THE EFFECTS OF LONG TERM STRENGTH TRAINING ON HEMODYNAMIC PARAMETERS AND RESISTIN LEVEL IN POSTMENOPAUSAL WOMEN

Efeitos do treinamento de força a longo prazo sobre parâmetros hemodinâmicos e concentração de resistina em mulheres na pós-menopausa

Efectos del entrenamiento de fuerza a largo plazo en los parámetros hemodinámicos y concentración de resistina en mujeres posmenopausia

Original Article

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ABSTRACT

Objective: Investigate the influence of strength training (ST) on serum resistin levels and blood pressure of postmenopausal women. **Methods**: Longitudinal study conducted at the Federal University of São Carlos with twenty-three sedentary postmenopausal women. The ST lasted 13 months (Dec./2008 to Jan./2010) and consisted of two weekly sessions with three sets of 8-12 maximum repetitions and one exercise for each main muscle group. Maximum muscular strength was tested in the following exercises: bench press, 45° leg press, and standing arm curl. Serum resistin level was determined using the ELISA method. ANOVA (with repeated measures) was used for the comparisons between periods Pre-, 6 months and 13 months ($p < 0.05$); Pearson's correlation test was used to evaluate the correlations between resistin × blood pressure, resistin × muscle strength and strength × blood pressure. **Results**: Women presented the following anthropometric profile: 61.33±3.8 years; height 148.5±32.7 cm; body mass 67.56±10.85 kg. The ST decreased resistin levels (30272.4 ± 8100.1 to 16350.6 ± 2404.6 pg/mL) and systolic blood pressure (120.5 ± 11.8 to 115.8 ± 1.6 mmHg), and increased muscular strength in the leg press 45º (172.3 ± 27.3 to 348.6 ± 40.8 kg), bench press (31.9 ± 4.1 to 41.8 ± 5.6 kg) and arm curl (21.0 ± 2.4 to 26.5 ± 2.9 kg) after 13 months ($p < 0.05$). **Conclusion**: The results of this study revealed that long-term ST increases maximum muscular strength, decreases systolic blood pressure and serum resistin levels, which are beneficial physiological alterations that reduce the risk for cardiovascular diseases in postmenopausal women.

Descriptors: Resistance Training Program for Weightlifting; Post-menopausal; Women; Resistin; Arterial Pressure.

RESUMO

***Objetivo**: Investigar a influência do treinamento de força (TF) sobre a concentração sorológica de resistina e pressão arterial de mulheres na pós-menopausa. **Métodos**: Estudo longitudinal, realizado na Universidade Federal de São Carlos, do qual participaram 23 mulheres sedentárias na pós-menopausa. O TF apresentou duração de 13 meses (dez/2008 a jan/2010), com duas sessões semanais, cada uma consistindo em três séries de 8-12 repetições máximas e um exercício para cada grupo muscular principal. Foi avaliada a força muscular máxima nos seguintes exercícios: supino, leg press 45° e flexão do cotovelo em pé. A concentração sérica de resistina foi determinada pelo método ELISA. No processamento estatístico, utilizou-se o ANOVA (com medidas repetidas) para comparar os momentos Pré, 6 meses e 13 meses (p<0,05). Para avaliar as correlações resistina × pressão arterial, resistina × força muscular e força × pressão arterial, utilizou-se o teste de correlação de Pearson. **Resultados**: As mulheres apresentaram o seguinte perfil antropométrico: 61,33±3,8 anos; estatura de 148,5±32,7 cm; massa corporal de 67,56±10,85 kg. O TF induziu a redução da concentração de resistina (30272,4±8100,1 versus 16350,6±2404,6 pg/mL) e pressão arterial sistólica (120,5±11,8 versus 115,8±1,6 mmHg), e o aumento da força muscular no*

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leg press 45º (172,3±27,3 versus 348,6±40,8 kg), supino (31,9±4,1 versus 41,8±5,6 kg) e flexão do cotovelo (21,0±2,4 versus 26,5±2,9 kg) após os 13 meses (p<0,05). **Conclusão***: Os resultados deste estudo revelaram que o TF a longo prazo aumenta a força muscular máxima, diminui a pressão arterial sistólica e os níveis séricos da resistina – alterações fisiológicas benéficas para a redução do risco de doenças cardiovasculares em mulheres na pós-menopausa.*

Descritores: *Programa de Musculação por Levantamento de Peso; Mulheres; Pós-menopausa; Resistina; Pressão Arterial.*

