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EFFECT OF STRENGTH TRAINING WITH BLOOD FLOW RESTRICTION ON BODY COMPOSITION, LIPID PROFILE AND SERUM IRISIN LEVELS IN ELDERLY WOMEN

EFEITO DO TREINAMENTO DE FORÇA COM RESTRIÇÃO DE FLUXO SANGUÍNEO NA COMPOSIÇÃO CORPORAL, PERFIL LIPÍDICO E NÍVEIS SÉRICOS DE IRISINA EM MULHERES IDOSAS

EFECTO DEL ENTRENAMIENTO DE FUERZA CON RESTRICCIÓN DEL FLUJO SANGUÍNEO SOBRE LA COMPOSICIÓN CORPORAL, EL PERFIL LIPÍDICO Y LOS NIVELES SÉRICOS DE IRISINA EN MUJERES DE EDAD AVANZADA

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Resumo
O envelhecimento vem acompanhado por alterações na homeostase corporal, aumento do risco de doenças crônicas não transmissíveis e declínio da capacidade funcional. Para retardar ou reduzir esse declínio, a população idosa pode aderir a programas de treinamento de força (TF), pois promovem adaptações morfofuncionais e metabólicas, além de induzir a produção da irisina, uma miocina relacionada ao emagrecimento e ao controle da composição corporal. Suas concentrações aumentam após a realização de exercícios com cargas elevadas, porém não está claro se o TF com baixas cargas, associado à restrição de fluxo sanguíneo (TFBC+RFS), pode alterar a composição corporal, o perfil lipídico e os níveis séricos de irisina em mulheres idosas. Objetivou-se avaliar o efeito de 16 semanas de TFBC+RFS na composição corporal, perfil lipídico e níveis séricos de irisina em mulheres idosas. Trinta e nove idosas saudáveis, entre 60 e 77 anos, distribuídas aleatoriamente nos grupos de TFBC+RFS; TF com carga moderada (TFCM); TF com baixa carga (TFBC) e controle (CON). Realizaram 4 exercícios, sendo 3 séries, 10 repetições, em 3 sessões semanais. Apenas o grupo TFBC+RFS apresentou aumento significativo na massa muscular (MM) p=0,015, após a intervenção, quantificada pelo InBody 570 Biospace®; o perfil lipídico, quantificado pelo analisador automatizado CHEMWELL-T; e os níveis séricos de irisina, com o método ELISA, não sofreram alterações *p>0,05*. Conclui-se que o TFBC+RFS foi eficiente no aumento da MM, mesmo não sendo efetivo para alterar o perfil lipídico e os níveis séricos de irisina.
Palavras-chave: Irisina. Treinamento Resistido. Envelhecimento. Isquemia Vascular. Marcadores Bioquímicos.

Abstract
Aging is accompanied by changes in body homeostasis, an increased risk of chronic non-communicable diseases, and a decline in functional capacity. To delay or reduce this decline, the elderly population can adhere to strength training (ST) programs, as they promote morphofunctional and metabolic adaptations, in addition to inducing the production of irisin, a myokine related to weight loss and body composition control. Its concentrations increase after performing exercises with high loads, but it is unclear whether ST with low loads associated with blood flow restriction (LLST+BFR) can alter body composition, lipid profile, and serum irisin levels in elderly women. The objective was to evaluate the effect of 16 weeks of LLST+BFR on body composition, lipid profile, and serum irisin levels in elderly women. Thirty-nine healthy elderly women, aged 60 to 77 years, were randomly distributed into the following groups: LLST+BFR; moderate load ST (MLST); Low-load ST (LLST) and control (CON) groups performed 4 exercises, consisting of 3 sets of 10 repetitions, in 3 weekly sessions. Only the LLST+BFR group showed a significant increase in muscle mass (MM) p=0.015 after the intervention, quantified by the InBody 570 Biospace®; the lipid profile, quantified by the automated CHEMWELL-T analyzer; and serum irisin levels, measured by ELISA, did not change *p>0.05*. It is concluded that LLST+BFR was effective in increasing MM, even though it was not effective in altering the lipid profile and serum irisin levels.
Keywords: Irisin. Resistance Training. Aging. Vascular ischemia. Biochemical Markers.

Resumen

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El envejecimiento se acompaña de cambios en la homeostasis corporal, un mayor riesgo de enfermedades crónicas no transmisibles y una disminución de la capacidad funcional. Para retrasar o reducir este declive, la población de edad avanzada puede adherirse a programas de entrenamiento de fuerza (EF), ya que promueven adaptaciones morfofuncionales y metabólicas, además de inducir la producción de irisina, una miocina relacionada con la pérdida de peso y el control de la composición corporal. Sus concentraciones aumentan después de realizar ejercicios con cargas altas, pero no está claro si el EF con cargas bajas asociadas con restricción del flujo sanguíneo (EFCB+RFS) puede alterar la composición corporal, el perfil lipídico y los niveles séricos de irisina en mujeres de edad avanzada. El objetivo fue evaluar el efecto de 16 semanas de EF+RFS sobre la composición corporal, el perfil lipídico y los niveles séricos de irisina en mujeres de edad avanzada. Treinta y nueve mujeres de edad avanzada sanas, de 60 a 77 años, fueron distribuidas aleatoriamente en los grupos de EFCB+RFS; EF con carga moderada (EFCM); EF con cargas bajas (EFCB) y control (CON). Los participantes realizaron 4 ejercicios, consistentes en 3 series de 10 repeticiones, en 3 sesiones semanales. Solo el grupo EFCB+RFS mostró un aumento significativo de la masa muscular (MM) p=0,015 tras la intervención, cuantificado con el InBody 570 Biospace®; el perfil lipídico, cuantificado con el analizador automatizado CHEMWELL-T; y los niveles séricos de irisina, medidos mediante ELISA, no se modificaron *p>0,05*. Se concluye que EFCB+RFS fue eficaz para aumentar la MM, aunque no lo fue para alterar el perfil lipídico ni los niveles séricos de irisina.
Palabras clave: irisina. Entrenamiento de Resistencia. Envejecimiento. Isquemia Vascular. Marcadores Bioquímicos.

