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ORIGINAL ARTICLE

Postmenopausal women with high TNF-α concentrations presented less reduction in fat and blood lipids: a randomized controlled clinical trial

Mulheres em pós-menopausa com maior concentração de TNF-α são menos responsivas à perda de gordura corporal: ensaio clínico randomizado

Las mujeres posmenopáusicas con concentraciones elevadas de TNF-α presentaron menor reducción de grasas: un ensayo clínico controlado aleatorizado

Jamylle Araújo Almeida[1]
orcid.org/0000-0002-2972-960X
jamylle.araujo@gmail.com

Liliane Viana Pires[1]
orcid.org/0000-0003-1710-0836
lvianapires@gmail.com

Luana Edla Lima[1]
orcid.org/0000-0003-4929-5228
edlaluana@gmail.com

Francismayne Batista Santana[1]
orcid.org/0000-0002-7065-4283
francismaynesantana@gmail.com

Walderi Monteiro da Silva Júnior[1]
orcid.org/0000-0002-6815-4386
walderim@yahoo.com.br

Marzo Edir Da Silva-Grigoletto[1]
orcid.org/0000-0003-3338-1359
medg@ufs.br

Raquel Simões Mendes Netto[1]
orcid.org/0000-0001-8238-8958
raquel@academico.ufs.br

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Higher concentrations of TNF-α may hinder body fat loss

Abstract

Aims: evaluate the effects of a high-protein diet associated with physical exercise on inflammatory markers and body composition.
Methods: the study is a 12-week clinical trial of 26 postmenopausal women who received an individualized high-protein food plan and participated in three multicomponent training sessions each week. Food intake was monitored through eight 24-hour food recalls, and the habitual food intake was estimated. At the beginning and end of the study, anthropometric variables were measured; fat content and lean mass were estimated using formulas, and blood was collected for C-reactive protein (CRP) quantification, including TNF-α, IL-6, IL-10, and IL-18. One-way ANOVA was performed.
Results: it was identified that 13 participants had a high-protein (HP) diet and 13 had a standard-protein (SP) diet. The HP group lost weight ($p = 0.032$); however, there were no changes in the fat content, the lean mass content, or the inflammatory markers. Only women who started the program with lower TNF-α values showed significant loss of total fat ($p = 0.049$), visceral fat ($p = 0.037$), triglycerides ($p = 0.031$), and LDL cholesterol ($p = 0.003$).
Conclusion: postmenopausal women with high concentrations of inflammatory markers are less responsive to strategies for modifying body composition.

Keywords: weight loss, inflammation, high-protein, physical conditioning.

Resumo

Objetivo: avaliar os efeitos de uma dieta rica em proteínas associada ao exercício físico sobre marcadores inflamatórios e composição corporal.
Métodos: o estudo é um ensaio clínico de 12 semanas com 26 mulheres na pós-menopausa que receberam um plano alimentar hiperproteico individualizado e participaram de três sessões de treinamento semanal. A ingestão alimentar foi monitorada por meio de oito recordatórios alimentares de 24 horas e a ingestão alimentar habitual foi estimada. No início e no final do estudo foram medidas as variáveis antropométricas; o teor de gordura e a massa magra foram estimados por meio de fórmulas, e o sangue foi coletado para quantificação da proteína C reativa (PCR), incluindo TNF-α, IL-6, IL-10 e IL-18. ANOVA *one-way* foi realizada.

[1] Universidade Federal de Sergipe, São Cristóvão, SE, Brasil.

Resultados: identificou-se que 13 participantes tinham uma dieta hiperproteica (HP) e 13 uma dieta proteica padrão (SP). O grupo HP perdeu peso (p = 0,032); no entanto, não houve alterações no teor de gordura, no teor de massa magra ou nos marcadores inflamatórios. Apenas as mulheres que iniciaram o programa com valores mais baixos de TNF-α apresentaram perda significativa de gordura total (p = 0,049), gordura visceral (p = 0,037), triglicerídeos (p = 0,031) e colesterol LDL (p = 0,003).
Conclusão: mulheres em pós-menopausa com altas concentrações de marcadores inflamatórios são menos responsivas a estratégias para perda de gordura corporal.
Palavras-chave: perda de peso, inflamação, dieta rica em proteínas, condicionamento físico humano.

Resumen

Objetivos: evaluar los efectos de una dieta rica en proteínas asociadas al ejercicio físico sobre marcadores de inflamación y composición corporal.
Métodos: el estudio es un ensayo clínico de 12 semanas con 26 mujeres posmenopáusicas que recibieron un plan de alimentación alto en proteínas individualizado y participaron en tres sesiones de entrenamiento físico cada semana. La ingesta de alimentos se controló a través de ocho recordatorios de alimentos de 24 horas y se estimó la ingesta habitual de alimentos. Al inicio y al final del estudio se midieron variables antropométricas; el contenido de grasa y la masa magra se estimaron mediante fórmulas, y se recolectó sangre para la cuantificación de proteína C reactiva (PCR), incluidos TNF-α, IL-6, IL-10 e IL-18. Se realizó ANOVA one-way.
Resultados: se identificó que 13 participantes tenían una dieta alta en proteínas (HP) y 13 tenían una dieta estándar en proteínas (SP). El grupo HP perdió peso (p=0,032); sin embargo, no hubo cambios en el contenido de grasa, el contenido de masa magra o los marcadores inflamatorios. Solo las mujeres que iniciaron el programa con valores más bajos de TNF-α mostraron una pérdida significativa de grasa total (p=0,049), grasa visceral (p=0,037), triglicéridos (p=0,031) y colesterol LDL (p=0,003).
Conclusiones: las mujeres posmenopáusicas con altas concentraciones de marcadores inflamatorios responden menos a las estrategias de modificación de la composición corporal.
Palabras clave: pérdida de peso, inflamación, dieta rica en proteínas, acondicionamento físico humano.

