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original article

Effect of resistance training and detraining on the oxidative stress in obese older women

Efeito do treinamento com pesos e do destreinamento sobre o estresse oxidativo em mulheres idosas obesas

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Abstract – The aim of this study was to investigate the effect of resistance training (RT) followed by a similar detraining period on the modulation of oxidative stress (OS) in obese older women. Fourteen obese women (age: 68.7 ± 4.8 years, body mass: 71.3 ± 14.8 kg, height: 156.3 ± 7.2 cm, body fat: 44.3 ± 4.4%) were submitted to 12 weeks of a RT program followed by a similar detraining period. Advanced oxidation protein products (AOPP) and total radical-trapping antioxidant potential (TRAP) were used as oxidative stress indicators. AOPP was not changed by RT or detraining ($P = 0.31$). Furthermore, TRAP was increased with RT (+ 15.1%; $P < 0.001$) and remained high even after 12 weeks of detraining (10.5%; $P < 0.001$). The results suggest that OS can be improved by RT and the 12-week detraining period does not seem to be enough to reverse adaptations induced by RT in obese older women.

Key words: Antioxidant capacity; Resistance exercises; Obesity.

Resumo – *O objetivo deste estudo foi investigar a efetividade do treinamento com pesos (TP), seguido por um período semelhante de destreinamento, sobre a modulação do estresse oxidativo (EO) em mulheres idosas obesas. Quatorze mulheres (idade: 68,7 ± 4,8 anos; massa corporal: 71,3 ± 14,8 kg; estatura: 156,3 ± 7,2 cm; gordura corporal: 44,3 ± 4,4%) obesas (gordura corporal relativa ≥ 30%) foram submetidas a 12 semanas de um programa de TP seguido por igual período de destreinamento. Os produtos de proteínas de oxidação avançada (AOPP) e a capacidade antioxidante total plasmática (TRAP) foram utilizados como indicadores de estresse oxidativo. A AOPP não foi alterada pelo TP ou pelo destreinamento (P = 0,31). Por outro lado, a TRAP foi aumentada com o TP (+15,1%; P < 0,001) e se manteve elevada mesmo após 12 semanas de destreinamento (+10,5%; P < 0,001). Os resultados sugerem que o EO pode ser melhorado pelo TP e o período de 12 semanas de destreinamento não parece ser suficiente para desfazer as adaptações induzidas pelo TP em mulheres idosas obesas.*

Palavras-chave: *Capacidade antioxidante; Exercícios com pesos; Obesidade.*

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INTRODUCTION

Oxidative stress (OS) is a phenomenon characterized by an imbalance between the generation of free radicals (FR) and oxygen and nitrogen reactive species (ROS / RNS), and the inability to neutralize them by an antioxidant defense system[1]. This imbalance can damage the cell membrane and lead to oxidation of important macromolecules responsible for providing energy and tissue repair, such as carbohydrates, proteins and lipids[1].

With advancing age, the OS profile is quite changed, so that older people have reduced capacity of the antioxidant system[2]. In addition, the natural aging process is also characterized by major changes in the body composition components such as decreased skeletal muscle mass and increased body fat, especially visceral fat[2], which in most cases results in metabolic disorders[3] such as increased generation of FR and ROS / RNS[3]. Accordingly, older individuals with excess body fat deserve special attention, particularly due to the deleterious and cumulative effects of free radicals, ROS / RNS and obesity[4].

Resistance training (RT) is an exercise modality often recommended to improve athletic performance, health and well-being, given the numerous morphological, neuromuscular, psychological, physiological, and metabolic benefits associated with this practice[5]. More recently, RT has been indicated as part of weight control programs, in particular, for the treatment of obesity[6], since it increases the resting metabolic rate, helps in the retention of muscle mass and has a positive effect on the oxidative balance, improving the antioxidant capacity and decreasing the deleterious effects of ROS / RNS[7].

Although the adhesion of older individuals in RT programs is an emerging phenomenon, adhesion is often compromised by temporal interruptions brought about for several reasons, such as travel, injuries, fractures, disorders or diseases. Such interruptions can result in important damage to training-induced adaptations, causing loss of muscle mass, bone mineral density and content, strength, power, muscular endurance, balance, coordination, among others[8].

Therefore, investigations that provide information on the impact of training followed by detraining may greatly contribute to the understanding of the role of physical activity and sedentary behavior on aging. Based in this information, the aim of this study was to analyze the effect of RT followed by detraining on the OS modulation in obese older women. Our hypothesis would be that RT programs could favor OS modulation and a similar detraining period would result in significant losses of training-induced adaptations.

METHODOLOGICAL PROCEDURES

Study design

This study was conducted over 30 weeks, and the first two weeks were used

for a series of measures (anthropometry, body composition, strength tests, and blood collection), 12 weeks of RT followed by two weeks for the retest

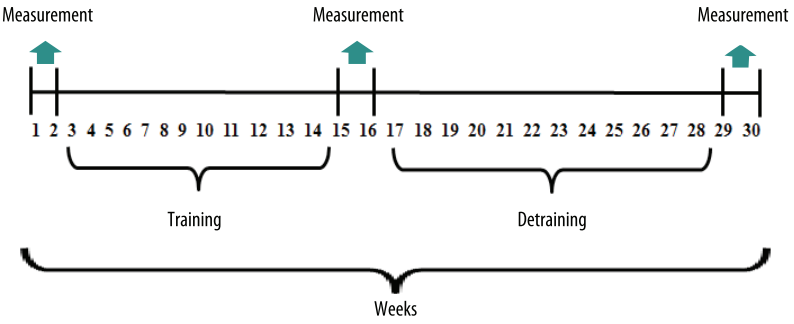

Figure 1. Experimental design.