1. Introduction

Aging is a natural and progressive process that occurs in all living organisms over time. In the human context, it is characterized by physiological changes, such as sarcopenia, responsible for the loss of up to 75% of type II muscle fibers, which directly impacts functional performance and production of muscular power, as well as an increase in the percentage of body fat (%BF) and changes in the lipid profile, causing a pathological condition, significantly reducing the capacity to perform daily activities and the quality of life in elderly populations (CHEN et al., 2014).

Changes in body composition affect lipid metabolism, promoting an increase in the circulation of low-density lipoprotein (LDL) and a significant decrease in high-density lipoprotein (HDL) in the blood. (FALUDI et al., 2017; SEMADHI et al., 2019; XAVIER et al., 2013). Furthermore, in old age, a significant portion, corresponding to 25% of men and 42% of women, still maintains total cholesterol (TC) values considered undesirable (>240 mg/dL), favoring the development of chronic diseases, especially those cardiovascular. (FALUDI et al., 2017; XAVIER et al., 2013).

Regular physical exercise plays a fundamental role in regulating lipid metabolism and reducing TC, LDL and triglyceride (TG) levels, favoring the regression of emerging chronic diseases and increasing longevity (MCARDLE; KATCH; KATCH, 2011). The musculoskeletal contraction carried out during physical

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exercise is responsible for the synthesis and release of several myokines, which promote communication between the muscle and other organs and tissues (LIEGRO et al., 2019).

Irisin is an important myokine that has gained prominence in recent years, due to its ability to regulate metabolism, convert white fat cells into brown fat, increase caloric expenditure by increasing thermogenesis and reduce the accumulation of lipids, in addition to promoting weight loss. and control of body composition (BOSTRÖM et al., 2012). Given the above, irisin is emerging as a key molecule capable of combating metabolic, neuromuscular diseases and other disorders that typically improve with physical exercise (MA; CHEN, 2021).

In this sense, studies on the molecular mechanisms of physical exercise have presented evidence that irisin brings clear benefits related to the prevention or treatment of chronic diseases (CHEN et al., 2016; KIM et al., 2019; MAAK et al., 2021) , such as sarcopenia (Colaianni et al., 2017), type 2 diabetes (Zhang et al., 2016), bone metabolism (Ma et al., 2018), obesity (Arhire; Mihalache; Covasa, 2019), neurodegenerative disease (Young; Valaris; Wrann, 2019), cancer (Kim et al., 2021), cardiovascular diseases (Fu et al., 2021) and stroke (LIU et al., 2020).

From this perspective, increasing irisin levels in the body could mitigate the deleterious effect of aging and improve functional capacity. Therefore, it is already well established in the literature that strength training (ST) with high loads is effective in significantly increasing serum levels of this myokine in populations of advanced and elderly women (GHANBARI-NIAKI et al., 2018; KIM et al., 2016; PLANELLA-FARRUGIA et al., 2019). This type of training is also efficient in reversing the decrease in muscle mass in the elderly Kong et al. (2022), however, high loads in certain situations may not be well tolerated by this population, compromising their adherence (PAHLAVANI, 2022).

As an alternative, it is feasible to use low load ST (LLST) (20-50%) of one repetition maximum (1RM), associated with blood flow restriction (BFR). This strategy is performed using tourniquets, fixed to the appendicular skeleton, restricting the passage of blood flow to the exercised muscles (ABE; KEARNS; SATO, 2006; ABE et al., 2010).

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Low-load strength training associated with BFR (LLST+BFR) has been widely used in the elderly population, as it significantly increases hypertrophy and muscle strength (CENTNER et al., 2019; KONG et al., 2022; DANTAS et al., 2026), increases metabolism and stimulates signaling in the positive cascade The activation of mTORC1 promotes the recruitment of type II muscle fibers and the inhibition of myostatin, thus expanding the functionality of growth hormone (GH) Takarada, et al. (2000a), testosterone and growth factor insulin-like -1 (IGF-1) (ABE et al., 2005).

To date, few studies (CORDINGLEY; ANDERSON; CORNISH, 2023; KRAEMER et al., 2015; MOHAMMADIYAN, MOGHADDAM, HAKKAKDOKHT, 2021; PAZOKIAN; AMANI-SHALAMZARI; RAJABI, 2022) have tested the efficiency of LLST+BFR aiming to observe the behavior of serum irisin levels, however, gaps in knowledge are still present regarding the chronic effect of this training method on irisin production in elderly women and its relationship with body composition and lipid variables, after this type of intervention.

Our hypothesis is that LLST associated with BFR will promote changes in body composition, lipid profile and serum irisin levels.

2. Methods

2.1 Participants and eligibility criteria

Sixty-two elderly women, aged between 60 – 77 years, participated in the present study, recruited through advertisements on social networks, television and local radio. The eligibility criteria were as follows: absence of motor, visual and auditory impairment (uncorrected); no previous ST experience; level of education (complete primary education or higher); not present ankle brachial index (ABI), < 0.90 and > 1.40) which would characterize a sign of peripheral arterial disease Resnick et al. (2004); present a value above 24 on the Mini-Mental State Examination (MMSE) questionnaire; physically active (cutoff point considered for moderate to vigorous physical activity of 1,041 counts/min), measured using an accelerometer (COPELAND; ESLIGER, 2009). Participants were excluded when they withdrew from the study at any stage; when they were unable to regularly attend the training