Introduction

The proportion of postmenopausal women is increasing due to general population aging. The climacteric represents an important boundary in female aging; it is characterized by altered hormone production, increased follicle-stimulating hormone, and reduced estrogen.[1,2] In addition to influencing the aging process, these hormonal alterations generate physiological changes, including lean mass reduction and an increase in fat tissue.[1,3,4]

Both the aging process and the increase in fat mass, especially in the abdominal area, interfere positively in the production of pro-inflammatory cytokines, which characterize subclinical chronic inflammation.[5,6] Studies have shown that a pro-inflammatory state is associated with a lower lean mass content; furthermore, it affects muscle gain from physical training.[7–10] Additionally, chronic subclinical inflammation is associated with the development of many chronic diseases, such as obesity, diabetes, cancer, cirrhosis, metabolic syndrome, and cardiovascular diseases.[5,11]

A healthy lifestyle is crucial to prevent obesity and aging-related morbidities.[1] Therefore, regular physical exercise[11–14] and a healthy diet are associated with a low stable level of inflammatory markers.[15,16] In addition to regular physical exercise, many authors have proposed a high-protein diet to facilitate the gain and maintenance of lean mass[17–21]; however, its effects on inflammatory markers remain controversial.[22–24]

Considering the strong association between body composition and chronic inflammatory markers and their influence on the pathogenesis of many chronic diseases, it is important to develop strategies that improve these conditions, especially for women in postmenopause, which may present as an unfavorable physiological condition. Thereby, the aim of this study was to identify changes in body composition and inflammatory markers during the consumption of a high-protein diet combined with multicomponent training in postmenopausal women.

Methods

Participants

The sample was composed of 26 non-institutionalized women between 57 and 77 years old from the northeast region of Brazil. They were recruited from within and around the university community through posters and radio invitations. To be female with spontaneous amenorrhea for at least 12 months was adopted as an inclusion criterion. The exclusion criteria were as follows: to present any diseases that would present a safety risk during the physical

exercise program (for example, unstable or untreated cardiovascular diseases), to have a severe musculoskeletal condition that makes walking or moving difficult, to be having nutritional counseling, to be classified as a food intake sub-reporter, to not have increased the protein intake during the program, to have six or more absences for the physical training, and to use anti-inflammatory drugs. The study protocol followed the principles of the Declaration of Helsinki and was approved by the Research Ethics Committee of the University (Protocol No. 1.586.11).

We used a block randomization design with blocks of size two to equally distribute forty active older women according to their lower limb power in: Traditional Training (TT: n = 20), Functional Training (FT: n = 20).

In a spreadsheet in Excel software we organized the files from the best to the worst lower limb power values/results and we started from top to bottom the distribution of the participants in the groups. We opted for this type of distribution to guarantee homogeneity of the groups. The allocation was concealed, performed by an independent researcher (Fig. 1)

Sample size was calculated using the G*Power program version 3.1.9.2 (25) using the outcome variables lower limb muscle power from the results obtained by Aragão-Santos et al., (2019) and cytokine concentration from the results of Tomeleri (2016) expecting an average 10% increase in muscle power and a minimum 10% reduction in proinflammatory cytokines.

Experimental Design

This was a clinical, interventional, controlled, and randomized study with a 12-week physical training and nutritional counseling program (the Trial Registration Number is RBR-6xqt44) (**Figure 2**). Data were collected from April to May 2016. All the participants received physical training and an individualized diet plan for a high-protein diet. Before initiating the intervention protocol (A1) and after the 12 weeks (A3), all participants were assessed (Figure 2).

Anthropometric Assessment

To calculate the BMI, the body mass (Balança Digital Lider, P150C, Ribeirão Preto, São Paulo, Brazil) and height (Estadiômetro Sanny, ES2030, Araraquara, São Paulo, Brazil) were determined. The BMI classification was performed according to cutoff points proposed by the World Health Organization (28) and Lipschitz (1994) for older women. The circumferences of the relaxed arm (AC), waist (WC), hip (HC), and calf (CC) were obtained with an inelastic tape (Sanny, American Medical do Brasil LTDA, São Bernardo do Campo, São Paulo, Brazil). For the triceps fold (TF) measurement, an adipometer was used (Lange, 3008239, Santa Cruz, California) with an accuracy of 0.1 mm. Each assessment was performed in triplicate by a nutritionist. The muscle arm circumference was calculated using the Frisancho formula (1974). The total body fat, abdominal fat, and lean mass were quantified using a formula developed by Asgari et al. (2015). All anthropometric measurements were performed according to Lohman, Roche and Martorell (1988).

