Journal of Basic Research in Medical Sciences
Ilam University of Medical Sciences
Online ISSN: 2383-0972
Print ISSN: 2383-0506
Homepage: https://jbrms.medilam.ac.ir

The Impact of Varying Circuit Resistance Training Intensity on Apolipoproteins in Men with Obesity

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Article Info

Article type:
Research article

Article History:
Received: 30 Sept 2022
Revised: 28 Dec 2022
Accepted: 27 Feb 2023
Published Online:27 Nov 2023

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ABSTRACT

Introduction: This study aimed to investigate the impact of 12 weeks of circuit resistance training at varying intensities on Apolipoproteins A (Apo A), B (Apo B), and J (Apo J) in men with obesity.

Materials & Methods: A total of 44 young men with obesity, aged 23-32 years, were divided into four groups: control (n=11), low-intensity (n=11), moderate-intensity (n=11), and high-intensity circuit resistance training (n=11) groups. The training program spanned 12 weeks and was conducted with three sessions per week. Blood samples were collected 72 hours before and 72 hours after the 12-week training programs. These blood samples were transferred to specialized plasma test tubes containing EDTA and were then centrifuged at 10 rpm for 10 minutes.

Findings: A significant decrease in Apo B levels ($P < 0.0001$) and an increase in Apo A levels ($P < 0.05$) were observed in the low-intensity training group compared to the control group. Additionally, a significant decrease in Apo J levels was observed in all exercise training groups compared to the control group ($P < 0.05$).
Discussion & Conclusion: The findings of this study suggest that circuit resistance training, particularly at lower intensities, may lead to a reduction in the risk of cardiovascular diseases in obese individuals through the modification of Apo A, Apo B, and Apo J levels.

Keywords: Circuit Resistance Training, Obese Men, Apolipoprotein, Training Intensity

➢ **How to cite this paper**
Nouri-Habashi A, Rezaei Mahbobi M. The Effect of Different Intensity of Circuit Resistance Training on Apolipoproteins in Obesity mens. J Bas Res Med Sci. 2023; 10(3): 1-11.

 Publisher: Ilam University of Medical Sciences

Introduction

Obesity has profound implications for human health, and it is linked to a range of diseases, including type 2 diabetes, lipid disorders, cardiovascular ailments, and various types of cancer. Ultimately, obesity is associated with reduced life expectancy and premature mortality, imposing a substantial burden on public health (1).

Insulin resistance stands as a significant risk factor for type 2 diabetes, with notable abnormalities in fat and plasma lipoproteins, including reduced HDL cholesterol and elevated triglyceride levels. These changes are linked to increased hepatic triglyceride secretion. Apolipoproteins, a group of proteins located at the outermost layer of lipoproteins, play a pivotal role in regulating lipid transport and lipoprotein metabolism (2).

Emerging research suggests that two key apolipoproteins, apolipoprotein A (Apo A) and apolipoprotein B (Apo B), which are major components of HDL-C and LDL-C, respectively, may offer a more accurate assessment of coronary heart disease risk than conventional lipid markers (3). Multiple studies have demonstrated Apo B's pivotal role in the structure of LDL-C and VLDL-C, with its interaction with LDL-C receptors playing a crucial role in their uptake by peripheral cells and the liver (4). Plasma VLDL concentration is influenced by Apo B's hepatic secretion and catabolism and is a determining factor in LDL-C levels and plasma density (5). Human studies have consistently revealed a significant inverse relationship between HDL-C levels, particularly Apo A, and the risk of atherosclerosis (6). The Apo B/Apo A-1 ratio, when compared to LDL-C, provides a more reliable indicator of coronary artery disease risk (7). LDL-C alone is insufficient as an indicator for predicting cardiovascular risk (8). In essence, Apo A, the primary protein associated with HDL-C, possesses well-known antioxidant properties (9, 10). Together with Apo A, HDL-C plays a critical role in the reverse transfer of cholesterol from lipid-rich macrophages to the liver, preventing the accumulation of cholesterol esters in macrophages and the formation of foam cells (9,10).