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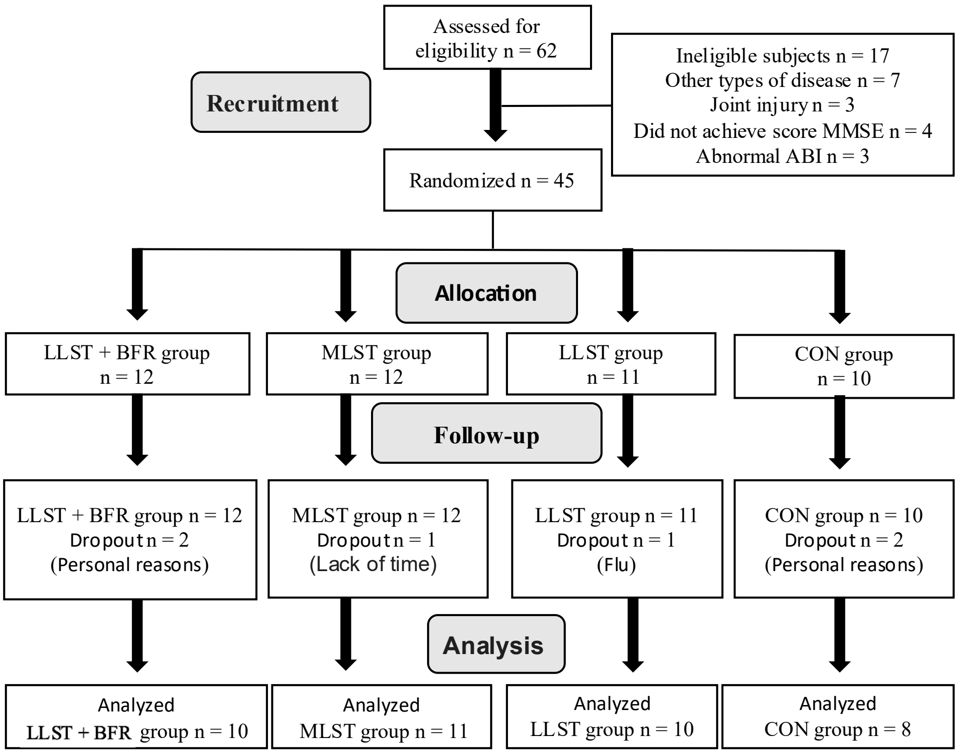
sessions, missing more than 25% of the total sessions, or missing some stage of the tests.

Of the 62 volunteers, 17 did not meet the inclusion criteria; 6 withdrew for personal reasons, lack of time or flu-like illness and 39 participants completed the study. Figure 1 shows the sample flow diagram according to CONSORT and the number of participants in the treatment groups at each stage of the study.

Considering that the nature of the intervention was a non-pharmacological strategy, masking researchers and participants was not possible. The volunteers were randomly distributed into each of the three experimental groups: LLST+BFR, moderate load ST (MLST), LLST and the control (CON). This allocation was carried out immediately after the pre-experimental evaluation by another researcher, using a hidden sequence, stratified by muscle strength measurements and age, using the website http://www.randomizer.org.

Figure 1. Study flowchart



Caption: ABI: ankle brachial index; LLST+BFR: low load strength training associated with partial blood flow restriction; MLST: moderate load strength training; LLST: low load strength training; CON: control.

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2.2 Experimental design and procedures

This is a randomized, single-blind clinical study (with blinding of the evaluators), which evaluated the effect of sixteen weeks of ST, with and without BFR, on serum levels of irisin, TC, TG, LDL, HDL, body mass (BM), body mass index (BMI), muscle mass (MM) and %BF, of healthy elderly women.

The study was approved by the ethics committee of the Federal University of Paraíba (UFPB), CAAE number: 11399019.7.0000.5188, complying with the ethical standards of the Declaration of Helsinki (GRECO, 2013). The guidelines of the "Standart Protocol Items: recommendations for Interventional Trials" (SPIRIT) (CHAN et al., 2013) were followed. All participants signed the free and informed consent form before the pre-experimental assessments. The study was carried out between February and December 2019 in the city of João Pessoa – PB, Brazil.

2.2.1 Randomization

The sample calculation was carried out based on the results of two studies methodologically similar to the present study (PEREIRA et al., 2019; PLUMMER-D'AMATO et al., 2012). Thus, the parameters considered were: $\alpha = 0.05$; power ($1 - \beta$) = 0.80; effect size = 0.32; number of groups = 4; number of measurements = 2; and sample loss of 15%. The minimum total sample required was set at 36 volunteers.

2.2.2 Data collection

Data collection was carried out at the Laboratory of Kinanthropometry and Human Performance (LABOCINE), at the UFPB. Three participants were randomly assigned to different experienced raters, who tested them simultaneously. The descriptive evaluation of the general characterization of the participants included data on age (years) carried out during the face-to-face interview.

2.2.3 Ankle Brachial Index Assessment

The ABI was used as the cutoff point for inclusion in the present study, and was performed by measuring the systolic blood pressure (SBP) of the lower limbs

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(anterior tibial artery) and upper limbs (brachial artery). The ABI value was obtained bilaterally, using the ratio: right ankle SBP/right arm SBP and left ankle SBP/left arm SBP (RESNICK et al., 2004).

2.2.4 Height assessment

Height (m) was measured using a stadiometer (Wiso®, model E210, Santa Catarina, Brazil), with the volunteers barefoot and standing, in an anatomical position, with their face facing forward in the Frankfurt plane, on a surface flat and with the back of the body leaning against a wall.

2.2.5 Body composition assessment

Body mass, MM and BF% were measured using bioimpedance (InBody 570 Biospace®, San Francisco – California, USA), according to the manufacturer's instructions. Body mass index was determined from the equation (kg/m^2).

2.2.6 Assessment of physical activity level

The level of physical activity was measured in minutes (min) using an accelerometer (Actigraph, model GT3X, Pensacola, FL), which was attached to the elderly women's clothing at waist height with the aid of an elastic band, for 24 hours, for a period of seven consecutive days, according to the recommendations of (GARATACHEA; LUQUE; GALLEGO, 2010).

2.2.7 Blood collection and handling

All volunteers attended the laboratory between 7:00 am and 9:00 am after an overnight fast, one day before and one day after the last session of the training program. Venous blood was collected from the antecubital vein and the samples were collected in tubes containing EDTA and centrifuged immediately at 2.000 RPM for 15 min. Serum was isolated and stored at -80°C for later analysis.