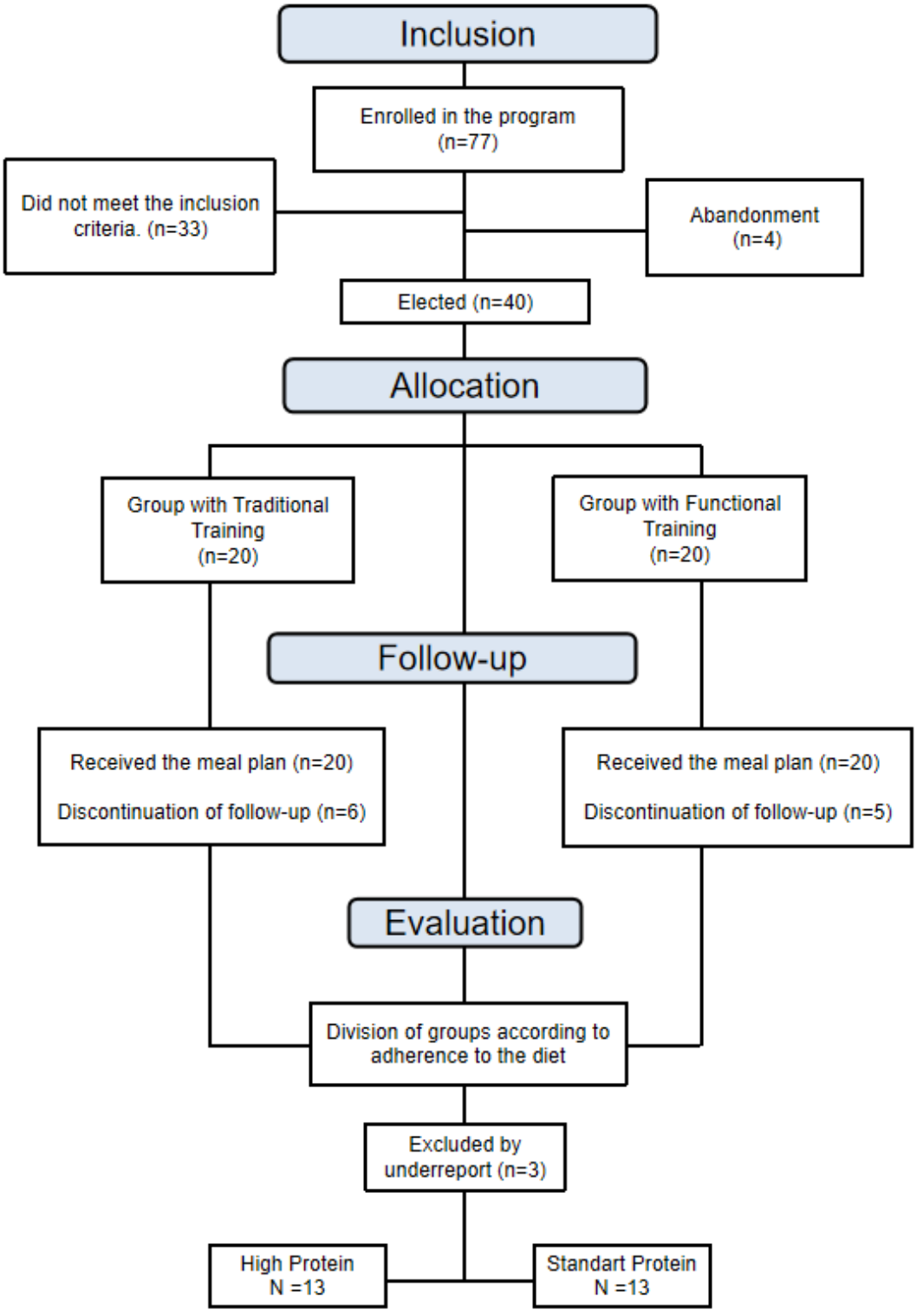
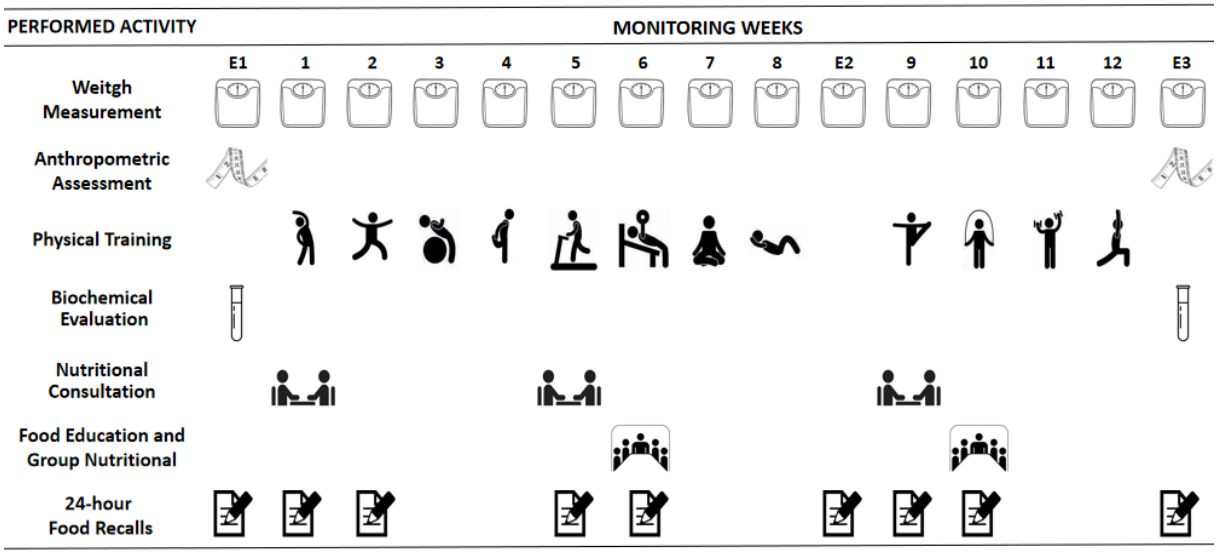


Figure 1 – Twelve-week intervention experimental design. São Cristóvão, SE, Brazil, 2018.



