
Acute effects of different intensities of resistance training on blood glucose, triglycerides, and total cholesterol in young men

Efeito agudo de diferentes intensidades do treinamento de força sobre a glicemia, triglicerídeos e colesterol total em homens jovens

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Bruno Moreira Candeloro

ORCID: <https://orcid.org/0000-0002-3213-6629>

Faculdade de Medicina de Marília (FAMEMA), Brasil

E-mail: bruno_candeloro@hotmail.com

Eduardo Federighi Baisi Chagas

ORCID: <https://orcid.org/0000-0001-6901-9082>

Universidade de Marília (UNIMAR) / Faculdade de Medicina de Marília (FAMEMA), Brasil

E-mail: efbchagas@gmail.com

ABSTRACT

This study examined the acute effects of different intensities of resistance training on blood glucose, triglycerides, and total cholesterol levels in healthy young men. Twelve participants with prior resistance training experience were included, and they performed a one-repetition maximum (1RM) test to assess their maximal strength capacity. Four experimental sessions were conducted, targeting both the upper and lower body. Blood glucose, triglycerides, and total cholesterol levels were measured before and after each session. Statistical analysis revealed a significant decrease in blood glucose levels after resistance training with 5 and 10 repetitions. There were no significant differences in total cholesterol levels across different repetition intensities. However, triglyceride levels significantly decreased after all repetition intensities, with significant differences observed in the 15 and 20 repetitions. In conclusion, acute resistance training at different intensities has immediate effects on specific metabolic markers, such as blood glucose and triglycerides, in healthy young men.

Keywords: Blood glucose; Metabolic markers; Resistance training; Total cholesterol; Triglycerides.

RESUMO

Este estudo examinou os efeitos agudos de diferentes intensidades de treinamento resistido nos níveis de glicose, triglicerídeos e colesterol total em homens jovens saudáveis. Doze participantes com experiência prévia em treinamento resistido foram incluídos e realizaram um teste de uma repetição máxima (1RM) para avaliar sua capacidade máxima de força. Foram conduzidas quatro sessões experimentais, direcionadas tanto para a parte superior quanto para a parte inferior do corpo. Os níveis de glicose, triglicerídeos e colesterol total foram medidos antes e após cada sessão. A análise estatística revelou uma diminuição significativa nos níveis de glicose após o treinamento resistido com 5 e 10 repetições. Não foram observadas diferenças significativas nos níveis de colesterol total entre as diferentes intensidades de repetição. No entanto, os níveis de triglicerídeos diminuíram significativamente após todas as intensidades de repetição, com diferenças significativas observadas nas repetições 15 e 20. Em conclusão, o treinamento resistido agudo em diferentes intensidades tem efeitos imediatos em marcadores metabólicos específicos, como glicose sanguínea e triglicerídeos, em homens jovens saudáveis.

Palavras-chave: Glicose; Marcadores metabólicos; Treinamento resistido; Colesterol; Triglicerídeos.

INTRODUCTION

A sedentary lifestyle and the aging process contribute to adverse changes in body composition, aerobic fitness, and strength, increasing the risk of metabolic conditions and low-grade inflammation (ANDERSSON; LUNDAHL; WECKE; LINDBLOM *et al.*, 2011). Moreover, elevated levels of low-density lipoprotein cholesterol (LDL-c), triglycerides (TG), and total cholesterol (TC), along with reduced levels of high-density lipoprotein cholesterol (HDL-c), are well-established risk factors for cardiovascular diseases (AGUILAR; BHUKET; TORRES; LIU *et al.*, 2015; RODRÍGUEZ-COLÓN; HE; BIXLER; FERNANDEZ-MENDOZA *et al.*, 2015; SOARES-MIRANDA; SANDERCOCK; VALE; SANTOS *et al.*, 2012; STEVENS; WOOD; KOSHIARIS; LAW *et al.*, 2016). These changes contribute to the development of metabolic syndrome, a complex disorder characterized by cardiovascular risk factors, such as central fat deposition and insulin resistance, which is associated with a 2.5-fold increase in cardiovascular mortality (ALBARELLO; BOUFLEUR FARINHA; RECKELBERG AZAMBUJA; LOPES DOS SANTOS, 2017).