2.2.8 Irisin assessment

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After thawing, the samples were centrifuged at 10.000 RPM for 10 min to completely remove the plaques. Serum irisin concentrations were determined using the enzyme-linked immunosorbent assay (ELISA) method according to the technical specifications of the KIT, HUMAN IRISIN/FNDC5 DUOSET ELISA, 5 PLATE, USA R&D SYSTEMS INC. The occurrence was read on a spectrophotometer at 450 nm. All samples from the same individual were tested using the same plate, and irisin levels were expressed in ng/ml, with all samples being tested in duplicates.

2.2.9 Lipid profile assessment

Total Cholesterol, TG and HDL variables were measured through enzymatic assays, using the ChemWell®-T automated biochemical analyzer. All reagents were obtained from Labtest and their protocols were carried out in accordance with the manufacturer. High density lipoprotein values were obtained from the following equation: LDL = TC - HDL - (TG/5), (FRIEDEWALD; LEVY; FREDRICKSON, 1972).

2.2.10 Determination of blood flow restriction pressure

A portable vascular doppler (MedPeg® DV -2001, Ribeirão Preto, SP, Brazil) was used, as described by Laurentino et al. (2012), and a special sphygmomanometer (komprimeter pneumatic tourniquet for hemostasis in extremities - Riester®), whose cuffs measured (10 cm wide x 54 cm long for the lower limbs and 6 cm wide x 47 cm long for the upper limbs). The volunteers were positioned in the supine position and the cuffs were placed on the most proximal portion of the thighs and arms, and were subsequently inflated until the arterial auscultatory pulse was inaudible, moment at which the point of total arterial restriction was determined.

2.2.11 Intervention

The experimental groups performed a ST program that consisted of four exercises, two for the upper limbs (flat bench press and barbell curl) and two for the lower limbs (45º leg press and squat), performed non-consecutively. The training program lasted 16 weeks and had its volume, rest interval and time under tension

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equalized for all groups. In general, the training consisted of 3 sets of 10 repetitions for each exercise, with a recovery interval of 60 seconds between sets and 120 seconds between exercises, as well as a movement execution cadence of 1 second in the concentric phase and 2 seconds in the eccentric phase.

The load used by the MLST group was 60% of 1RM and by the LLST and LLST+BFR groups, it was 20% of 1RM. During the exercises, the LLST+BFR group used a sphygmomanometer (komprimeter pneumatic tourniquet - Riester®), located in the most proximal part of the exercised limbs, being constantly monitored to ensure partial compression that remained at ~50% of the point of total arterial restriction for each individual. The cuffs were only deflated between exercises.

Load adjustment and progression were carried out after 8 weeks of training according to the recommendations of the American College of Sports Medicine (ACSM, 2017). The CON group maintained their daily routine without training, until reassessment, after the end of the experimental period.

The three experimental groups began training the following week, after completing the initial assessments, and were supervised by 4 specialized instructors at a ratio of 2 participants per instructor. The frequency and percentage of interventions carried out were recorded and calculated according to the participants' attendance.

2.3 Data analysis

Data normality was checked using the Shapiro Wilk test for each dependent variable. Levene's test was performed to verify homogeneity of variance and Mauchly's test for sphericity. Differences between groups were tested with one-way ANOVA in the pre- and post-experiment moments, with Tukey's post hoc test. Intragroup analyzes before and after 16 weeks of training were performed using the Student's t test. Cohen's d effect size was also calculated, and the relationships between the outcome variable (serum irisin levels) and the lipid profile and body composition variables were analyzed using Pearson's correlation. The results are displayed as mean and standard deviation and significance adopted at $P \leq 0.05$. All

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statistical procedures were performed by a blind researcher, using SPSS version 22.0 software (SPSS Inc., Chicago, New York, USA).

3. Results

The adherence of volunteers in the experimental groups was 83.3% for the LLST+BFR group, 91.7% for the MLST group and 90.9% for the LLST group. The mean frequency was 88.2 ± 1.2% in the LLST+BFR group; 87.3 ± 1.3% in the MLST group and 89.1 ± 1.4% in the LLST group. There were no accidental occurrences or other adverse events during the experimental period.

The analysis of variance showed that there was homogeneity among the experimental groups regarding the studied variables, and it is possible to observe in Table 01 the descriptive characteristics (mean + standard deviation) of age, physical activity level, body composition, lipid variables, and serum irisin levels at baseline.

Table 01: Descriptive characteristics (mean + standard deviation) of the participants at baseline and time and group effect after 16 weeks of intervention among the experimental groups.

VARIABLES	TIME	LLST+BFR (n=10)	MLST (n=11)	LLST (n=10)	CON (n=8)
Age (years)	Pre	65.70 ± 3.30	66.09 ± 3.59	67.40 ± 5.89	65.38 ± 3.58
	Post	-	-	-	-
Level of physical activity (min/day)	Pre	42.79 ± 14.53	39.26 ± 19.65	35.04 ± 21.06	32.58 ± 14.28
	Post	-	-	-	-
Body Composition					
Body Mass (kg)	Pre	59.16 ± 7.01	64.15 ± 11.74	69.59 ± 10.25	64.95 ± 10.97
	Post	59.15 ± 7.22	63.63 ± 11.58	70.66 ± 10.33	65.14 ± 10.70
BMI (kg/m^2)	Pre	25.03 ± 2.58	27.97 ± 4.88	28.46 ± 5.04	27.43 ± 4.66
	Post	25.14 ± 2.61	27.76 ± 4.88	28.90 ± 5.21	27.55 ± 4.39
Mascle mass (kg)	Pre	19.20 ± 3.10	19.91 ± 2.38	22.16 ± 1.40	19.16 ± 2.24
	Post	**19.71 ± 2.86***	20.37 ± 2.35	**22.46 ± 1.44**[§ #]	19.26 ± 2.22
Body fat (%)	Pre	38.80 ± 5.43	40.84 ± 6.89	39.62 ± 7.91	43.23 ± 6.72
	Post	37.47 ± 5.19	39.35 ± 6.94	39.76 ± 7.85	43.34 ± 6.11
Lipid Profile					
Cholesterol (mg/dL)	Pre	223 ± 43.29	214 ± 39.07	205 ± 51.02	255 ± 67.40
	Post	225 ± 44.26	218 ± 38.20	208 ± 62.36	239 ± 72.39
Triglycerides (mg/dL)	Pre	194 ± 82.26	139 ± 66.11	121 ± 50.81	110 ± 30.13
	Post	176 ± 41.18	147 + 80.48	116 ± 36.72	134 ± 44.17
HDL (mg/dL)	Pre	40 ± 18.85	37 ± 16.59	50 ± 19.99	46 ± 21.32
	Post	44 ± 14.32	41 ± 16.02	53 ± 16.73	42 ± 20.84
LDL (mg/dL)	Pre	145 ± 31.83	149 ± 40.67	131 ± 54.15	187 ± 66.43
	Post	138 ± 50.34	139 ± 34.68	135 ± 56.96	186 ± 59.08
Irisin (ng/ml)	Pre	0.113 ± 0.06	0.169 ± 0.10	0.118 ± 0.04	0.168 ± 0.15
	Post	0.088 ± 0.04	0.141 ± 0.10	0.096 ± 0.03	0.156 ± 0.15