E: Evaluation
Figure 2 – Twelve-week intervention experimental design. São Cristóvão, SE, Brazil, 2018.

Biochemical Evaluation

To minimize variation, all blood samples were obtained between 7:00 and 9:00 am after overnight fasting. Blood collection was performed by a nursing technician through venipuncture, from the antecubital hein in aliquots of 12 mL. The blood samples were collected at two instances in laboratory (A1 and A3, **Figure 1**) and stored at −80˚C prior to analysis. Serum concentrations of high density lipoprotein cholesterol (HDL-c), low density lipoprotein cholesterol (LDL-c), triglycerides (TG), C-reactive protein (CRP), tumor necrosis factor alpha (TNF-α), and interleukins 6 (IL-6), 10 (IL-10), and 18 (IL-18) were investigated.

Biochemical analysis was performed with a Luminex-100 system (Luminex Corporation), using a high-sensitivity kit for cytokines (Bender MedSystems GmbH, Vienna, Austria). The standard curves were generated by Luminex software (average R2 = 1). All samples were analyzed on a single plate, and the coefficient of variation for all the analytes was 0%. The detection limits for TNF-α, IL-10, IL-18, and IL-6 were, 34.200, 10.100, 55.700, and 38.300 pg/ml, respectively.

Evaluation of Dietary Habits

Starting at week two, nutritionists applied seven 24-hour food recalls (R24h), it was possible to identify the participants' habitual food intake during the study. The R24h data were recorded using a photograph album for greater precision in estimating the portions consumed. The data were tabulated using the Nutrition Data System for Research (NDSR) software, 2011 version (NCC, University of Minnesota, Minneapolis, MN).

To calculate the usual intake of food and nutrients, the method of statistical modeling incorporated in the online Multiple Source Method (MSM) was performed.[33] The MSM involves removing intrapersonal variability from two or more 24-hour recalls and calculating the usual intake for each individual using three statistical procedures. The first estimates the likelihood of intake on a random day. Subsequently, the usual intake is estimated for the days of consumption; finally, the numbers resulting from steps one and two are multiplied to estimate the individual daily intake.[34]

To identify possible underreporting, the ratio of caloric intake reported using the total predicted energy expenditure was considered.[35] The predicted resting energy expenditure was calculated using an equation developed by Vinken et al. (1999).

The internal coefficient of variation was calculated based on data from this study. The cutoff point ± 2.0 standard deviation (SD) was considered to identify possible people who

underreport, which were excluded from the final analysis. The total energy of proteins was used as a cutoff point to delimit the standard and high-protein diet groups. The high-protein (HP) group had a habitual intake ≥ 20% and the standard-protein (SP) group < 20%.[37]

Intervention Protocols

Nutritional Counseling

The nutritional counseling was performed during three individual sessions, the first for delivery of the diet plan and the subsequent ones to identify and overcome potential difficulties or barriers. Furthermore, two educational sessions were conducted with groups of 10 to 15 women (Figure 2). All the participants attended these sessions, which aimed to enable a high protein intake and support follow-up of the nutritional status. The participants received three individualized food plans with a protein content between 1.3 and 1.6 g^{-1} kg^{-1} d^{-1}.[38]

Elaboration of the food plans followed the principles of a healthy diet. As they were financially more accessible in Brazil, foods and recipes with eggs and milk were given preference as animal protein sources (**Figure 3**).

Multicomponent Physical Training

Thirty-six physical training sessions, supervised by physical education professionals, were conducted. Each session lasted 50 minutes and occurred on three non-consecutive days per week. In the week prior to the intervention period, adaptation to the exercises occurred, applying 50% of the intensity planned for the first training session. The 0 to 10 OMNI-GSE scale was used to control and standardize the overall training intensity. An intensity of 6–8 (moderate to intense) was prevalente.[39]

The exercises performed during the multicomponent training involved pulling, pushing, squatting, and lifting, performed at a maximum speed. The load was progressively increased to maintain the delimited number of repetitions per series.

Nutrients		(DP)
Energy	**kcal**	1772.28 (128.65)
Carbohydrates	**g/day**	232.42 (27.11)
	g/kg	3.65 (1.04)
	E%	52.42 (4.11)
Fiber (g/day)	**Total**	33.52 (2.17)
	Soluble	9.18 (0.57)
	Insoluble	23.99 (1.69)
Total Protein	**g/total**	98.89 (17.66)
	g/kg	1.48 (0.07)
	E%	22.42 (4.13)
Animal Protein	**g/total**	72.50 (18.56)
	Protein%	72.35 (6.04)
Vegetable Protein	**g/total**	26.38 (2.08)
	Protein%	27.65 (6.04)
Fat	**g/day**	57.11 (5.36)
	g/kg	0.88 (0.19)
	E%	28.97 (0.82)
SAT	**g/total**	19.92 (2.72)
	E%	10.12 (1.20)
MUFA	**g/total**	21.40 (3.55)
	E%	10.83 (1.35)
PUFA	**g/total**	10.89 (1.19)
	E%	5.52 (0.27)
Cholesterol	**g/day**	332.61 (71.61)

***SAT:** saturated fat; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; E%: percentage of total energy; $\bar{x}$: average; (DP): standard deviation.