RESUMEN

Objetivo*: Investigar la influencia del entrenamiento de fuerza (EF) sobre la concentración serológica de resistina y presión arterial en mujeres posmenopausia.* **Métodos***: Estudio longitudinal realizado en la Universidad Federal de São Carlos en el cual participaron 23 mujeres sedentarias posmenopausia. El EF tuvo duración de 13 meses (diciembre de 2008 a enero de 2010) con dos sesiones semanales, siendo cada sesión constituida de tres series de 8-12 repeticiones máximas y un ejercicio para cada grupo muscular principal. Fue evaluada la fuerza muscular máxima en los siguientes ejercicios: supino, leg press 45° y flexión de codo de pie. La concentración sérica de resistina fue determinada por el método ELISA. En el procesamiento estadístico se utilizó ANOVA (con medidas repetidas) para las comparaciones entre los momentos pre, 6 meses y 13 meses (p < 0,05); se utilizó la prueba de correlación de Pearson para evaluar las correlaciones entre resistina × presión arterial, resistina × fuerza muscular y fuerza × presión arterial.* **Resultados***: Las mujeres presentaron el siguiente perfil antropométrico: 61,33±3,8 años; altura 148,5±32,7 cm; masa corporal 67,56±10,85 kg. El EF llevó a la reducción de la concentración de resistina (30272,4±8100,1 versus 16350,6±2404,6 pg/mL) y presión arterial sistólica (120,5±11,8 versus 115,8±1,6 mmHg) y aumento de fuerza muscular en el leg press 45º (172,3±27,3 versus 348,6±40,8 kg), supino (31,9±4,1 versus 41,8±5,6 kg) y flexión de codo (21,0±2,4 versus 26,5±2,9 kg) después de los 13 meses (p < 0,05).* **Conclusión***: Los resultados del estudio revelaron que el EF a largo plazo aumenta la fuerza muscular máxima, disminuye la presión arterial sistólica y los niveles séricos de la resistina, alteraciones fisiológicas benéficas para la reducción del riesgo de enfermedades cardiovasculares en mujeres posmenopausia.*

Descriptores: *Entrenamiento de Resistencia; Mujeres; Posmenopausia; Resistina; Presión Arterial*

INTRODUCTION

The constant increase in the number of women in relation to men and especially the overload of work performed by them in modern society[1] have caused them an increased prevalence of diseases that were previously more related to men – For instance, the cardiovascular and cerebrovascular diseases[2]. Additionally, age induces the onset of aging-associated diseases and disturbs (breast cancer, osteoporosis, cardiovascular diseases, etc.), which are common in postmenopausal women and are associated with high morbidity and mortality rates in this population[3].

Premenopausal women present a lower prevalence of arterial hypertension and associated diseases in relation to men. However, after menopause, it becomes similar to men's[4]. Estrogen deficiency, alterations in lipid profile, weight gain and sedentariness are among the main factors associated with arterial hypertension in postmenopausal women[4].

An important biomarker related to alterations in the lipid profile, blood pressure and cardiovascular diseases is the resistin, an adipokine that has been recently identified and that belongs to a cysteine-rich protein family. Resistin is specifically expressed in the white adipose tissue, and its secretion is strongly associated with inflammation, obesity, insulin resistance, diabetes, dyslipidemias, arterial hypertension and the onset of coronary artery disease[5-7].

Among the exercise modalities available, strength training (ST) has been responsible for emotional aspects, improved mineral bone density and quality of life, reduction of pain and inflammation in postmenopausal women[8,9]. It is recommended as an important component of physical exercise programs for elders, promoting strength and muscle mass gain[10,11]. In addition to these factors, studies have showed a possible association between muscle strength and a reduction of cardiovascular risk factors[12], obesity[13], blood pressure[14,15], metabolic syndrome[16,17] and early death[18].

However, the chronic effects of ST on plasma resistin levels in elders still require a better understanding[19]. There is a need for studies to confirm the efficiency of ST as a therapeutic intervention for the reduction of cardiovascular risk, including the resistin biomarker in elders[19].

Thus, this study aimed to assess the chronic effects of a 13-month ST on hemodynamic parameters and resistin levels of postmenopausal women. The initial hypothesis of the study was that ST could induce the reduction of systolic blood pressure (SPB), diastolic blood pressure (DPB), mean arterial pressure (MAP) and pulse pressure (PP), as well as the concentration of resistin.

