

## The effects of a single bout of circuit resistance exercise on metabolic syndrome risk factors: A randomized controlled trial

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### Abstract

*Introduction:* The concept of metabolic syndrome includes a number of metabolic disturbances linked by insulin resistance, which increase cardiovascular and diabetes risk. The purpose of the present study was to examine the effect of a single bout of circuit resistance training on metabolic syndrome risk factors in men with type 2 diabetes.

*Material & Methods:* 30 men (age:  $36.3 \pm 4.7$  yr; BMI:  $27.7 \pm 0.9$  kg/m<sup>2</sup>) with type 2 diabetes were randomly assigned to an exercise group (n = 15) that performed a single bout of circuit resistance training or a control group (n = 15) that

did not perform any type of physical exercise over the same period. Body composition, blood pressure, and blood sample measurements were performed before and after intervention.

*Results:* No significant differences were observed in fasting blood glucose, fasting insulin, insulin resistance index determined by HOMA-IR, total cholesterol [TC], triglyceride [TG], low-density lipoprotein cholesterol [LDL], high-density lipoprotein cholesterol [HDL], systolic and diastolic blood pressure [SBP and DBP] in the exercise group compare to the control group.

*Conclusion:* Our results suggest that a single bout of circuit resistance training had no significant effect on metabolic syndrome risk factors in the healthy young men.

**Keywords:** Metabolic syndrome, Resistance training, Insulin resistance, Cardiovascular diseases

## 1. Introduction

Metabolic syndrome is a group of cardiovascular disease risk factors that occur together, increasing one's risk for health consequences such coronary artery disease, stroke, and diabetes (1). Adult-Treatment Panel III (ATP-III) of the National Cholesterol Education Program adopted the increased waist circumference, elevated triglycerides (TG), reduced high-density lipoprotein cholesterol (HDL), elevated blood pressure (BP) and elevated glucose as a major component of the clinical diagnostic criteria of the metabolic syndrome (2). Nowadays, metabolic syndrome is one of major health problems and researchers believe that this syndrome increased risk of death, diabetes and cardiovascular complications (3,4).

Recently, there has been more attention and research given to the effects resistance training has on various metabolic and cardiac diseases. Resistance training can have a significant effect on some metabolic syndrome risk factors and should be part of an exercise program designed for managing metabolic syndrome (5). Some evidence indicated that resistance training performed at least 2 days per week can reduce the risk and prevalence of metabolic syndrome and its individual

components in U.S. adults (6,7). Numerous studies have reported that resistance training can improve glycemic control (8-11). For example, Bweir et al. (2009) showed that 10 weeks of resistance training was associated with better glycemic control in adults with type 2 diabetes compared with an aerobic (treadmill) exercise group (8).

There have been improvements seen in total cholesterol (TC), low-density lipoprotein cholesterol (LDL), and TG from resistance training (11,12). A significant reduction in LDL was observed in women who participated in a 16-week program combining caloric restriction and resistance training compared with women randomized into a caloric restriction-only group or control group (12).

Azarmehr et al. (2017) also indicated that fasting blood sugar (FBS) and TG levels were decreased and HDL level was increased significantly in response to 8 weeks of circuit resistance training in older women with type 2 diabetes (13). Recently, Tomeleri et al. (2018) found that 12 weeks of resistance training program reduces metabolic syndrome components and inflammatory biomarkers in older women (14). However, results from studies examining resistance training and its effects on blood lipids (*e.g.*, increases in HDL) have reported inconsistent findings (15). Resistance training has been shown to decrease both resting and ambulatory BP in individuals with hypertension (16,17). A meta-analysis by Kelley and Kelley (2000) indicates that regular resistance training can reduce resting systolic blood pressure (SBP) by approximately 2% and resting diastolic blood pressure (DBP) by approximately 4% (18). Research findings indicate that adults engaging in resistance training at least twice weekly may have lower odds of developing prehypertension (19). Therefore, because of controversy between studies relating to the effect of resistance training on metabolic syndrome risk factors and the lack of studies about the effect of a single bout of resistance training on these risk factors in type 2 diabetic patients, the purpose of this investigation was to examine the effect of a single bout of circuit resistance training on metabolic syndrome risk factors in men with type 2 diabetes.