Figure 3 – Description of the calorie and macronutrient content of prescribed meal plans.

Statistical Analysis

The descriptive statistics included the mean, standard deviation, and absolute and relative frequencies. Initially, the data distribution was analyzed using the Shapiro-Wilk test. The independent t-test and the Mann-Whitney U-test were conducted to compare the dietary intake of nutrients and food consumption between groups. The one-way ANOVA was used to compare the biochemical and anthropometric variables between the groups in the pre- and post-intervention moments. Besides the HP and SP group division, individuals with higher and lower TNF-α concentrations were divided based on the sample medians and compared according to the body composition and blood lipid variation. The IBM SPSS Statistics 20.0 software was used for the statistical analysis. Statistical significance was set at $p < 0.05$ with a confidence interval of 95%.

Results

The participants had a mean age of 65 ± 5 years old; half of the women had up to nine years of schooling, 65% were housewives, 88.5% used medicine continuously, 53.8% were overweight, 84.6% had high abdominal fat contents, and 100% had excess body fat.

Table 1 – Comparison of habitual dietary intake between standard and high-protein diet groups during the intervention program. 2018

Dietetic Variables	Standard-protein n = 13	High-protein n = 13	P-value
	$\bar{X}$ (DP)	$\bar{X}$ (DP)	
Energy (kcal)	1528.45 (327.38)	1504.01 (147.30)	0.809
Carbohydrates			
Total (g)	237.95 (58.16)	214.12 (26.25)	0.196
E%	62.11 (4.30)	56.91 (3.67)	0.003
Fiber			
Total (g)	22.87 (5.28)	25.14 (4.90)	0.269
Insoluble (g)	16.94 (4.50)	18.42 (3.74)	0.372
Soluble (g)	5.74 (1.05)	6.54 (1.33)	0.102
Protein			
Total (g)	66.25 (13.18)	80.98 (8.21)	0.003
E%	17.45 (1.70)	21.54 (0.97)	0.000
g/kg	1.06 (0.33)	1.19 (0.30)	0.321
Animal (g)	44.88 (7.27)	55.02 (6.46)	0.001
Vegetable (g)	21.97 (6.96)	25.26 (5.68)	0.200
Fat			
Total (g)	39.06 (6.36)	41.88 (6.63)	0.383
E%	23.11 (3.45)	25.08 (3.18)	0.145
Saturated (g)	13.68 (4.17)	14.11 (2.75)	0.757
Monounsaturated (g)	13.20 (3.01)	14.32 (2.61)	0.319
Polyunsaturated (g)	8.44 (2.24)	9.52 (1.95)	0.203
Cholesterol (mg)	206. 00 (42.39)	218.80 (24.74)	0.359

Independent t-test and Mann-Whitney U-test
E%: percentage of total energy; $\bar{X}$: average; (DP): standard deviation.

Table 1 presents a comparison of the usual macronutrient intake during the program for the SP and HP groups. The groups had similar fiber and fat intakes. The HP group showed higher total and animal protein intakes with a lower caloric contribution from carbohydrates; however, no difference was observed between the groups in the total intake of this nutrient.

Considering protein consumption, it was observed that the HP group consumed more skimmed-milk powder and chicken. Other analyzed foods such as eggs, cows' milk, red meat, and beans did not present significant differences in consumption between the two groups. Due to the nutritional counseling, most of the chicken was consumed without the skin and was cooked in water or roasted. No difference was observed between the groups in the amount of red meat, eggs, and beans consumed.

Regarding the anthropometric variables, the HP group showed a reduction in the total weight and hip and arm circumferences. The SP group showed a reduction in the calf circumference. Both groups showed no change in body fat (**Table 2**). A significant difference in the lean mass was identified over time; however, no statistical difference was observed between the groups. The results shown in **Table 3** demonstrate that there was no difference in inflammatory markers between the groups after 12 weeks.

Table 2 – Variation of anthropometric markers between standard and high-protein groups. 2018.

