decreased significantly compared to the control group (P<0.05). However, no significant difference was found between circuit resistance training and HIFT training (P<0.05). Also, the glucose levels of overweight men decreased significantly after circuit resistance training (P=0.0001) and HIFT training (P=0.0001). Figure-1 shows the changes in mean glucose in different groups during the pre-test and post-test stages.

The results of the univariate analysis of covariance test show that there is a significant difference in insulin levels between circuit resistance training and HIFT with a significance of 0.0001 and an effect size of 0.473. The results of the Bonferroni post hoc test showed that in overweight men, the insulin levels of the training groups decreased significantly compared to the control group (P<0.05). However, no significant difference was found between circuit resistance training and HIFT training (P<0.05). The results of the dependent t-test show that the insulin levels of overweight men decreased significantly after circuit resistance training (P=0.0001) and HIFT training (P=0.0001

The results of the univariate analysis of covariance test show that circuit resistance training and HIFT have a significant difference in the level of insulin resistance with a significance of 0.0001 and an effect size of 0.437. The results of the Bonferroni post hoc test showed that in overweight men, the levels of insulin resistance in the training groups have decreased significantly compared to the control group (P<0.05). However, no significant difference was found between circuit resistance training and HIFT training (P<0.05). The results of the dependent t-test show that the levels of insulin resistance in overweight men have decreased significantly after circuit resistance training (P=0.0001) and HIFT training (P=0.0001). Figure-2 shows the changes in the mean insulin resistance in different groups during the pre-test and post-test stages.

## Discussion

The aim of the present study was to investigate the effect of high-intensity functional training (HIFT) and circuit resistance training (CRT) on glucose control and insulin resistance in overweight and obese individuals. The findings of the present study showed that fasting blood glucose, fasting insulin, insulin resistance, and leptin

levels decreased after 8 weeks of circuit resistance training (CRT) and high-intensity functional training (HIFT). While there was no significant difference between the experimental groups.

Overweight and obesity are important risk factors for T2D and contribute to insulin resistance in obese individuals. Even if body weight is within the normal range, individuals with abnormal BMI and waist circumference may also face an increased risk of abnormal glucose metabolism (9). The main mechanism of body weight loss induced by exercise training may be related to fat consumption and release from visceral fat stores (10).

One of the most important findings of the present study was the improvement of insulin resistance index after 8 weeks of high-intensity functional training (HIFT) and circuit resistance training (CRT); in such a way that in the HIFT and CRT groups, compared to the non-training group, fasting blood glucose (FBS), insulin, and insulin resistance (HOMA-IR) levels were significantly reduced. In addition, there was no significant difference between the groups, however, the highest reduction was in the HIFT group. The results of the present study are consistent with the findings of Feito et al. (1), Fiali et al. (11), and Niewedt et al. (12). Few studies have been conducted regarding the effect of high-intensity functional training (HIFT) and CRT on changes in glycemic factors. However, studies have shown that regular exercise can increase insulin sensitivity in obese individuals and T2DM patients as a non-pharmacological treatment (13). Recently, Niewedt et al. (12) examined changes in beta-cell function after six weeks of HIFT among 12 sedentary adults with T2DM. After completing 10–20 min sessions 3 days per week, participants demonstrated significant improvements in beta-cell function, while reducing body fat and maintaining lean mass (12). In another study, Feeley et al. (11) evaluated the effectiveness of their 6-week HIFT intervention on cardiometabolic risk factors and reported improvements in blood pressure, body composition, fat oxidation, plasma triglycerides, and very low-density lipoprotein. In addition, insulin sensitivity increased after exercise, although the downward shift in glucose after the intervention was not statistically significant. These two studies provided initial insight into the benefits of HIFT among individuals with T2DM and supported the idea that this type of exercise is beneficial for individuals with T2DM, even if

the total exercise volume was lower than usual (14, 15). In a similar study, Feito et al. (1) examined the effects of a standard aerobic + resistance training (A-RT) exercise program and a high-intensity functional training (HIFT) exercise program in overweight and obese, inactive adults. Improvements in body composition and glucose control variables were observed in both groups, but the HIFT group showed greater improvements in body composition and glucose control variables compared with the A-RT group. The only significant difference was in the increase in lean body mass of the legs in the HIFT group (1). Interestingly, lean body mass improved in the HIFT group, which holds promise for individuals with type 2 diabetes. Although no significant differences were observed between the experimental groups in the present study, our study provides the first look at the comparison between HIFT and circuit resistance training on glucose, insulin, and leptin control, which has not been observed in the literature to date. On the other hand, in studies that are inconsistent with the present study, researchers have found that 8–12 weeks of training may not be sufficient time to significantly improve glucose metabolism after endurance and resistance training programs in nondiabetic individuals (16, 17).