## 2. Material & Methods

### *Subjects*

The study was designed to investigate middle-aged participants as type 2 diabetes is often diagnosed within this age range. Individuals completed a thorough physical examination, including a medical history, blood pressure assessment, anthropometric, and orthopedic evaluation prior to participation in the experimental protocols. As inclusion criteria, the only participants included were those aged between 18–40 years and those without consistent resistance training for the past six months before the study period. Men with physical disabilities, under caloric restriction, diagnosis of musculoskeletal disease, recent use of medication and smoking or drug/alcohol abuse were excluded from the trial. All participants signed an informed consent document and the study was approved by the Islamic Azad University, Marvdasht branch Ethics Committee. The subjects were divided into exercise group ( $n = 15$ ) or control group ( $n = 15$ ).

### *Study design*

The present study was designed to investigate the effects of a single bout of circuit resistance training metabolic syndrome risk factors in type 2 diabetic men. Subjects were advised to maintain their normal daily eating habits throughout the study. Prior to physical evaluation, participants reported to the laboratory between 08:00–10:00 am following an overnight fast, for blood sampling from the antecubital vein for subsequent analysis of biochemical variables. Anthropometric and body composition variables and one-repetition maxim (1-RM) were determined. Volunteers completed a session of familiarization prior to testing, where they were advised regarding the execution of proper technique. After the familiarization session, 1-RM test was performed on the chest press, barbell shoulder press, seated cable rows, barbell curl, overhead triceps extension, curl up, squat and hamstring with machine. The resistance training protocol began three days after 1-RM testing.

### *Anthropometric and body composition measurements*

Height and body mass were measured for the calculation of the body mass index (BMI). Body fat percentage was assessed by skinfold

thickness protocol. Skinfold thickness was measured sequentially, in chest, abdominal and thigh by the same investigator using a skinfold caliper (Harpenden, HSK-BI, British Indicators, West Sussex, UK) and a standard technique. Anthropometric and body composition characteristics of the subjects are presented in the Table 1.

Table 1. Anthropometric and body composition characteristics of the subjects in each group (mean  $\pm$  SD)

Variables	Exercise (n = 15)	Control (n = 15)
Age (yr)	36.6 $\pm$ 4.6	35.9 $\pm$ 5.1
Height (cm)	173.2 $\pm$ 5.4	172.4 $\pm$ 4.7
Body mass (kg)	78.5 $\pm$ 4.9	79.4 $\pm$ 5.0
BMI (kg/m <sup>2</sup> )	27.6 $\pm$ 1.0	28.0 $\pm$ 0.9
Body fat percent (%)	21.1 $\pm$ 2.4	21.7 $\pm$ 3.1
Lean body mass (kg)	66.3 $\pm$ 2.6	65.0 $\pm$ 2.0

#### *Blood pressure measurement*

Systolic (SBP) and diastolic (DBP) blood pressure were measured before the initiation of the training program and four days after the resistance training was finished with an oscillometric device (ALP K2, Japan) according to the recommendations of the VI Brazilian Guidelines on Hypertension (20). The cuff size was adapted to the circumference of the arm of each participant according to the manufacture's recommendations.

#### *Biochemical parameters*

Participants reported to the laboratory between 08:00–10:00 am, after an overnight fast, for blood withdrawal from the antecubital vein. Total cholesterol (TC) and triglyceride (TG) levels were measured by enzymatic kits (Mann Chemical Company) using an auto analyzer. Low-density lipoprotein cholesterol (LDL) and high-density lipoprotein cholesterol (HDL) were measured by an auto analyzer using commercial kits (Pars Azema Company, Teheran, Iran). Glucose levels were measured by enzymatic CHOP-POD and plasma insulin concentration was measured using a Roche Diagnostics Elecsys 2010 system (Roche Diagnostics, Indianapolis, IN, USA) by the sandwich principle. Insulin resistance was calculated using the HOMA-IR model according to the following equation (21):

$$\text{HOMA-IR} = (\text{Fasting Insulin (IU/ml)} \times \text{Fasting Glucose (mmol/l)}) \div 22.5$$

#### *One-repetition maximum assessment*

Before the determination of initial 1-RM, at first the subjects familiarization with training technique by trainer and then there's 1-RM was determined. Exercise intensity was expressed as the intensity relative to 1-RM. In studies wherein the intensity was expressed as the number of repetitions to reach fatigue, relative intensity was estimated using this formula (13):

$$1RM = \frac{\text{weight}}{1.0278 - (0.0278 \times \text{Repeat})}$$

#### *Exercise training*

The exercise group performed resistance training in a fitness facility under instructions and supervision of licensed physical therapists. Circuit resistance training consisted of 8 stations in the following order: chest press, barbell shoulder press, seated cable rows, barbell curl, overhead triceps extension, curl up, squat and hamstring with machine. This training was circularly performed in 8 stations and included 4 sets with 6 maximal repetitions at 50-65% of 1-RM in each station. Each circuit and set was separated by 5 min and 60 s rest respectively (See Figure 1).