	Standard-protein (n = 13) $\bar{X}$ (DP)			High-protein (n = 13) $\bar{X}$ (DP)			P-value		
	Pre	Post	Δ%	Pre	Post	Δ%	G	T	G × T
Weight (kg)	65.0 (13.6)	64.7 (13.4)	−0.5 (3.4)	70.9* (16.2)	69.4 (15.0)	−1.9 (2.8)	0.364	0.055	0.032
BMI (kg/m²)	27.3 (5.1)	27.5 (5.5)	0.5 (4.8)	30.9 (6.3)	30.3 (5.7)	−1.8 (2.8)	0.165	0.362	0.091
WC (cm)	90.0 (15.8)	90.9 (16.2)	1.0 (5.1)	98.4 (13.7)	97.2 (11.3)	−0.9 (4.3)	0.199	0.811	0.314
HC (cm)	101.9 (10.1)	102.1 (10.6)	0.2 (1.9)	107.1* (10.3)	104.0 (8.8)	−2.8 (2.4)	0.365	0.008	0.000
AC (cm)	31.5 (4.2)	31.1 (4.3)	−1.1 (2.9)	33.4* (4.9)	32.5 (4.6)	−2.3 (2.6)	0.353	0.004	0.005
CC (cm)	37.3* (4.4)	36.8 (4.2)	−1.2 (2.2)	38.3 (5.8)	37.9 (5.6)	−1.0 (1.5)	0.600	0.007	0.031
TF (mm)	30.5* (7.4)	29.5 (7.7)	−2.7 (15.5)	37.4 (9.2)	36.9 (11.2)	−1.0 (20.3)	0.040	0.575	0.800
MCA (cm)	21.9 (2.4)	21.8 (3.1)	−0.2 (8.7)	21.6 (3.1)	20.9 (2.8)	−2.5 (9.1)	0.588	0.361	0.229
FM (kg)	32.0 (8.2)	32.2 (8.9)	0.6 (6.4)	37.7 (10.1)	36.7 (9.1)	−2.3 (3.6)	0.165	0.362	0.091
FM (%)	49.1 (6.4)	49.6 (6.8)	1.0 (4.4)	52.8 (3.5)	52.6 (3.1)	−0.4 (1.0)	0.108	0.669	0.594
AFM (kg)	15.8 (4.6)	16.0 (4.9)	0.8 (6.8)	18.9 (5.3)	18.4 (4.8)	−2.4 (3.7)	0.165	0.377	0.082
ALM (kg)	34.2 (4.6)	34.4 (4.9)	0.6 (3.5)	37.8 (5.6)	37.3 (5.0)	−1.2 (2.3)	0.117	0.450	0.092
ALM (%)	53.5 (5.9)	54.1 (5.9)	1.1 (2.0)	54.3 (5.3)	54.7 (5.5)	0.7 (2.0)	0.755	0.028	0.195

One-way ANOVA

WC: waist circumference; HC: hip circumference; AC: arm circumference; CC: calf circumference; TF: triceps fold; MCA: muscular circumference of the arm; FM: fat mass; AFM: abdominal fat mass; ALM: abdominal lean mass.
$\bar{X}$: average; (DP): standard deviation.
G: group; T: time; G × T: group time interaction

According to the division performed based on the TNF-α concentration median, significant losses in weight, BMI, total body fat, trunk fat, LDL-c, and TG were observed only for women who started the program with lower TNF-α concentrations (**Graphic 1**). No significant differences were observed for lean mass (p = 0.447). Significant increases in HDL-c were observed only for women who started the program with higher TNF-α concentrations (**Graphic 2**).

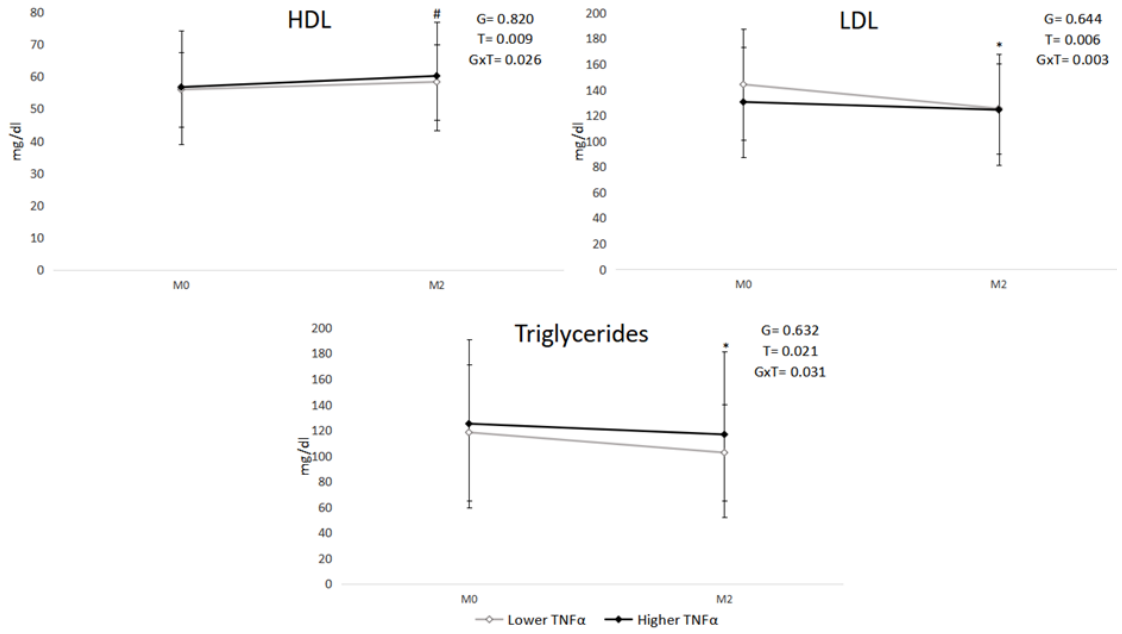
Table 3 – Variation of inflammatory markers between the SP and HP groups before and after the intervention. 2018.