METHODS

This quantitative longitudinal study took place in the period from October 2008 to January 2010 in the following places: physiotherapy clinic (assessments) and the gym (training) of the University Center Central Paulista (*Centro Universitário Central Paulista – UNICEP*); and the exercise physiology lab (biochemical analyses) of the Federal University of São Carlos (*Universidade Federal de São Carlos – UFSCar*).

The participants were invited through a dissemination campaign that included explanatory leaflets and local newspaper reports. A total of 23 women (61.33±3.8 years) were selected and clinically assessed by a cardiologist (anamnesis, vital signs assessment, general physical examination, complete blood count, rest- and stress- electrocardiogram, and musculoskeletal system examination). They met the following inclusion criteria: a minimum of three years of postmenopause, be sedentary (no consistent physical activity in the six months before the study), no current hormone replacement therapy, no metabolic or endocrine disorders that could affect either bone or muscle mass, and be cognitively able to understand the training instructions. They also met the following exclusion criteria: musculoskeletal alterations (orthopedic or rheumatic) that prevented the execution of the strength protocol proposed, diagnosis of congestive heart failure, severe arrhythmia and uncontrolled hypertension.

Initially, the participants took four weeks to get familiar with the strength exercises. Then, they underwent one repetition maximum testing (1-RM) for determining the load settings of the training program. The ST program lasted 56 weeks (13 months), with two training sessions a week (Monday and Thursday) and one full-body stretching session a week (Wednesday). The measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), pulse pressure (PP) and serum resistin occurred in three moments: before the ST (pre), 6 months (25 weeks) and 13 months after the ST.

SBP and DBP were assessed by the oscillometric method, employing the methodology recommended by the V Brazilian Guidelines for Arterial Hypertension (*V Diretriz Brasileira de Hipertensão Arterial*)[20] and using an oscillometric device (Microlife 3AC1-1, Widnau, Switzerland) validated by the European Society of Hypertension. Having the elder in a sitting position after a 10-minute rest and with the right arm supported at heart level, the device cuff (adjusted to the arm size) was placed circa 3 cm above the antecubital fossa, placing the center of the bladder over the brachial artery pulse. SBP and DBP values obtained were used to calculate MAP using the equation: MAP=DBP+[(SBP-DBP) ÷ 3][21]. PP was determined by the equation: PP = SBP - DBP[21].

During four weeks, the participants were informed about the adequate execution of each exercise. Then, in order to become familiar with the exercises, they performed two sessions of two sets of 12-15 submaximal repetitions in the exercises 45º leg press (≅ 40 kg), bench press (≅ 10 kg) and biceps curl (≅ 6 kg). After that, the 1-RM tests were performed in four different days, with a 10-minute interval, by the same evaluator, according to recommended descriptions[22].

The ST consisted of 13 exercises alternating between sets of upper and lower body exercises in the following order: 45º leg press, barbell bench press, knee extension, low row, cable elbow extension, knee flexion, standing biceps curl, smith machine calf raise, adduction chair, abduction chair and two sets of 20-30 repetitions of abdominal exercises. The training lasted 13 months and was performed twice a week (Monday and Thursday) with three sets of 8-12 maximum reps (8-12 RM) for each exercise, each repetition lasting 3-4 seconds. The training intensity was readjusted every session in order to ensure the RM zone.

Blood samples (3mL) were drawn from antecubital vein in vacuum centrifuge tubes for 20 minutes at 4°C and 2500 rpm; later, serum was separated in aliquots of 500 µL and stored in a freezer at -80°C awaiting for analyses. ELISA method determined the resistin dosage according to the specifications of the High Sensitivity Kit RayBio™ (RayBiotech, Inc, Norcross, GA, USA). In order to ensure accuracy of results, all dosages were determined in duplicate and presented in pg/mL.

Regarding the statistical analyses, all data were expressed in mean ± standard deviation (SD). Initially, Shapiro-Wilk (normality) and Levene's tests were performed, followed by ANOVA (repeated measures), to compare moments Pre-, 6 months and 13 months. In order to assess potential correlations between resistin × blood pressure, resistin × muscular strength and strength × blood pressure, Pearson's r was applied considering the following classification: null =0.0; weak = 0.01-0.3; regular = 0.31-0.6; strong = 0.61-0.9; very strong = 0.91-0.99; and full = 1.0[23]. For all calculations the critical value was set at 5% ($p < 0.05$).

The participants signed the free informed consent form and then the research was carried out according to Resolution 196/96 of the Brazilian National Health Council (*Conselho Nacional de Saúde – CNS*) after the approval of the Human Research Ethics Committee of the University Center Central Paulista (*Centro Universitário Central Paulista – UNICEP*) through protocol No.042/2008.