Note: BMI - Body Mass Index; LLST+BFR: Low Load Strength Training Associated with Blood Flow Restriction; MLST: Strength Training with Moderate Load; LLST: Low Load Strength Training;

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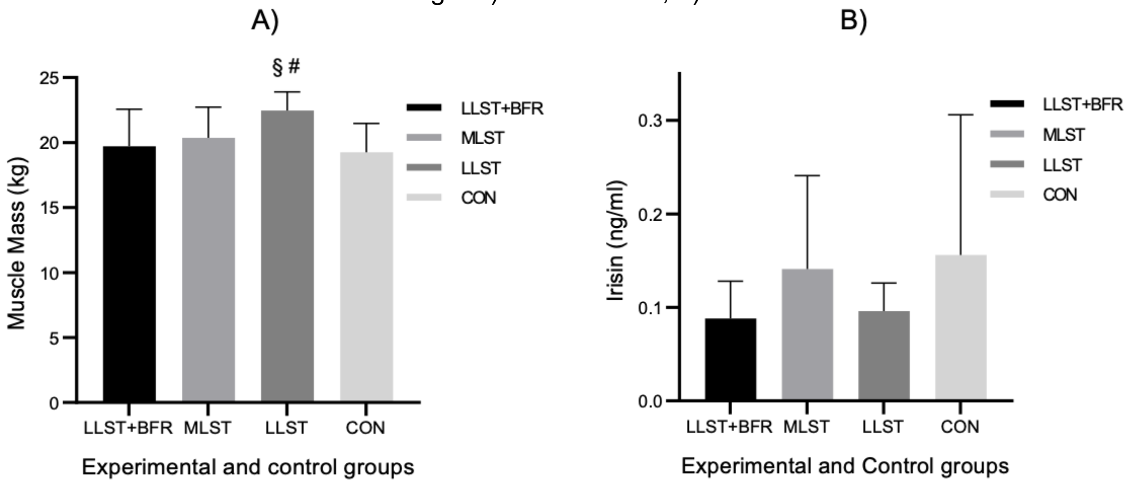
CON: Control Group; min/day: Minutes per Day; ng/ml: Nanogram per Milliliters; mg/dL: Milligrams per Deciliters; HDL: High Density Lipoproteins; LDL: Low Density Lipoproteins; kg/m^2: Kilograms Divided by Square Meter; *: P ≤ 0.05 between pre vs 16 weeks of training; §: P ≤ 0.05 between the LLST+BFR, MLST and LLST vs CON groups; #: P ≤ 0.05 between LLST+BFR vs LLST groups.

After 16 weeks of training, significant differences were observed between the groups in the variable muscle mass ($F_{(3,35)} = 3.660$; $p = 0.021$; $\eta^2 = 0.239$), figure 2 (a). The post hoc identified a significant difference between the LLST vs CON groups, presenting a large effect size ($p = 0.027$; $d = 1.71$), such that the LLST group presented its highest mean value (Δ = 14.24 %). It was also possible to observe another significant difference between the LLST+BFR and LLST groups ($p = 0.050$; $d = 1.21$), pointing to a large effect size and superiority of the LLST group in its average value (Δ = 12.24%).

It was not possible to observe significant differences between the experimental and control groups in the other body composition variables: body mass ($f_{(3.35)} = 2.211$; $p = 0.104$; $\eta^2 = 0.159$); BMI ($f_{(3.35)} = 1.291$; $p = 0.293$; $\eta^2 = 0.100$); %BF ($f_{(3.35)} = 1.186$; $p = 0.329$; $\eta^2 = 0.092$) and lipid profile: total cholesterol ($f_{(3.34)} = 0.511$; $p = 0.677$; $\eta^2 = 0.043$); triglycerides ($f_{(3.34)} = 2.133$; $p = 0.114$; $\eta^2 = 0.158$); HDL ($f_{(3.34)} = 1.024$; $p = 0.394$; $\eta^2 = 0.083$) and LDL ($f_{(3.34)} = 1.920$; $p = 0.145$; $\eta^2 = 0.145$), as well as serum irisin levels ($f_{(3.34)} = 1.292$; $p = 0,293$; $\eta^2 = 0,102$), figure 2 (b).

Figure 2: Comparison between experimental and control groups after 16 weeks of strength training – a) muscle mass; b) irisin.