Variable (pg/ml)	Standard-protein (n = 13) $\bar{X}$ (DP)		High-protein (n = 13) $\bar{X}$ (DP)		P-value		
	Pre	Post	Pre	Post	G	T	G × T
CRP	85.06 (53.31)	86.15 (54.35)	62.83 (35.65)	64.04 (27.77)	0.179	0.866	0.900
IL-6	8.10 (4.86)	8.88 (3.68)	8.98 (4.56)	8.30 (3.12)	0.919	0.928	0.426
IL-10	0.71 (0.65)	0.69 (0.68)	0.45 (0.18)	0.41 (0.11)	0.168	0.369	0.397
TNF-α	8.33 (3.40)	7.37 (3.01)	7.70 (4.72)	6.61 (2.75)	0.574	0.147	0.273
IL-18	60.81 (32.03)	65.03 (37.14)	48.29 (25.14)	49.10 (19.94)	0.173	0.648	0.917
Ratio TNF-α/IL-10	16.18 (8.23)	15.46 (8.77)	17.97 (9.63)	16.83 (7.79)	0.611	0.523	0.581

One-way ANOVA

CRP: C-reactive protein; IL: interleukin; TNF-α: tumor necrosis factor; $\bar{X}$: average; (DP): standard deviation. G: group; T: time; G × T: group time interaction

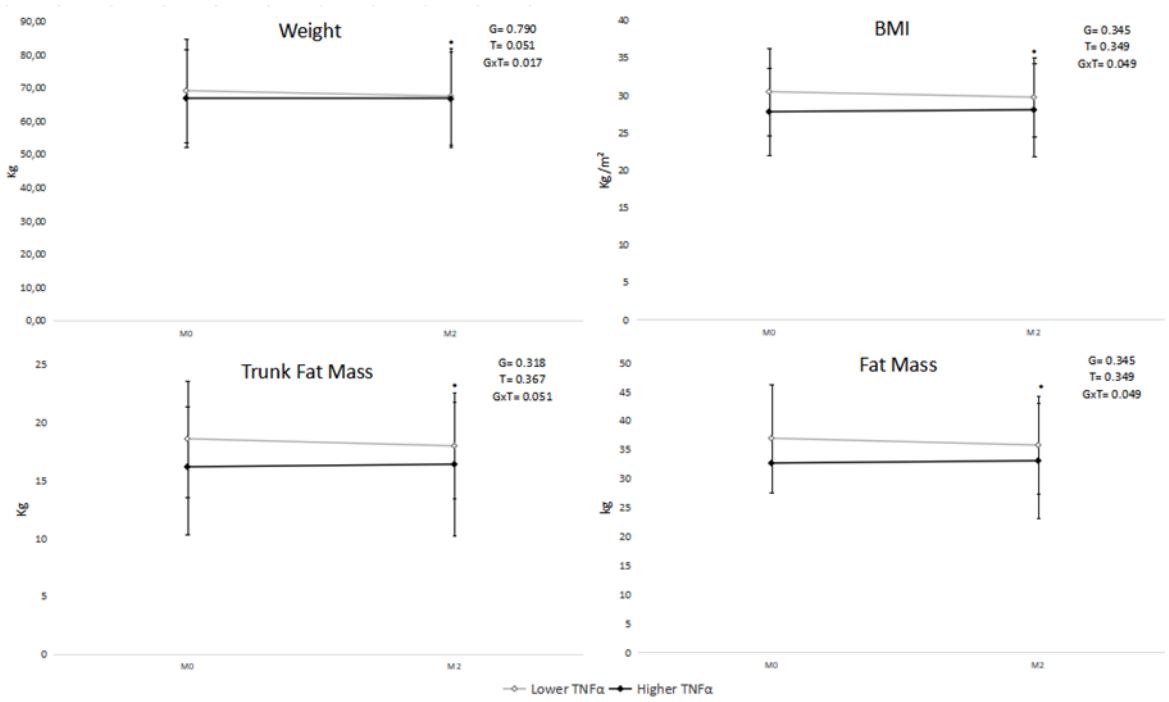
Graphic 1 – Body composition variation for women who started the program with lower and higher



TNF-α concentrations. 2018

* Significant difference in time for lower TNF-α

Graphic 2 – Blood lipid variation for women who started the program with lower and higher TNF-α concentrations. 2018.



* Significant difference in time for lower TNF-α
# Significant difference in time for higher TNF-α

Discussion

This study evaluated the effects of a HP diet on the inflammatory markers and body composition of postmenopausal women. High concentrations of pro-inflammatory cytokines were identified. The HP did not promote a significant improvement in body composition or alterations in the inflammatory markers when compared to the SP diet. It was also observed that individuals with lower TNF-α concentrations at the beginning of the program showed reductions in total fat, trunk fat, and blood lipids, unlike those with higher TNF-α concentrations.

High concentrations of pro-inflammatory cytokines may have blocked changes in body composition. Recent studies have shown, using an experimental model, a mechanism through which the presence of TNF-α can decrease fat loss. TNF-α interferes negatively with the activation of cyclic guanosine monophosphate (cGMP) in white adipocytes through the signaling activation of the nuclear factor κB (NF-κB) and c-Jun n-terminal kinase (JNK). The decrease in the white adipocyte cGMP pathway inhibits differentiation into brown adipocytes, which have a greater number of mitochondria and, consequently, greater thermogenic capacity.[40]

Additionally, pro-inflammatory cytokines, including TNF-α (also by activating the NF-κB and JNK) can potentially generate insulin resistance in multiple tissues.[5,41,42] Insulin resistance is important in that it interferes directly in all body homeostasis, decreasing glucose consumption and lipid oxidation.

Besides decreasing fat loss, higher concentrations of inflammatory cytokines may interfere with lean mass gain. Fisher, Bickel, and Hunter (2014) submitted older women to resistance and aerobic exercises for 16 weeks and identified that, although all the participants had gained strength, those with significantly higher TNF-α blood concentrations showed no significant increase in lean body mass.