RESULTS

After 13 months of ST, no significant alterations occured in body mass (67.5 kg ± 10.8 *versus* 66.5 kg ± 10.9) or body mass index (28.0 kg/m^2 ± 4.9 *versus* 27.5 kg/m^2 ± 4.5). However, there was a significant reduction in SBP within 6 months (-3.6 mmHg) and 13 (-4.8 mmHg) months, if compared to the Pre-training moment (Figure 1). There was no significant difference in DBP, MAP and PP values between the moments assessed (Figure 1).

There was a significant reduction in serum resistin concentration in all moments (Pre × 6 months; Pre × 13 months; 6 months × 13 months) assessed (Table I). There was a 46%-reduction after 13 months of training.

A significant increase in muscular strength was observed in the 45º leg press, bench press and elbow flexion (Table II) in all the moments (Pre × 6 months; Pre × 13 months; 6 months × 13 months). There was an increase of 98.5% in 45º leg press; 29.6% in bench press and 26.5% in biceps curls within 13 months.

Table III shows the correlation coefficients between resistin, SBP and muscular strength. There is a very strong positive correlation between resistin × SBP; and there is a very strong negative correlation between resistin × muscular strength and muscular strength × SBP.

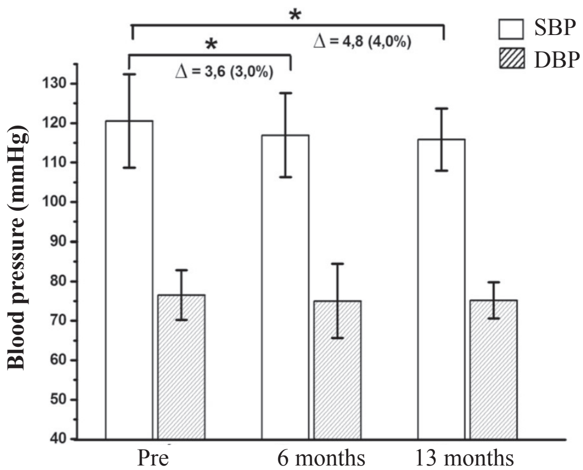

Figure 1 – Blood pressure values (mean ± SD, n=23) in the moments Pre, 6 months and 13 months of strength training program. Pre: pre-training moment; SBP: systolic blood pressure; DBP: diastolic blood pressure. Δ: absolute value of reduction in comparison to Pre-training moment. * p<0.05 in comparison to Pre-training moment.

Table I – Serum resistin concentration in moments Pre, 6 months and 13 months of strength training program.

	Pre	6 months	13 months
Resistin (pg/ml)	30272.49 ± 8100.15	20114.52 ± 4416.50*	16350.62 ± 2404.67*#

Data are expressed as mean ± SD (n=23). Pre: assessment before the start of the strength training program. * p < 0.01 in comparison to Pre-training moment. # p<0.01 in comparison to 6 months. ANOVA test (repeated measures).

Table II – Maximum strength in the moments Pre, 6 months and 13 months of the strength training program.

Exercices	Pre	6 months	13 months
45º leg press (kg)	172.35±27.35	226.96±31.36*	348.64±40.82*#
Bench press (kg)	31.95±4.18	38.73±6.03*	41.80±5.61*#
Elbow extension (kg)	21.00±2.43	23.31±2.67*	26.56±2.91*#

Data are expressed as mean ± SD (n=23). Pre: assessment before the start of the strength training program. * p < 0.01 in comparison to Pre-training moment. # p<0.01 in comparison to 6 months. ANOVA test (repeated measures).

Table III – Correlation coefficient between physiological variables at rest.

Correlations	r	Classification*	p Value
Resistin × Systolic Blood Pressure	0.99	Very strong	0.02
Resistin × Muscular Strength	-0.98	Very strong	0.01
Muscular Strength × Systolic Blood Pressure	-0.97	Very strong	0.01

r: Pearson’s correlation coefficient. *Classification of coefficient according to Albuquerque *et al*. (2010).

DISCUSSION

This study aimed to assess the chronic effects (13 months) of ST on hemodynamic variables and serum resistin concentration in postmenopausal women. The hypothesis was partially confirmed, and there was a clinically significant reduction in SBP values and serum resistin levels. However, there were no alterations in DBP, MAP and PP values within 13 months of ST. Additionally, there was a strong correlation between SBP × resistin × muscular strength. As it was expected, the ST program increased muscular strength of the muscle groups assessed.