Caption: Kg: kilograms; ng/ml: nanograms per milliliter; LLST+BFR: Low-load Strength Training Combined with Blood Flow Restriction; MLST: Moderate Load Strength Training; LLST: Low-

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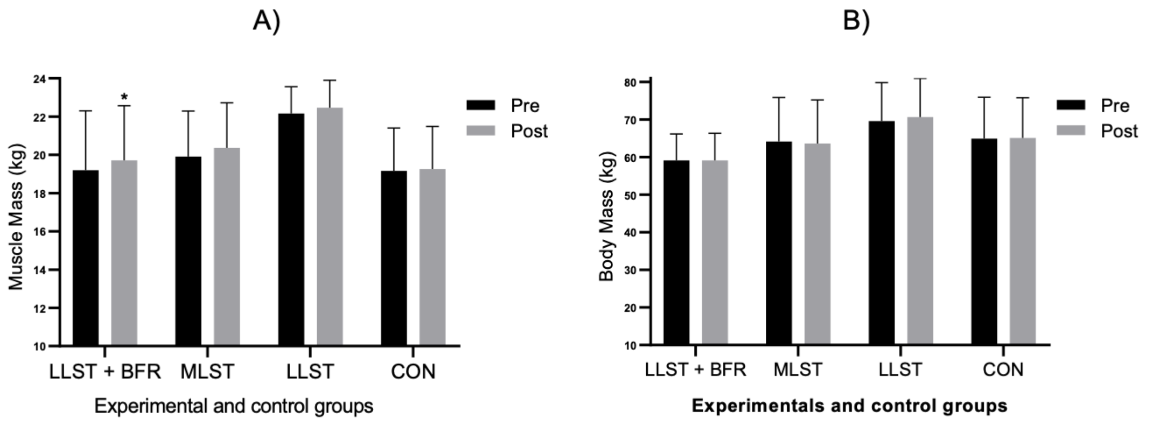
load Strength Training; CON: Control Group; §: P ≤ 0.05 between the LLST+BFR, MLST and LLST vs CON groups; #: P ≤ 0.05 between LLST+BFR vs LLST groups.

During intragroup inferential tests on body composition variables, a significant effect of time on muscle mass after 16 weeks of training was identified in the LLST+BFR group (t = -2.995; p = 0.015; d = -0.171). However, there were no significant differences in the other experimental groups and CON, MLST (t = -1.981; p = 0.076; d = -0.194), LLST (t = -1.983; p = 0.079; d = -0.211) and in the CON (t = -0.505; p =0.629; d = -0.044), figure 3 (a).

In relation to body mass, it was not possible to observe significant effects of training, after the intervention period, in all groups studied, as can be seen below: LLST+BFR (t = 0.018; p = 0.986; d = 0.001), MLST (t = 1.355 - p = 0.205; d = 0.044), LLST (t = -1.269; p = 0.236; d = -0.103), CON (t = -0.376; p = 0.718; d = -0.105) figure 3 (b).

Figure 3: Intragroup comparison after 16 weeks of strength training – A) Muscle Mass; B) Body Mass.



Caption: Kg: kilograms; LLST+BFR: Low-load Strength Training Combined with Blood Flow Restriction; MLST: Moderate Load Strength Training; LLST: Low-load Strength Training; CON: Control Group

With regard to BMI, no significant effects were observed in the groups studied as a result of training, LLST+BFR (t = -0.406; p = 0.694; d = -0.042), MLST (t = 1.213; p = 0.253; d = 0.043), LLST (t = -1.294; p = 0.228; d = -0.085), CON (t = -0.570; p = 0.587; d = -0.026), figure 4 (a).

Likewise, %BF did not undergo significant changes resulting from the training program, in any of the groups evaluated, LLST+BFR (t = 1.883; p = 0.092; d = 0.250),

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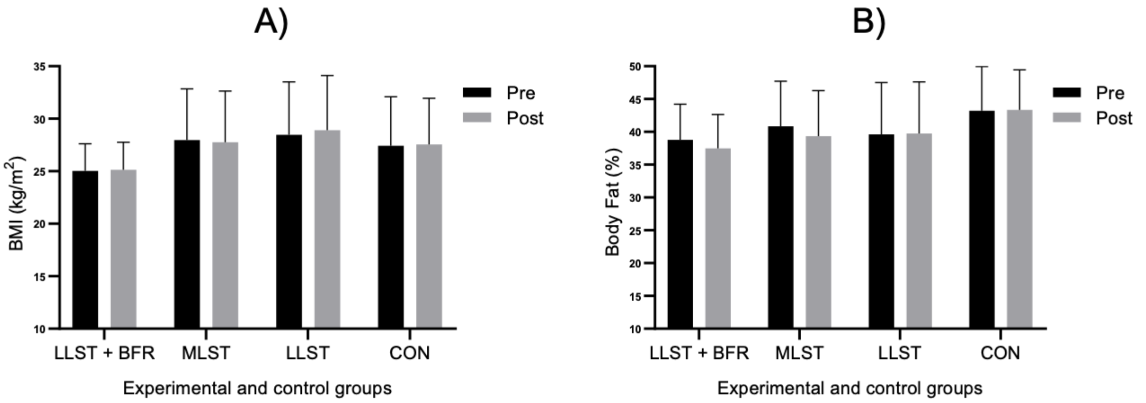
MLST (1.861; p = 0.092; d = 0.215), LLST (t = -0.149; p = 0.885; d = 0.078) and CON (t = -0.291; p = 0.780; d = -0.017), figure 4 (b).

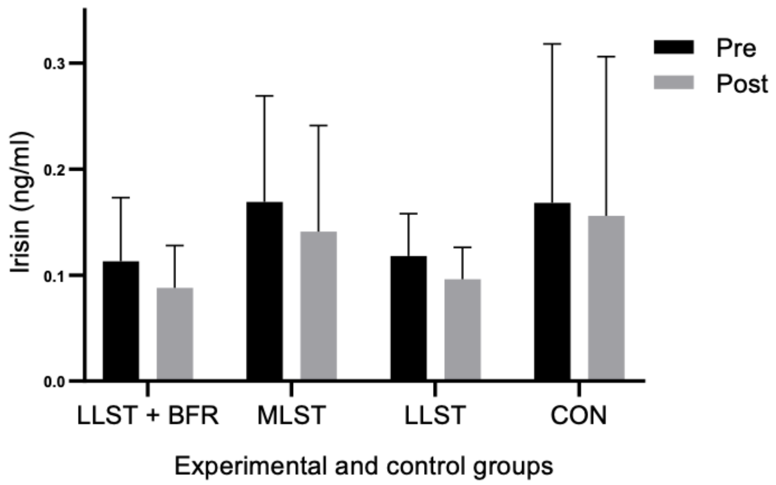
Figure 4: Intragroup comparison after 16 weeks of training – A) BMI; B) Body fat (%).