Researchers have shown that in T2DM and obese individuals, fasting insulin concentrations, fasting glucose, and homeostasis model assessment of insulin resistance (HOMA-IR) were lower after prolonged HIIT compared with continuous aerobic exercise (18). Based on these results, the researchers suggested that the lower fasting insulin is due to adaptations in available glucose (improved skeletal muscle insulin signaling) rather than effects on pancreatic β-cell insulin secretion (18). Millard et al. (19) also reported a reduction in fasting insulin, fasting glucose, and homeostatic insulin resistance (HOMA-IR) in postmenopausal women with T2DM after 16 weeks of HIIT. The researchers found that behavioral differences in energy intake (18) and mitochondrial biogenesis (20) were effective in reducing insulin resistance and glucose homeostasis after HIIT. On the other hand, another study reported that 33 sessions of HIIT on an ergometer bicycle did not change fasting insulin, fasting glucose, and homeostatic insulin resistance (HOMA-IR) in patients with T2D (21). Since the studies described above were of different duration and were conducted using different methods (treadmill running, walking, and cycling), the biochemical effects of HIFT on fasting insulin,

fasting glucose, and homeostatic insulin resistance (HOMA-IR) in obese patients with T2DM are contradictory. However, a recent study reported lower fasting insulin concentrations, fasting glucose, and homeostasis model assessment of insulin resistance (HOMA-IR) after 18 sessions of high-intensity interval training with increased VO2max (22). Since VO2max is negatively associated with chronic inflammation (23), it is possible that less chronic inflammation was present in the participants in the present study, leading to improved insulin resistance and glucose homeostasis in both training groups.

The molecular approach to the effect of exercise training, especially high-intensity exercise, on insulin resistance index may be due to higher GLUT4 transport and decreased glycogen after exercise and vasodilation function. However, the effects of long-term high-intensity aerobic and resistance training on HOMA-IR are contradictory. In fact, one study reported that 33 HIIT sessions on a stationary bike resulted in a decrease in HOMA-IR (21); the lower glycemic index after interval training was due to improved hepatic insulin sensitivity (24). Another study used 36 HIIT sessions and reported a change in HOMA-IR (25). Previous studies have shown that insulin secretion is inhibited by exercise due to increased norepinephrine levels. It is also possible that the decrease in insulin due to exercise is due to glucose sparing, which limits the use of blood glucose by the muscles and makes more blood glucose available to the brain. Among the possible causes of decreased insulin resistance due to activity, we can also point to insulin-independent mechanisms such as increased GLUT-4 levels due to muscle contractions (26).

## Conclusion

The findings of the present study showed that both HIFT and resistance training are equally effective in improving insulin resistance in obese individuals, so despite the shorter duration of intense functional training compared to resistance training, their effects on cardiovascular risk factors and glucose control are similar.

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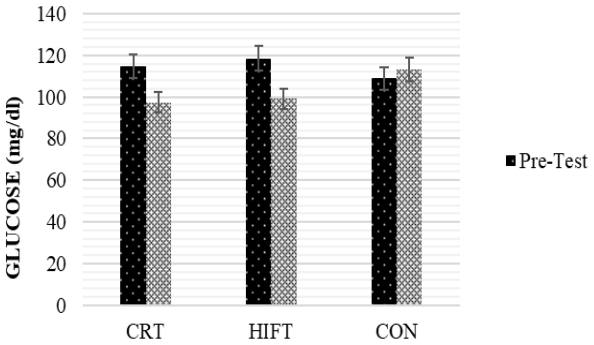


**Figure 1. Changes in mean fasting blood glucose (mg/dL) in different groups during the pre-test and post-test phases. High-intensity functional training (HIFT), Circuit Resistance training (CRT). Control (CON)**

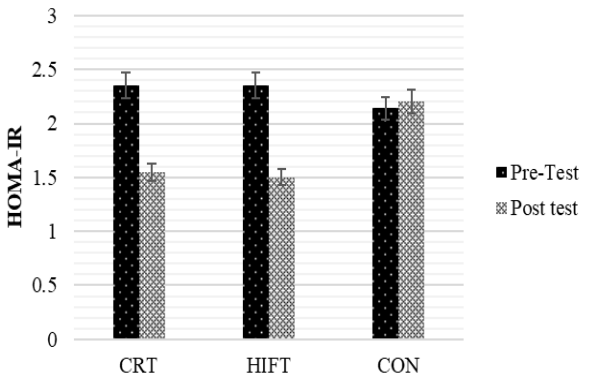


**Figure 2. Changes in mean HOMA-IR in different groups during the pre-test and post-test phases. High-intensity functional training (HIFT), Circuit Resistance training (CRT). Control (CON).**