Apolipoprotein J (Apo J), also known as clusterin, represents a disulfide-linked heterodimer protein expressed in various tissues and bodily fluids (11). Apo J is a fundamental component of high-density cholesterol and low-density cholesterol, and its function activates enzymes involved in lipoprotein metabolism (2). Apo J is found in a subset of dense HDL particles that include Apo A I and Paraoxonase (PON). It is also present in various physiological fluids, such as human plasma, urine, breast milk, semen, and cerebrospinal fluid (11). Increased levels of circulating Apo J are associated with various pathological conditions, including obesity, diabetes, Alzheimer's disease, and cardiovascular disorders (12). Recent research has highlighted the close relationship between Apo J circulation and markers of cardiovascular metabolism, with documented links between Apo J and insulin resistance in humans (13). Changes in serum Apo J levels are inversely correlated with improvements in insulin sensitivity in patients with type 2 diabetes, suggesting that Apo J turnover reflects insulin resistance (14). Interestingly, Apo J in HDL has been linked to insulin sensitivity, while Apo J in LDL/VLDL has been associated with insulin resistance, suggesting a potential connection between Apo J and insulin function (14). Consequently, some studies propose that Apo J may have a protective role in individuals with insulin resistance, and elevated serum Apo J levels could serve as a marker for assessing insulin resistance (15). Research has shown that oral administration of Apo J reduces atherosclerosis in Apo E-null mice and improves the anti-inflammatory properties of HDL in monkeys (16). Apo J is identified as a multifunctional protein and may serve as an effective and sensitive predictor of atherosclerotic lesions and cardiovascular disease (17).

Exercise is widely acknowledged as a key factor in preventing and treating obesity and its related ailments, significantly enhancing insulin sensitivity and mitigating associated complications (18). Aerobic exercise enhances insulin sensitivity, while resistance training increases glucose uptake in muscle tissue by augmenting muscle mass and Glut4 expression. The combined effects of these two exercise types are instrumental in both preventing and treating obesity-related diseases. Circuit resistance training, characterized by performing multiple exercises in quick succession, offers an effective way to lose weight and increase muscle strength (19,20).

Navab et al. demonstrated that 12 weeks of combined resistance-aerobic exercise training in women with type 2 diabetes resulted in significant reductions in insulin resistance and Apo J levels (16). Given the scarcity of studies on the effects of exercise training, especially circuit resistance training at different intensities, on changes in Apo J and its precise role in obesity, this study aimed to investigate the effects of 12 weeks of circuit resistance training with varying intensities on Apo J, Apo A, and Apo B levels in obese individuals.

Materials and Methods

Given that the study focused on obese male subjects and extended over a 12-week research period, it can be categorized as both practical and quasi-experimental.

Participant Selection

The study's participants were obese male volunteers who were recruited through outreach to public, academic, and administrative institutions. To be eligible for the study, participants had to meet specific criteria, which included the absence of drug and alcohol addiction, a lack of regular exercise for at least six months before the study's commencement, no history of kidney, liver, cardiovascular disease, or diabetes, and meeting specific health conditions (BMI $\geq$ 30 and Waist-to-Height Ratio (WHtR) $>$ 0.5). Furthermore, each participant underwent a comprehensive medical examination to confirm their physical fitness. Prior to their involvement in the research, all participants received a detailed explanation of the study's procedures and methods. After gaining full understanding and completing a medical questionnaire, written consent was obtained from each participant. The study selected 44 volunteers within an age range of 23-32 years. All research procedures were subjected to scrutiny and approval by the Research and Ethics Committee of Urmia University (Ethics code: IR-UU1400-16), and all activities adhered to the latest revision of the Declaration of Helsinki.

Initial Assessments

During the initial session, participants' height, weight, and dietary habits (recorded via a food frequency questionnaire) were documented.

Furthermore, all participants received training on the study's various stages, the correct execution of the exercise program, and safety precautions related to the exercises.

Second Session

In the second session, participants completed appetite and physical activity questionnaires. Blood samples were collected, and a one-repetition maximum test was conducted.

Group Allocation

Participants were evenly distributed into four groups based on their maximum strength in the one-repetition maximum test:

Control group (n=11)

Low-intensity circuit resistance training group (n=11)

Medium-intensity circuit resistance training group (n=11)

High-intensity circuit resistance training group (n=11).