Caption: BMI: Body Mass Index; Kg/m^2: kilograms divided by height squared; %: Percentage; LLST+BFR: Low-load Strength Training Combined with Blood Flow Restriction; MLST: Moderate Load Strength Training; LLST: Low-load Strength Training; CON: Control Group.

In figure 5 it is possible to observe that serum irisin levels were not affected by time in the experimental and control groups, LLST+BFR (t = 1.176; p = 0.270; d = 0.49); MLST (t = 1.179; p = 0.266; d = 0.28); LLST (t = 2.127; p = 0.062; d = 0.62) and CON (t = 0.470; p = 0.653; d = 0.08).

Figure 5: Intragroup comparison of serum Irisin levels after 16 weeks of strength training.



Caption: ng/ml: nanograms per milliliter; LLST+BFR: Low-load Strength Training Combined with Blood Flow Restriction; MLST:

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Moderate Load Strength Training; LLST: Low-load Strength Training; CON: Control Group.

The changes that occurred in lipid variables from the 16 weeks of training were not statistically significant in any of the groups tested, total cholesterol: LLST+BFR (t = -0.432; p = 0.676; d = -0.05), MLST (t = -0.214; p = 0.835; d = -0.10), LLST (t = -0.327; p = 0.751; d = -0.05) and CON (t = 1.958; p = 0.091; d = 0.23); the same result occurred in triglycerides: LLST+BFR (t = 0.804; p = 0.442; d = 0.276), MLST (t = -0.573; p = 0.580; d = -0.108), LLST (t = 0.520; p = 0.616 ; d = 0.112) and CON (t = -1.966; p = 0.090; d = -0.634).

Similarly, no significant differences were observed in HDL: LLST+BFR (t = -1.294; p = 0.228; d = -0.238), MLST (t = -1.085; p = 0.303; d = -0.245), LLST (t = -0.916; p = 0.384; d = -0.162) and CON (t = 0.916; p = 0.390; d = 0.189), and in LDL: LLST+BFR (t = 0.429; p = 0.678; d = 0.166) , MLST (t = 0.765; p = 0.464; d = 0.291), LLST (t = -0.196; p = 0.849; d = -0.071) and in the CON group (t = 0.057; p = 0.956; d = 0.015).

Regarding the correlational analyzes between irisin and other variables studied, it was possible to observe that in the LLST+BFR group, there was a weak interaction after 16 weeks of training, between irisin and the total cholesterol variables (r= -0.316; p = 0.374), HDL (r = -0.309; p = 0.385), muscle mass (r = -0.323; p = 0.363) and %BF (r = 0.339; p = 0.338). A very weak correlation was also observed with the variables body mass (r = -0.127; p = 0.727), BMI (r = -0.052; p = 0.886), triglycerides (r = 0.074; p = 0.839) and LDL (r = 0.068; p = 0.853).

In the MLST group, there was a moderate interaction between irisin and muscle mass (r = -0.480; p = 0.135) and triglycerides (r = -0.447; p = 0.168). However, a weak interaction was observed between irisin and BMI (r = 0.244; p = 0.470), %BF (r = 0.240; p = 0.478) and total cholesterol (r = 0.279, p = 0.407). In relation to body mass (r = -0.104; p = 0.760), HDL (r = 0.129; p = 0.705) and LDL (r = 0.178; p = 0.622), there was a very weak correlation.

In the LLST group, a strong interaction was observed between irisin and body mass (r = 0.714; p = 0.020), and a moderate interaction with muscle mass (r = 0.622; p = 0.055), BMI (r = 0.527; p = 0.118), %BF (r = 0.539; p = 0.108) and LDL (r = 0.498;

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p = 0.143). A weak interaction was also observed between irisin and HDL (r = -0.359; p = 0.309), and a very weak correlation with total cholesterol (r = -0.064; p = 0.860) and triglycerides (r = 0.055; p = 0.881).

4. Discussions

The present study aimed to analyze the effect of sixteen weeks of ST, using moderate and low loads, associated with the BFR technique on body composition, lipid profile and serum irisin levels in elderly women.

The results partially confirmed the hypothesis of this study, considering that the LLST+BFR experimental group showed an improvement in body composition, related to the significant increase in MM, and a notable reduction in %BF. This finding corroborates a growing body of evidence that this type of training carried out in elderly people is capable of promoting hypertrophy, favoring body composition and reducing sarcopenia (COOK et al., 2017; LIBARDI et al., 2015; SCARPELLI et al., 2021; TAKARADA et al., 2000; THIEBAUD et al., 2013; VECHIN et al., 2015; YASUDA et al., 2016).

Additionally, some review and meta-analytic studies have confirmed the positive effect of the BFR technique associated with training with low loads, both in young and elderly populations. These studies concluded that this type of interventionist approach is proven to be an effective alternative for stimulating muscular hypertrophy and strength gains in these populations, especially when it is impossible to perform high-load exercises (CENTNER et al., 2019; KONG et al., 2022; LABATA-LEZAUN et al., 2022; RODRIGO-MALLORCA et al., 2021; SLYSZ; STULTZ; BURR, 2016).

In the current study, LLST+BFR proved to be more effective than MLST and LLST in promoting hypertrophy, even though the latter two groups showed improvements in this variable, however, not significant. A significant effect of time was also observed between the LLST+BFR vs LLST (Δ = 12.24%) and LLST vs CON (Δ = 14.24%) groups, with percentage superiority for the LLST group in both cases, however, when the average values were observed in the pre and post intragroup moments, it was possible to notice that the LLST+BFR group (pre = 19.20; post =

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19.71) had a greater increase in MM, when compared to the group LLST (pre = 22.16; post = 22.46), further confirming the effectiveness of the BFR. Similar results had already been reported in a meta-analysis that evaluated 47 studies, whose objective was to compare groups that performed LLST and LLST+BFR, among which, 26 were with men only, 7 with women and 14 included men and women, with average age aged (34±18 years) (SLYSZ; STULTZ; BURR, 2016).