These results are similar to those in a study by Peake et al. (2011), which identified that individuals classified with greater inflammation showed lower lean mass gains. Another study with postmenopausal women verified that alterations in lean mass during resistance training were inversely associated with

IL-6 concentrations.[10] Although this mechanism is not fully elucidated, it is possible that chronic subclinical inflammation induces degradation and decreases muscle protein synthesis through many pathways, as it reduces amino acid availability and promotes insulin resistance, ectopic deposition of adipose tissue, and oxidative stress.[43,44]

Only the group with lower TNF-α showed significantly reduced triglycerides and LDL-c. This result is similar to that of Yukiko (2015), who identified that in older people, the plasma TNF-α level was positively associated with serum triacylglycerol and negatively associated with HDL cholesterol. LV (2015), when researching the role of TNF-α in lipid deposition, noted that on adding TNF-α to liver cells, a significantly increased TG concentration was observed due to inhibition of the AMP-kinase pathway.

It is already known that chronic inflammation plays a role in the pathophysiological causes of atherosclerosis through endothelial dysfunction. TNF-α is one of the mediators of endothelial dysfunction through its receptor (TNFR) and this may lead to increased adhesion molecule expression via multiple pathways. Furthermore, lipid abnormalities are byproducts of systemic inflammation that affect peripheral tissues such as liver and adipose (Steyers, 2014), so much so that in clinical practice, statins are used to reduce inflamatory markers (Tabrizi, 2019).

The limitations of the present study include a small sample size and the possible impact of other lifestyle factors; however, this problem is inherent in any nutritional intervention in humans. Additionally, the high concentration of inflammatory markers in the participants in this study limits the application of these results to people with this characteristic and response time to the program was limited to 12 weeks, limiting the evaluation to a longer period of time.

Another important limitation of this study is that the percentage of protein energy was used as a criterion for dividing the groups. Although g/kg is frequently used to describe protein intake, because it standardizes the caloric intake, when used in this sample, it resulted in an invalid comparison. Eutrophic women were classified as HP and those with excess weight as SP, making a statistical analysis infeasible. This problem could be avoided in future studies by selecting individuals within a narrower weight range.

A strength of this study is that the nutritional counseling recommended only foods that achieved a HP intake, a situation that may be closer to the reality of many communities. Additionally, conducting individual consultations and considering dietary habits and cost in addition to conducting food and nutrition education can facilitate adherence. In our dietary analysis, considered adherence and underreport for great veracity of the data.

The methods used in this article to assess body composition were the sum of anthropometric measurements performed by a nutritionist in triplicate added to predictive models previously validated through studies that contracted the data obtained with DEXA. (Asgari, 2015). The predictive equation used indicated as more suitable for postmenopausal women (de Branco et al., 2018).

More studies are needed to understand the effects and mechanisms by which training associated with a HP diet may affect inflammation and body composition in postmenopausal women as well as potential differences in the effects of these interventions between individuals with higher and lower pro-inflammatory cytokine concentrations.

Conclusion

Although the HP diet promoted weight loss, there was no significant improvement in body composition compared to the SP diet. Postmenopausal women showed high pro-inflammatory cytokine concentrations, and the HP diet gave similar results to those obtained with the SP diet, having no effect on the concentration of inflammatory cytokines. It is possible that individuals with high concentrations of inflammatory markers are less responsive to strategies for modifying body composition.

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Jamylle Araújo Almeida

Mestre em Ciências da Nutrição e graduada em Nutrição pela Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Luana Edla Lima

Mestre em Ciências da Nutrição e graduada em Nutrição pela Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Marzo Edir Da Silva-Grigoletto

Doutor em "Ciencias Aplicadas a la Actividad Física y el Deporte" pela Universidad de Córdoba, com pós-doutorado no Hospital Reina Sofia. Professor da Universidade Federal de Sergipe, em São Cristóvão, SE, Brasil.

Liliane Viana Pires

Doutora e mestre em Ciências dos Alimentos pela Universidade de São Paulo (USP), em São Paulo, SP, Brasil; com pós-doutorado pela Universidade de São Paulo (USP), em São Paulo, SP, Brasil e pela Universidad de Granada, Espanha. Graduada em Nutrição pela Universidade Federal do Piauí. Professora do Curso de Nutrição e do Programa de Pós-graduação em Ciências da Nutrição (PPGCNUT) da Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Walderi Monteiro da Silva Júnior

Doutor em Clínica Médica pela Universidade Federal do Rio de Janeiro (UFRJ), no Rio de Janeiro, RJ, Brasil. Mestrado em Engenharia Biomédica e graduado em fisioterapia pela Universidade Federal da Paraíba. Professor Associado da Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Francismayne Batista Santana

Especialista em Saúde do Adulto e do Idoso e graduada em Nutrição pela Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Raquel Simões Mendes Netto

Doutora e mestre em Ciências dos Alimentos pela Universidade de São Paulo (USP), em São Paulo, SP, Brasil. Graduada em Nutrição pela Universidade Federal de Pernambuco. Professora associada da Universidade Federal de Sergipe (UFS), em São Cristóvão, SE, Brasil.

Endereço para correspondência

Raquel Simões Mendes Netto

Universidade Federal de Sergipe

Av. Marechal Rondon, s/n

Departamento de Nutrição

Rosa Elze, 49100-000

São Cristóvão, SE, Brasil

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