This rigorous selection and grouping process ensured the participants' homogeneity, facilitating an effective study.

Table 1. Characteristics of the subjects in each group

Variable \ Group	Control	LT	MT	HT
Age (years)	25±40	26.00±50	28±30	27±60
Height (cm)	174.18±4.75	178.10±6.08	174.36±4.60	175.92±5.31
Weight (kg)	95.91±9.40	98.10±10.51	96.36±8.21	94.42±8.46
BMI (kg/m^2)	31.35±0.96	30.91±0.72	31.68±0.60	30.72±0.93

Data are shown as mean ± SD. LT; low, MT; moderate and HT; severe intensity circuit resistance training groups

Determination of 1RM

To establish the one-repetition maximum (1RM), the Berziski method was utilized with subjects from the 1RM resistance training group. We selected weights for participants that allowed them to complete a maximum of 6-8 repetitions. Subsequently, the calculated weight, taking repetitions into account, was applied to the appropriate formula (22):

1RM = weight / (1.0278 – 0.0278 × reps)

Circuit Resistance Training Protocol

The circuit resistance training protocol consisted of eight exercises targeting the upper and lower torso, which included squat, forearm exercises, chest press, knee opening, knee flexion, barbell head lifts, leg presses, and armpit wire exercises from behind. These exercises were conducted at varying intensities (23,24)

High-Intensity Circuit Exercise Group: 3 sets of 10 repetitions at 80% of 1RM.

Medium-Intensity Circuit Exercise Group: 3 sets of 13 repetitions at 60% of 1RM.

Low-Intensity Circuit Exercise Group: 3 sets of 20 repetitions at 40% of 1RM.

Training Volume Calculation:

The training volume was calculated using the formula presented by Baechele et al (1994). RT volume = number of sets × repetitions × weight lifted (25).

Rest Periods

Rest intervals between exercise stations were minimized to the time required for participants to transition from one station to another (≤15 seconds). Rest intervals between sets were set at 2 minutes and were passive in nature (26).

Blood Sampling and Analysis

Fasting blood samples were collected 72 hours before and after a twelve-week training period from the right arm vein of the participants. The blood samples were collected in specialized plasma test tubes containing EDTA and then centrifuged at 10,000 rpm for 10 minutes. The resulting plasma was stored at -70°C. Plasma Apolipoprotein A-1 was measured using the immunoturbidimetric method with a quantitative detection kit from Bionic Company, with a variation coefficient and sensitivity of 4.8% and 0.31 mg/100 ml, respectively. Plasma Apolipoprotein B was measured using the immunoturbidimetric method with a quantitative detection kit from Bionik Company, featuring a variation coefficient and sensitivity of 1.2% and 20 mg/100 ml, respectively. Plasma ApoJ concentration was measured using an ELISA kit from Boster Biological Technology according to the manufacturer's protocols, with a sensitivity of <20 pg/mL. The coefficients of variation within and between tests were 4.2% to 4.6% and 6.9% to 7.5%, respectively.

Statistical Analysis

Descriptive statistics were employed for classification and determination of dispersion indices. The Golmogorov-Smirnov test confirmed that the data followed a normal distribution. A paired t-test was used to compare pre-test and post-test changes within each test group. For intergroup comparisons, a repeated two-way analysis of variance and Bonferroni post hoc test were applied. All data were expressed as mean ± standard deviation. Statistical analyses were carried out using SPSS version 22, with significance set at $P < 0.05$.

Results

Analysis of Apo A Values

The analysis of Apo A values in subjects before and after 12 weeks of circuit resistance training at different intensities, using a repeated measures analysis of variance test with the intergroup factor, revealed that both the time factor ($P < 0.0001$, $F = 0.66$) and the time-group interaction ($P < 0.0001$, $F = 3.40$) were statistically significant.

Bonferroni Test Results

The results of the Bonferroni test indicated that there was no statistically significant difference between the changes in Apo A values of subjects in the control group and the low-intensity training group ($P = 0.181$). However, significant differences were observed when comparing the control group with the moderate training group ($P < 0.0001$) and the high-intensity training group ($P < 0.0001$). Additionally, a significant difference was found when comparing the low-intensity training group with the high-intensity training group ($P < 0.0001$) and the moderate-intensity training group ($P <0.0001$).