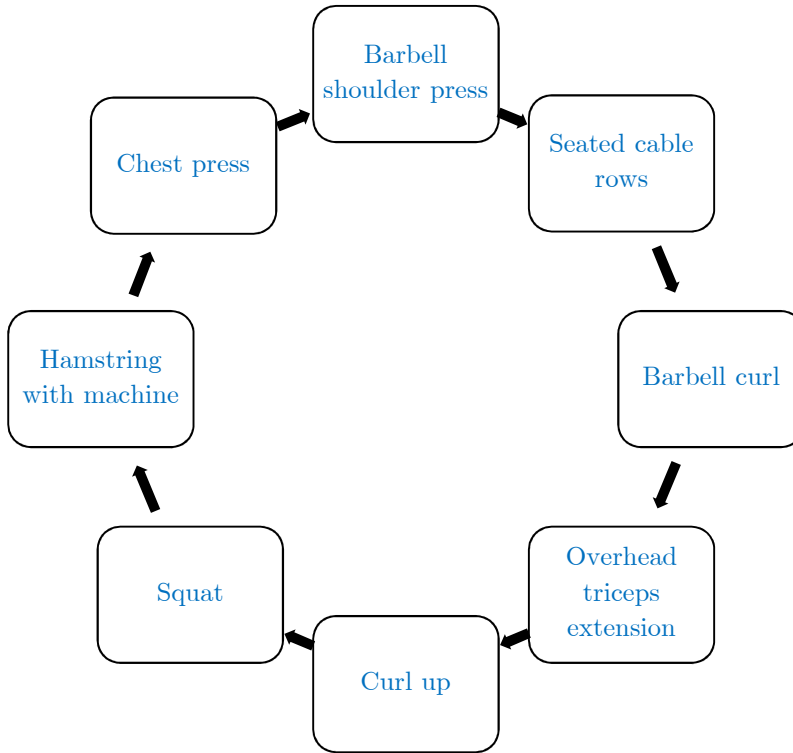


Figure 1. Resistance exercise protocol

### *Statistical analysis*

Results were expressed as the mean  $\pm$  SD and distributions of all variables were assessed for normality using Shapiro-Wilk test. Paired-sample t-test and independent-sample t-test were used to assess the impact of the intervention. The level of significance in all statistical analyses was set at  $P < 0.05$ . Data analysis was performed using SPSS software for windows (version 17, SPSS, Inc., Chicago, IL).

### **3. Results**

Table 2 presents data from physiological and biochemical variables. Independent-sample t-test indicated that there were no significant differences in fasting blood glucose, fasting insulin, insulin resistance index determined by HOMA-IR, TC, TG, LDL, HDL, SBP and DBP between exercise group and control group.

Table 2. Changes on metabolic syndrome risk factors  
in response to a single bout of circuit resistance training

Variables	Baseline (mean $\pm$ SD)	After intervention (mean $\pm$ SD)	Paired t-test (Sig)	Independent t-test (Sig)
<b>SBP (mmHg)</b>				
Exercise	114.0 $\pm$ 0.9	123.4 $\pm$ 1.0	0.06	0.07
Control	117.3 $\pm$ 0.8	119.2 $\pm$ 0.8	0.1	
<b>DBP (kg/m<sup>2</sup>)</b>				
Exercise	7.8 $\pm$ 0.5	7.9 $\pm$ 0.5	0.3	0.8
Control	7.6 $\pm$ 0.6	7.7 $\pm$ 0.5	0.9	
<b>Glucose (<math>\mu</math>g/l)</b>				
Exercise	8.6 $\pm$ 0.3	8.9 $\pm$ 0.4	0.07	0.5
Control	8.8 $\pm$ 0.7	9.0 $\pm$ 0.7	0.1	
<b>Insulin (IU/ml)</b>				
Exercise	11.3 $\pm$ 3.4	12.6 $\pm$ 5.0	0.07	0.7
Control	11.7 $\pm$ 5.1	13.5 $\pm$ 4.8	0.06	
<b>HOMA-IR</b>				
Exercise	4.3 $\pm$ 1.2	4.9 $\pm$ 1.8	0.06	0.5
Control	4.9 $\pm$ 1.8	5.5 $\pm$ 2.1	0.06	
<b>TC (mg/dl)</b>				
Exercise	136.0 $\pm$ 23.9	140.0 $\pm$ 24.8	0.07	0.9
Control	146.3 $\pm$ 36.5	148.8 $\pm$ 39.5	0.08	
<b>TG (mg/dl)</b>				
Exercise	77.5 $\pm$ 38.2	85.5 $\pm$ 43.7	0.07	0.06
Control	111.6 $\pm$ 60.0	137.7 $\pm$ 91.1	0.04*	
<b>LDL (mg/dl)</b>				
Exercise	75.2 $\pm$ 24.1	76.5 $\pm$ 23.8	0.8	0.9
Control	88.8 $\pm$ 27.3	83.8 $\pm$ 28.5	0.7	
<b>HDL (mg/dl)</b>				
Exercise	46.1 $\pm$ 9.1	46.7 $\pm$ 8.3	0.9	0.4
Control	41.3 $\pm$ 7.6	37.7 $\pm$ 8.6	0.1`	