Regarding blood pressure control, the American College of Sports Medicine[24] and the American Heart Association[25] recommend ST as a form of prevention and/or non-drug therapy for cardiovascular diseases in women and elders. In this research, there was a reduction of 4.8 mmHg in SBP values and DBP was maintained (4% and 2%, respectively) at rest after 13 months of ST. These results corroborate the findings of a meta-analysis[26] that found a reduction of 2% and 4% in SBP and DBP values, respectively. Another meta-analysis of nine randomized controlled studies observed a reduction of 3.2 and 3.5 mmHg in SBP and DBP, respectively[27]. Although the reduction in SBP values of the aforementioned studies is small, it is clinically important and strongly related to the reduction from 5% to 9% in cardiac death, 8% to 14% in the occurrence of cerebrovascular accident and 4% in mortality by all the causes[28].

Among the physiological mechanisms involved in blood pressure control, the number and caliber of small arteries and arterioles stand out with an important role in the control of total peripheral resistance and MAP[21]. In clinical practice, blood pressure is defined by the values of SBP and DBP. However, a more detailed analysis of the arterial pressure curve should take into account the sum of the mean component – the MAP – and the pulse component – the PP. The MAP is the pressure for the proper delivery of blood flow and oxygen to tissues and organs, depending mainly on cardiac output and peripheral vascular resistance. PP is characterized by the role of major arteries that minimize the pulsatility and depends on ventricular ejection, arterial stiffness and the timing of wave reflection[29]. MAP and PP are associated with the adequate control of blood pressure and independent cardiovascular risk factors, especially for cardiac death in women between 50 and 60 years old[21]. Thus, it is evident the clinical importance of this research, which, in addition to the reduction of SBP, promoted the maintenance of MAP and PP during 13 months of ST program.

Evidences show that the aging process is accompanied by an increase in serum levels of different inflammatory mediators, such as C-reactive protein, tumor necrosis factor alpha, interleukin 6, interleukin-1 beta and resistin, which are associated with the physiopathology of systemic arterial hypertension[30-32]. Resistin is an inflammatory marker and has been associated with the onset of cardiovascular diseases[5,6,7]. Furthermore, there is a negative correlation between physical activity and the levels of circulating inflammatory mediators[33].

There was an association of resistin levels, senile inflammation and vascular disorders with increased incidence of hypertension in postmenopausal women over 55 years old[5]. This study observed a reduction of 46% in serum resistin concentration and a strong correlation between SBP and resistin after 13 months of ST. Hence, ST may contribute to the reduction of senile inflammation and cardiovascular risk in the group of postmenopausal women.

Data from an investigation[34] confirm the results of this study concerning the increase in muscular strength. There has been an increase in resistance and walking speed, climbing up stairs and dynamic balance, with a consequent fall prevention[28]. It was also observed a reduction serum resistin levels after 16 weeks of ST in postmenopausal women[10]. One of the aspects that should be highlighted in this research is that the reduction of serum resistin levels and the increase in muscular strength occurred after 6 and 13 months of training.

The strong inverse relation between SBP and muscular strength was also another interesting finding. Previous studies conducted with sedentary middle-aged women have showed similar results[14,15]. Furthermore, there have been higher incidences of arterial hypertension in men with low muscular strength[35] and mortality in middle aged and elderly men with hypertension and low muscular strength[36]. A possible beneficial relationship between the increase in muscular strength and the reduction in blood pressure may be explained by the peripheral arterial complacency reduction, which occurs during exercises that require muscular strength. This alteration in complacency is a long-term protective effect caused by changes in the smooth muscle tissue of arterial walls and in collagen and elastin properties, which partly reduces blood pressure at rest[37].

The results of this study should be carefully interpreted due to some possible methodological limitations. First, the relatively reduced number of volunteers hinders the generalization and application of results to the general population. Secondly, there is the lack of a control group, which does not allow for effective comparisons of results obtained from a group that has not performed the training. However, there have been rumors that a control group is not always necessary, mainly because, in this age group, health may be compromised due to sedentariness[10-12,25,33].

Additionally, the results from a control group do not show a positive effect on muscular strength and cardiovascular risk factors [38-40].

CONCLUSION

Finally, the 13-month ST promoted an increase in muscular strength, reduction in the levels of resistin and systolic blood pressure of the patients assessed. These adaptations are very important to the reduction of the risk of diseases and cardiovascular events in postmenopausal women, highlighting the clinical importance of ST to this population.

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