However, no statistically significant difference was detected between the moderate-intensity training group and the high-intensity group (P = 0.99).

Intra-Group Changes in Apo A Values

An examination of intra-group changes in Apo A values using a paired t-test revealed that the changes following 12 weeks of training were statistically significant in the control group (P = 0.008), the moderate intensity group (P = 0.001), the high-intensity group (P <0.0001), and the low-intensity training group (P = 0.001). Please refer to Figure 1 for a visual representation of these changes.

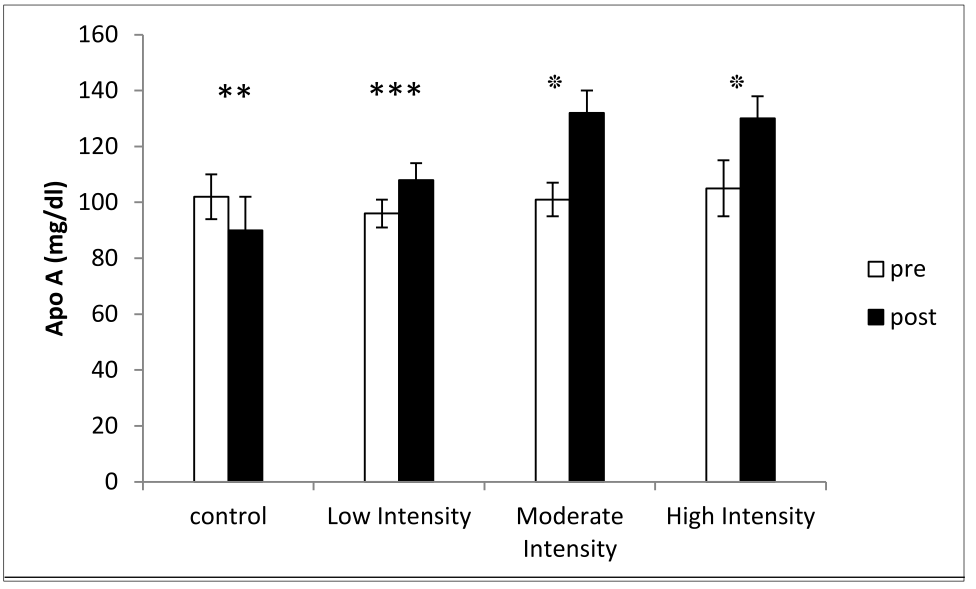

Figure 1. Apo A values of subjects before and after 12 weeks of circuit resistance training with different intensities. * sign indicates a significant difference within the group. ** sign indicates a significant difference between the control group and other high and medium intensity groups. *** sign shows a significant difference between low intensity groups and high and medium intensity groups.

Analysis of Apo B Values

An analysis of Apo B values in subjects before and after 12 weeks of circuit resistance training with different intensities, employing a repeated measures analysis of variance test with the intergroup factor, revealed that both the time factor ($P < 0.0001$, $F1.40 = 30.9$) and the time-group interaction ($P < 0.0001$, $F3.40 = 8.8$) were statistically significant.

Bonferroni Posthoc Test Results

The results of the Bonferroni posthoc test indicated that there was no statistically significant difference between the changes in Apo B values of subjects in the control group and the low-intensity exercise group (P = 0.481). However, significant differences were observed when comparing the control group with the moderate exercise groups (P <0.0001) and the high-intensity group (P <0.0001). Additionally, a significant difference was found when comparing the low-intensity training groups with the high-intensity training group (P = 0.044) and the moderate-intensity group (P = 0.022). However, no statistically significant difference was detected between the moderate-intensity training group and the high-intensity group (P = 0.99).

Intra-Group Changes in Apo B Values

An examination of intra-group changes in Apo B values using a paired t-test revealed that the changes after 12 weeks of training were not statistically significant in the control group (P = 0.363) and the low-intensity training group (P = 0.076). However, these changes were statistically significant in the medium-intensity group (P = 0.006) and the high-intensity group (P <0.0001). Please refer to Figure 2 for a visual representation of these changes.