Physical exercise, particularly resistance training, is widely recognized for its numerous health benefits and it is recommended to increase energy expenditure, improve muscle strength (FLECK; KRAEMER, 2017), enhance glucose uptake by muscles, boost insulin sensitivity, and elevate maximal oxygen consumption (VO₂Max) (BIRD; HAWLEY, 2017; FARINATTI; CASTINHEIRAS NETO; AMORIM, 2016). Furthermore, resistance training plays a significant role in weight control by raising resting metabolic rate, preserving or increasing muscle mass, and

boosting post-exercise energy expenditure (STAVRES; ZEIGLER; BAYLES, 2018). In studies involving healthy older adults, resistance training has demonstrated positive effects on body composition, including increased muscle mass and decreased fat mass, which can contribute to reversing metabolic risk factors and reducing low-grade inflammation (FORTI; VAN ROIE; NJEMINI; COUDYZER *et al.*, 2016; WALKER; PELTONEN; SAUTEL; SCARAMELLA *et al.*, 2013).

Resistance training has been shown to have positive effects on lipoprotein profiles, studies suggest that it can lead to an increase in HDL cholesterol levels by 8% to 21%, a decrease in LDL cholesterol levels by 13% to 23%, and a reduction in triglyceride levels by 11% to 18% (KELLEY; KELLEY, 2009; TAMBALIS; PANAGIOTAKOS; KAVOURAS; SIDOSSIS, 2009). However, the effects of resistance training on metabolism and inflammation depend on various program characteristics, such as volume and frequency (CALLE; FERNANDEZ, 2010; LIRA; YAMASHITA; UCHIDA; ZANCHI *et al.*, 2010). Higher-volume training is superior in reducing total cholesterol, LDL cholesterol, waist-to-hip ratio, and waist circumference (NUNES; BARCELOS; OLIVEIRA; FURLANETTO JÚNIOR *et al.*, 2016). Greater reductions in fat mass and inflammation markers are observed with more frequent and longer-duration exercise (EKLUND; HÄKKINEN; LAUKKANEN; BALANDZIC *et al.*, 2016; IHALAINEN; SCHUMANN; EKLUND; HÄMÄLÄINEN *et al.*, 2018). A meta-analysis conducted in older adults demonstrated that exercise programs with higher weekly frequency and durations exceeding 12 weeks significantly reduced inflammation markers (SARDELI; TOMELERI; CYRINO; FERNHALL *et al.*, 2018).

The objective of this study is to examine the immediate effects of various intensities of resistance training on blood glucose, triglycerides, and total cholesterol levels in young men. By exploring these acute metabolic responses, the study aims to contribute valuable insights for exercise prescription and strategies to enhance metabolic health.

MATERIALS AND METHODS

Study Design

The procedures employed in this study adhered to the Ethics in Human Research Criteria outlined in Resolution 466/12 of the National Health Council, with approval number 2.589.790. Prior to participation, all individuals were provided with detailed instructions regarding the study protocols and objectives and subsequently signed the Informed Consent Form (ICF). The sample for this study comprised healthy men who had prior experience with resistance training and did

not have any conditions that could potentially impact the study outcomes. Anthropometric measurements, including body mass (kg) and height (m), were taken to calculate the body mass index (BMI) (kg/m²). Furthermore, body composition was assessed using bioimpedance analysis, providing data on body fat percentage (%BF) and fat-free mass (FFM) in kilograms (kg).

Experimental Protocol

The study consisted of five sessions, the initial session dedicated to performing the one-repetition maximum test (1RM), with the protocol proposed by Brown and Weir (MARTINS; VIANA; SILVA; OLIVEIRA *et al.*, 2023). This test is used to assess an individual's maximum strength capacity by determining the maximum weight they can lift for a single repetition with proper technique. The selected exercises and their sequence for both the 1RM test and the experimental sessions were as follows: 1) bench press, 2) leg press, 3) barbell shoulder press, 4) free squat, 5) barbell biceps curl, and 6) knee extension machine.

Experimental Sessions

Four experimental sessions were conducted, with a seven-day interval between. Each session consisted of six exercises, targeting both the lower and upper body. All exercises were performed for three sets, with a two-minute rest interval between sets. The loads used in the experimental sessions were determined based on the relationship between the number of repetitions and the percentage of the estimated maximum load from the 1RM test (GRGIC; LAZINICA; SCHOENFELD; PEDISIC, 2020). The repetition ranges were as follows: 20 repetitions (50 to 59% of 1RM), 15 repetitions (60 to 69% of 1RM), 10 repetitions (70 to 79% of 1RM), and 5 repetitions (80 to 89% of 1RM). If a participant could not complete the proposed number of repetitions in the first set of an exercise, the load was adjusted for the subsequent sets. Prior to all experimental sessions, participants were instructed to have a meal 1 to 2 hours beforehand.

Data Collection

Blood glucose, triglycerides, and total cholesterol levels were measured before and five minutes after the completion of each experimental session. The measurements were conducted using a spectrophotometric reflectance biochemical analyzer (Accoutered Plus, Roche Diagnostics, 2007) with venous blood samples obtained through cubital puncture (COQUEIRO; SANTOS; NETO; QUEIROZ *et al.*, 2014).