\* Significant differences (P<0.05)

#### 4. Discussion

The aim of the present study was to analyze the effect of a single bout of circuit resistance training on metabolic syndrome risk factors in men with type 2 diabetes. The results of the present study revealed that a single bout of circuit resistance training had no significant effect on metabolic syndrome risk factors.



Resistance training is recommended by the American Heart Association (22), the American College of Sports Medicine (23) and the American Diabetes Association (24) as an effective tool to prevent and treat metabolic diseases. These recommendations are based on evidence showing that resistance training promotes increased muscle mass, glucose transporter (GLUT-4), protein kinase B and glycogen synthase in obese and diabetic individuals (25). However, fully understanding of the mechanisms responsible for the decrease in BP and dyslipidemia remain to be determined. In line with the our results, Tibana et al. (2013) reported that 8 weeks of resistance training induced an increase of muscle thickness and muscle strength, with no effects on anthropometric, cardiovascular and biochemical risk factors of metabolic syndrome risk factors in overweight/obese women (26). Ghanbari-Niaki and Rashidlamir (2011) also noted that there was no significant change in TG, TC and LDL concentrations in response to a single session of wrestling techniques-based circuit exercise (27). Similarly, meta-analytic data showed that isolated exercise programs without caloric restriction induced limited improvements on cardiovascular risk factors. Shaw et al. (2006) found that exercise without caloric restriction control is associated with a lower decrease of body mass, BP and blood glucose as compared with exercise associated with dietary restriction (28). Orozco et al. (2008) compared the effects of isolated diet and diet + aerobic and RT. Results showed that diabetes risk was lower in the combined group. Additionally, individuals submitted to exercise training + diet presented a decrease of blood pressure and anthropometric indexes of obesity, which was not observed for the group of isolated exercise (29).

Another relevant difference of the present study as compared with other interventions with overweight/obese individuals was that no aerobic exercise was allowed, which may explain the limited results found on risk factors for metabolic syndrome. This is reinforced by the results from Libardi et al. (2012), in which overweight individuals completed 16 weeks of aerobic + resistance training and exhibited increased aerobic capacity and improved lipid profile (30). In this sense, Ismail et al. (2012) found that aerobic exercise training induced a decrease in visceral fat, while resistance training induced no modification on this parameter (31). Another study from Potteiger et al. (2012) compared the effects of

aerobic exercise at 65–80% of maximum heart rate and resistance training at 5-10RM with caloric restriction on the cardiovascular risk factor of metabolic syndrome. The authors reported that aerobic training induced a decrease of metabolic syndrome Z score after six months, while no results were found for resistance training (32).

Sigal et al. (2007) investigated the effects of aerobic, resistance training and combined (aerobic + resistance training) training on cardiovascular risk factors in type 2 diabetic individuals. Similar to the results of the present study, there was no alteration on BP, HDL, LDL and TG after isolated resistance training. Furthermore, only aerobic and combined training induced significant modifications on body composition (33). The non-significant variation of the biochemical data, such as glucose and insulin values can be, at least in part, attributed to the lack of dietetic control.

## 5. Conclusion

Our results suggested that a single bout of circuit resistance training had no significant effect on metabolic syndrome risk factors in men with type 2 diabetes. It can be hypothesized that longer interventions and the association of resistance training with aerobic exercise, in addition to the caloric restriction would induce superior results on risk factors of metabolic syndrome.

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**Conflict of interests:** There was no conflict of interest among authors.

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