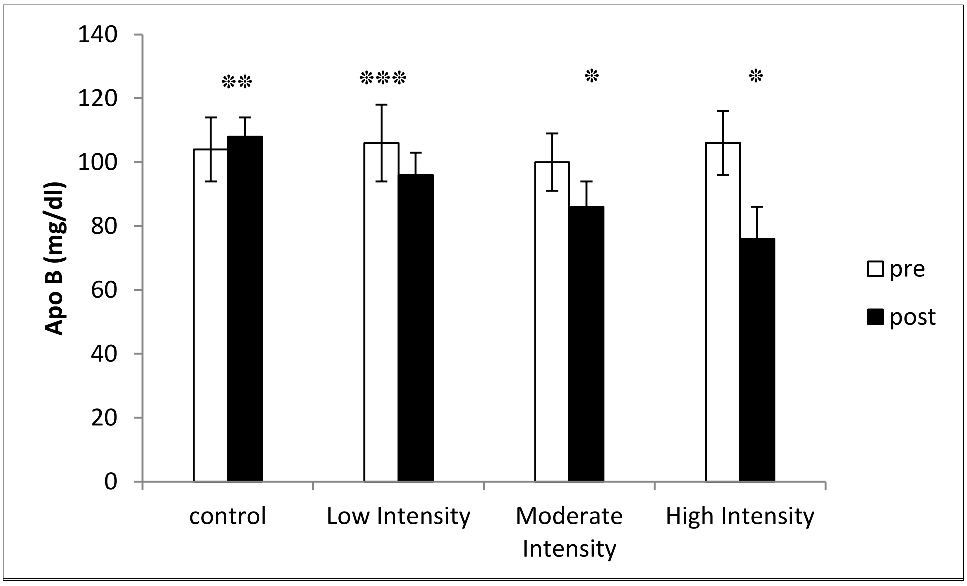

Figure 2. Apo B values of subjects before and after 12 weeks of circuit resistance training with different intensities .The * sign indicates a significant difference within the group .The ** sign indicates a significant difference between the control group and other high and medium intensity groups. the mark *** Shows a significant difference between low intensity groups and high and medium intensity groups.

Analysis of Apo J Values

The analysis of Apo J values in subjects before and after 12 weeks of circuit resistance training at different intensities, employing a repeated measures analysis of variance test with the intergroup factor, revealed that both the time factor ($P < 0.0001$, $F1.40 = 118.4$) and the time-group interaction ($P < 0.0001$, $F3.40 = 11.4$) were statistically significant.

Bonferroni Test Results

The results of the Bonferroni test indicated that there were significant differences between the changes in Apo J values of subjects in the control group and the low-intensity group ($P < 0.0001$), the moderate-intensity group ($P < 0.0001$), and the high-intensity group ($P < 0.0001$).

Intra-Group Changes in Apo J Values

An examination of intra-group changes in Apo J values using a paired t-test revealed that the changes after 12 weeks of training were not statistically significant in the control group (P = 0.132). However, these changes were statistically significant in the low-intensity training group ($P < 0.0001$), the moderate-intensity group ($P < 0.0001$), and the high-intensity group ($P < 0.0001$). For a visual representation of these changes, please refer to Figure 3.