Changes in body composition, such as an increase in MM, positively influence the increase in strength in the elderly, which is extremely important for carrying out daily activities and performing dual tasks during walking, which is widely recognized as a functional mobility concern among They are therefore a considerable public health problem, due to the risk of falling (BEAUCHET et al., 2009; DA SILVA; CAVALCANTE NETO, 2019).

In relation to BM, the LLST+BFR and MLST groups showed a slight reduction in this variable, even with the increase in MM, which can be explained by the effectiveness of training in reducing body fat, however, the LLST group showed results contrasting, subtly increasing BM and %BF. These changes caused a slight increase in BMI in the LLST+BFR and LLST groups, which can be explained by the increase in BM, while the MLST group showed a small decrease, explained by the reduction in BM and only a slight increase in MM.

The 16-week training program did not promote significant changes in the lipid variables (TC, TG, HDL and LDL) in the groups studied, with only a slight fluctuation in these variables. However, it is important to highlight that, even though it was not significant, there was an increase in HDL levels, in the proportion of 9.1%, 9.8% and 5.7% in the LLST+BFR, MLST and LLST groups respectively.

These increases should be considered as a promising result for this population, as we observe that the MLST group at the pre-experimental moment had an average value of 37±16.59 mg/dL of this substance, classified by the literature as high risk for developing cardiovascular diseases Précoma et al. (2019), however, post-training, the mean values increased to 41±16.02 mg/dL, becoming classified as low risk. These observations can be extended to the other experimental groups,

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considering that they were already outside the risk classification and became even further away.

The findings of the present research corroborate the results of a recent systematic review that studied the effect of training with BFR on anthropometric and lipid variables in overweight/obese adults. Where it has been seen that this type of training is an effective intervention to reduce TC, TG and increase the level of HDL, but not to a level significantly different from the initial one (SUN, 2022).

In the same way as lipid variables, none of the groups studied suffered significant changes in serum irisin levels after the training protocol. This result may have been motivated by the slight reduction in %BF, as white adipose tissue is considered the second largest precursor of this myokine (COSIO et al., 2021). Therefore, the reduction %BF in the experimental groups, except in the LLST group, may have influenced the non-change in serum irisin levels, since Huh et al. (2012), found that the significant decrease in white body fat, leads to a reduction in circulating levels of this substance, after a chronic training program.

Another important factor that possibly influenced the results was the time interval between blood collection, which occurred approximately 24 hours after the last training session of the experimental period, that is, after the circadian period of peak irisin production, which it can occur temporarily, between one and three hours after the end of the training session. In this sense, if blood collection for analysis is carried out much beyond this period, it can probably affect the results, especially after chronic TP (TSIANI et al., 2021).

It is also necessary to consider that the storage time of the serum samples, until the moment of analysis, may have interfered with the quality of the results, as the longer the freezing time, the greater the possibility of sample degradation (HUH et al., 2012; SCHARHAG-ROSENBERGER et al., 2014). Perhaps for this reason, the study by Kraemer et al. (2015), with young university students, observed after an acute session of low-load exercise and BFR, a significant increase in serum irisin levels, 15 minutes after the end of the session of training. In contrast (CORDINGLEY; ANDERSON; CORNISH, 2023; PAZOKIAN; AMANI-SHALAMZARI; RAJABI, 2022),

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they did not observe significant changes in serum irisin levels after an acute session of strength exercise with BFR.

The results of the present study showed that chronic ST, with or without the implementation of BFR, does not appear to have significantly influenced circulating levels of irisin in elderly women. Similar results to these were found by Mohammadiyan; Moghaddam; Hakkakdokht, (2021), after a six-week strength TP with BFR, in young women; where the researchers tested two groups with different intensities (20%-30% and 40%-50% of 1RM), which was only sufficient to significantly reduce the %BF in the groups, but not to change the serum irisin levels.

Other investigations methodologically similar to ours, but without the use of BFR, which studied populations of elderly women (HECKSTEDEN et al., 2013; POUTAFKAND; MAREFATI; TAHERICHADORNESHIN, 2020), and young women (FERNANDEZ-DEL-VALLE et al., 2018; SHABANI; IZADDOUST, 2018), obtained similar results to the present study. On the other hand, the results obtained by (GHANBARI-NIAKI et al., 2018; KIM et al., 2016), who studied populations of older women, and Planella-Farrugia et al. (2019), when studying women elderly women, observed significant increases in serum irisin levels after the ST program.

As far as we know, the current study was the first to correlate serum irisin levels with lipid variables and body composition in elderly women, after a ST program with BFR. However, no correlations were found between irisin and lipid and body composition variables in the experimental groups, except for a strong and significant interaction between this myokine and BM in the LLST group.

In 2016, a population study carried out in Western Pomerania, a rural region in northeastern Germany, found a positive association between circulating levels of irisin and the lipid profile in the general population, therefore intuiting a possible protection induced by high levels of irisin against non-communicable diseases associated with lipids (OELMANN et al., 2016). However, previous studies have shown inconsistencies when correlating irisin and lipid profile, showing the need for more correlational studies (GOUNI-BERTHOLD et al., 2013; HUH et al., 2012; LIU et al., 2013; PANAGIOTOU et al., 2014; PARK et al., 2013; WEN et al., 2013).

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There are some limitations in the present study, such as the nature of the intervention between groups, which prevented the blinding of participants, potentially leading to bias in this investigation. Another limitation relates to the characteristics of the sample, as only healthy elderly women were evaluated, and therefore, the results cannot be extrapolated to unhealthy elderly individuals or males.

5. Conclusion

It is concluded that sixteen weeks of low-load strength training, combined with blood flow restriction, was effective in altering the body composition of healthy elderly women, promoting an increase in muscle mass. Although lipid variables and serum irisin levels did not change after the experimental period, the therapeutic potential of this type of intervention in the prevention or treatment of metabolic disorders, cardiovascular diseases, and chronic non-communicable diseases became clear.

Therefore, further investigations in male populations with larger samples are suggested, as well as the acute measurement of irisin levels at certain points during a training program.

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