Statistical Analysis

The data were presented as mean and standard deviation (SD), and the normality of the data distribution was assessed using the Shapiro-Wilk test. Paired Student's t-test was used to compare the differences between pre- and post-training measurements. The significance level was set at 5%. Statistical analysis was performed using SPSS software (version 24.0).

RESULTS

The study included a sample of 12 healthy men with a mean age of 24.1±2.5 years. A descriptive analysis of the sample data was conducted to examine the age and body composition characteristics (Table 1). The analysis of body composition revealed the absence of overweight individuals, with a maximum body fat percentage of 24.5% (VAN DIJK; TAKKEN; PRINSEN; WITTINK, 2012).

Table 1: Descriptive statistics of the sample characteristics for age and body composition.

	Minimum	Maximum	Mean	SD
Age	21,0	28,0	24,1	2,5
Weight (kg)	69,0	108,0	78,2	10,9
Height (m)	1,7	1,9	1,8	0,1
%Body Fat	8,7	24,5	13,4	4,3
Fat free mass (kg)	6,1	26,5	10,7	5,5

Note: standard deviation (SD).

Table 2 presents the results for the variables blood glucose (GL), total cholesterol (TC), and triglycerides (TG) at pre- and post-training moments, considering different intensities of exercise repetitions. Regarding blood glucose, a significant decrease ($p \leq 0.05$) was observed in the 5 and 10 repetitions compared to pre-training levels. However, in the 15 and 20 repetitions, there was a decrease in blood glucose, but this difference was not statistically significant ($p > 0.05$). For total cholesterol, variations were observed across different repetitions, but no significant differences were found. In terms of triglyceride levels, there was a reduction in all repetitions at the post-training moment, with statistically significant differences observed only in the 15 and 20 repetitions.

Table 2: Mean and standard deviation (SD) of blood glucose, total cholesterol, and triglycerides at pre- and post-training moments for different intensities based on the number of repetitions.

	Repetitions	Pre		Post		Delta		p-valor
		Mean	SD	Mean	SD	Mean	SD	
Blood glucose (mg/dL)	5	91,9	6,5	83,4	6,9	-8,5	9,7	0,009*
	10	95,9	16,2	80,3	14,0	-15,6	10,4	<0,001*
	15	88,4	14,5	77,0	10,2	-11,4	20,1	0,057
	20	77,0	9,4	70,4	15,7	-6,6	18,6	0,152
Total cholesterol (mg/dL)	5	177,5	14,6	168,4	9,3	-9,1	8,31	0,060
	10	170,8	14,4	180,6	15,6	9,8	9,88	0,065
	15	173,8	21,9	173,7	15,1	-0,2	12,1	0,981
	20	179,3	25,0	182,6	24,5	3,2	5,84	0,306
Triglycerides (mg/dL)	5	123,8	36,3	116,4	37,5	-7,4	25,3	0,433
	10	180,3	43,4	165,6	55,5	-14,7	25,2	0,289
	15	144,4	42,8	115,2	26,6	-29,3	32,3	0,046*
	20	146,1	40,1	117,9	30,9	-28,2	25,4	0,043*

Note: Delta (difference between pre- and post-training moments); * indicates significant difference between pre- and post-training moments using Student's t-test for p-value ≤ 0.05 .

DISCUSSION

This study aimed to investigate the acute effects of different intensities of resistance training on the metabolic markers of blood glucose, triglycerides, and total cholesterol in healthy young men. The results demonstrated a significant decrease in blood glucose levels with low repetitions sessions, while all intensities led to a reduction in triglyceride levels. However, no statistically significant differences were observed in total cholesterol.

Regarding blood glucose, a significant decrease was observed after resistance training with 5 and 10 repetitions, which aligns with previous studies demonstrating the beneficial effects of exercise on glucose regulation (ROCCA; TIRAPEGUI; MELO; RIBEIRO, 2008; SANTOS; POZZOBON; PÉRICO, 2012; TOMELERI; RIBEIRO; CAVAGLIERI; DEMINICE *et al.*, 2018). This decrease can be attributed to increased glucose uptake by muscle cells during exercise, resulting in enhanced utilization of this energy substrate (PANISSA; JULIO; DINIZ; ANTUNES *et al.*, 2016).

However, in the 15 and 20 repetitions, although a decrease in blood glucose was observed, the difference was not statistically significant, consistent with earlier research (GONÇALVES; LOPES; NETO; SANTOS, 2009; SANTOS; POZZOBON; PÉRICO, 2012). These findings suggest that higher intensities may involve other metabolic mechanisms, such as the utilization of alternative energy sources like fatty acids (MANN; BEEDIE; JIMENEZ, 2014). Additionally, exercise duration may also influence the glycemic response, warranting further investigation (GOROSTEGI-ANDUAGA; CORRES; MARTINEZAGUIRRE-BETOLAZA; PÉREZ-ASENJO *et al.*, 2018; IZZICUPO; D'AMICO; DI BLASIO; NAPOLITANO *et al.*, 2017).