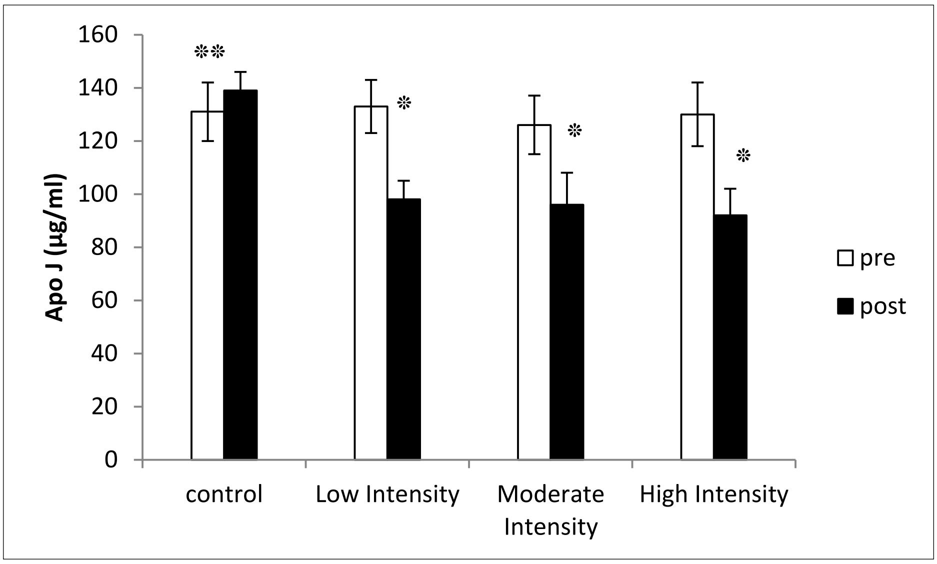

Figure 3. Apo J values of subjects before and after 12 weeks of circuit resistance training with different intensities .The * sign indicates a significant difference within the group .The ** sign indicates a significant difference between the control group and other groups.

Discussion

Insulin resistance is a significant risk factor for type 2 diabetes and is associated with disruptions in fat and plasma lipoproteins, leading to decreased HDL cholesterol, elevated triglyceride levels, and increased hepatic triglyceride secretion (27).

Our study revealed a noteworthy reduction in Apo J and Apo B levels following twelve weeks of low, medium, and high-intensity resistance training. Importantly, this decrease was more pronounced in the moderate and high-intensity training groups than in the low-intensity group, with no significant change observed in the control group. In contrast, Apo A levels displayed a significant increase following all three training intensities, with no significant change noted in the control group.

Our findings align with a prior study where women with type 2 diabetes underwent twelve weeks of combined aerobic resistance training. In that study, significant reductions in body weight, body fat percentage, and Apo J were observed post-training (15). Existing evidence suggests that Apo J levels are notably elevated in individuals with conditions associated with insulin resistance, such as obesity, metabolic syndrome, and type 2 diabetes (14, 28). Another study involving a post-intervention combination of weight loss and thiazolidinedione treatment to enhance insulin sensitivity resulted in reduced circulating Apo J levels (14). Interestingly, Apo J levels appear to be unaffected by BMI or the degree of weight loss, but they decrease significantly in cases where patients experience weight reduction following calorie restriction (15, 23). Apo J shows no significant correlation with BMI, weight loss, leptin, or lipoproteins, except for a modest association with plasma leptin (23).

Sevral studies have reported significant associations between circulating Apo J and total cholesterol and LDL cholesterol levels (21, 29). However, no definitive evidence links changes in Apo J levels with variations in lipid profiles following exercise. Results concerning the effects of exercise on Apo B and Apo A are conflicting. For instance, one study on healthy adults found that Apo A and Apo B values remained relatively stable after six weeks of moderate and high-intensity resistance training (30). Additionally, Valente et al. (2011) reported that resistance training in conjunction with nutritional intervention led to a significant reduction in Apo B levels and a non-significant decrease in Apo A levels (31).

The impact of exercise intensity on apolipoproteins appears variable. The effect of different aerobic exercise intensities on changes in Apo A and Apo B has been reported as statistically insignificant (32). Similarly, a study on anaerobic training courses with varying intensities showed no significant changes in cardiovascular risk factors or Apo A and Apo B levels (33). However, moderate-intensity exercise was found to significantly affect the Apo B/Apo A ratio but not Apo B levels (33).

Conclusion

In summary, our results demonstrate that circuit resistance training over twelve weeks, at varying intensities (low, medium, and high), leads to a significant decrease in Apo J and Apo B levels, while significantly increasing Apo A levels in obese individuals. These improvements are particularly notable in the moderate and high-intensity training groups. Consequently, regular circuit resistance training holds the potential to mitigate the risk of cardiovascular diseases in obese individuals by enhancing inflammatory parameters. It serves as a non-pharmacological treatment approach with considerable effectiveness in disease prevention.

Acknowledgment

I extend my gratitude to all the participants and colleagues who contributed to this manuscript.

Authors' Contributions

M. R. and A. N. collaborated throughout all stages of manuscript development.

Conflict of Interest

The authors declare no conflicts of interest.

Financial Support

The authors did not receive any financial support for this study.

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