Regarding total cholesterol, some studies have shown positive effects on lipid profiles resulting from resistance training (FETT; FETT; MARCHINI, 2009; MONTEIRO; ROLIM; SQUINCA; SILVA *et al.*, 2007), while others have not found significant changes in blood lipid levels (WESTCOTT, 2012). Our study observed variations in total cholesterol levels across different repetition intensities, but without statistical significance. This aligns with meta-analyses of controlled clinical trials examining the impact of resistance exercise training on total cholesterol levels, which have yielded inconsistent results (CORNELISSEN; FAGARD; COECKELBERGHS; VANHEES, 2011; PATTYN; CORNELISSEN; ESHGHI; VANHEES, 2013; STRASSER; SIEBERT; SCHOBERSBERGER, 2010). The lack of significant improvement in total cholesterol in these studies may be attributed to short intervention periods, limited statistical power due to small sample sizes, and initially low levels of total cholesterol in relatively healthy populations, these factors can diminish the potential effects of resistance exercise on lipid profiles (BAKKER; LEE; SUI; EIJSVOGELS *et al.*, 2018).

These findings highlight the complexity of the cholesterol response to exercise, as factors such as intensity, duration, and frequency of training can influence the lipid profile effects (SOUSA; MENDES; ABRANTES; SAMPAIO *et al.*, 2014). A linear dose-response relationship seems to exist between activity levels and HDL cholesterol, with more intense activity needed to induce reductions in LDL cholesterol and triglyceride levels. In the context of resistance training, increasing the volume of movement by adding sets and/or repetitions has shown a greater impact on the lipid profile than increasing intensity alone (FETT; FETT; MARCHINI, 2009; LIRA; YAMASHITA; UCHIDA; ZANCHI *et al.*, 2010).

Regarding triglycerides, a reduction was observed at all repetition intensities in the post-training moment, with statistically significant differences observed only in the 15 and 20 repetitions. These findings are consistent with previous studies demonstrating decreased triglyceride levels after exercise (FETT; FETT; MARCHINI, 2009; RIBEIRO; TOMELERI; SOUZA; PINA *et al.*, 2015; TOMELERI; RIBEIRO; CAVAGLIERI; DEMINICE *et al.*, 2018). This decrease can be attributed to increased lipolytic activity during exercise, leading to the

utilization of fatty acids as an energy source (DE FREITAS; NOBREGA; TRONCOM; FRANCO, 2012).

Other factors that can influence the results should be taken into consideration, such as pre-exercise feeding and genetic factors. Genetic characteristics may play a role in determining the extent to which resistance training affects lipid profiles (HURLEY; HANSON; SHEAFF, 2011). Blood lipid levels are influenced by both non-modifiable factors, such as sex, age, and genetics, and modifiable factors, including dietary habits, physical activity, and body weight. In this study, participants were instructed to have a meal 1 to 2 hours before training sessions. However, it should be acknowledged that variations in pre-exercise feeding can affect acute metabolic responses to exercise (FARIA; OLIVEIRA; SALES; MARINS *et al.*, 2014).

Another possible explanation for the lack of improvement in the lipid profile could be that more significant changes usually occur in individuals with more pronounced dyslipidemia at the beginning of the study. Given the participants' clinically normal baseline levels of triglycerides, total cholesterol, and blood glucose, it is not surprising that there were no significant changes in the mean values before and after training (PANISSA; JULIO; DINIZ; ANTUNES *et al.*, 2016; SOUSA; MENDES; ABRANTES; SAMPAIO *et al.*, 2014).

In summary, this study demonstrated that different intensities of resistance training have distinct effects on blood glucose, triglycerides, and total cholesterol in healthy young men. It is important to note that this study assessed the acute effects of resistance training, and the long-term effects may be more pronounced. These findings highlight the importance of considering various aspects of resistance training to evaluate its metabolic effects. Future research should explore the chronic responses of these variables. The results align with previous studies showing the benefits of physical exercise in regulating blood glucose and reducing triglyceride levels, underscoring the importance of regular resistance training for metabolic health.

CONCLUSION

In conclusion, acute resistance training at different intensities has immediate effects on specific metabolic markers, such as blood glucose and triglycerides, in healthy young men. Incorporating regular resistance training into exercise routines is crucial for improving metabolic health. Further research is needed to investigate the long-term effects of resistance training on metabolic markers and its applicability across different population groups.

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