Study subjects

Fourteen older women (> 60 years), participants of the Active Ageing Project, were intentionally selected to participate in this study because they present relative body fat ≥ 30%, being considered obese[9]. For the present study, the following inclusion criteria were adopted: age of 60 years or older, overweight, not hypertensive or have blood pressure controlled by medications (systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg), absence of any musculoskeletal condition that prevent from participating in the RT program, not user of supplements based on vitamins and antioxidants, not under treatment with hormone replacement, not being engaged with the regular practice of systematic physical activity more than once a week over six months before the study. In addition, all participants were allowed to participate in regular physical exercise programs after being submitted to cardiac stress test performed by cardiologist. Frequency below 85% in RT sessions was used as an exclusion criterion. After being informed about the procedures to be adopted, benefits and possible risks of the study, participants signed an Informed Consent Form. The study was conducted in accordance with the Declaration of Helsinki and approved by the local Ethics Research Committee (Process 10656/2012 and Protocol 048/2012)

Anthropometry

Body mass was measured in the morning period on a digital scale with a 0.1 kg scale (Balmak, model Class III, São Paulo, Brazil), while height was determined using stadiometer with scale of 0.1 cm. Participants were asked to attend dressed in comfortable clothes for carrying out these measures.

Body composition

Dual energy x-ray absorptiometry (DEXA) was used for determining body composition. The measurements were performed on Lunar Prodigy equipment (model GE Healthcare, ID 14739, Madison, WI, USA) by whole body scanning. Equipment calibration followed the manufacturer's recommendations, while analyzes were performed by a lab technician with

experience in this type of exam. Participants were submitted to the exams wearing light clothes, barefoot and without carrying any metal object or other accessories. All remained lying and still on the equipment table until the completion of the measurements. After total body scans, the software provided data on fat tissue, bone tissue, lean and soft tissue for the whole body and for specific areas (trunk, arms and legs). Limbs were demarcated and separated from the trunk and head using patterns lines generated by the equipment software. The lines were adjusted by the technician through specific anatomical points in accordance with procedures described in the equipment handbook. Skeletal muscle mass (SMM) was estimated based on the quantification of lean and soft tissue through the use of predictive equation proposed by Kim et al.[10]

Muscular Strength

The maximum muscular strength was determined through 1RM tests in two exercises performed in the following order: chest press and knee extension. Each of the exercises was preceded of a series of warm-up exercises (6-10 repetitions) with approximately 50% of the estimated load for the first attempt of the 1RM test. Tests were performed two minutes after warm-up. Participants were asked to try to complete two repetitions. If at least one repetition was completed on the first attempt, or even if one repetition was not completed, a second attempt was performed after interval of 3-5 min, with a higher load (first possibility) or lower load (second possibility) compared to that used in the previous attempt. This procedure was repeated again in a third attempt. The load recorded as 1RM was that in which it was possible to complete only one repetition maximum. The rest interval between exercises was 5 min. All participants were tested in situation similar to the protocol adopted in three distinct sessions (ICC > 0.96) with intervals of 48 h[11]. The largest lifted load was recorded as the 1RM value. It is noteworthy that the form and execution technique of each exercise were standardized and continuously monitored in an attempt to ensure test efficiency. Participants were instructed to remain hydrated during all testing sessions.

Oxidative stress indicators

Blood was collected from the antecubital vein with participants in the sitting position after a 12-hour fasting period. After collection, tubes containing *ethylenediamine tetraacetic acid* plus samples were centrifuged at 3.000 g for 5 min at 4ºC for plasma separation.

Advanced oxidation protein products (AOPP) were determined by semiautomatic method[12] for assessing the oxidant capacity in micromole per liter (μmol/L), equivalent to chloramine-T. The antioxidant capacity was determined by evaluation of the total radical-trapping antioxidant potential (TRAP)[13] through chemiluminescence method for induction time of 2.2-azobis (2-amidinopropane) and calibrated with analogue TROLOX vitamin E. This method detects water-soluble and soluble an-

tioxidants in the plasma, and the TRAP values were expressed in μmol Trolox equivalents.

Resistance exercise program

The RT program was composed of eight exercises that were performed on a single set of 10-15 repetitions maximum[14], according to an order alternate by segment. The order of execution of exercises adopted for the RT program was the following: chest press, horizontal leg press, seated row, knee extension, preacher curl, leg curl, triceps pushdown and seated calf raise. The interval between exercises was 2-3 min. Participants were instructed to control the speed of execution of movements in the ratio of 1: 2 (concentric and eccentric muscle actions, respectively). RT was developed using a combination of free weights and machines for 12 weeks, with frequency of three times a week on non-consecutive days (Monday, Wednesday, and Friday). The progression of training loads in each exercise occurred when individuals completed 15 repetitions in two consecutive sessions, with increases of 2-5% in exercises for the upper limbs and 5-10% in exercises for the lower limbs. It is noteworthy that participants were individually supervised during RT sessions by professionals experienced in this type of exercise.

Statistical Analysis

Data distribution was tested by the Shapiro-Wilk test. Levene´s test was used to analyze the homogeneity of variances. To check the sphericity assumption, the Mauchly´s test was applied. Two-way ANOVA for repeated measurements *followed by Bonferroni's post hoc test* for multiple comparisons. The effect size (ES) was calculated to verify the magnitude of the differences by Cohen's d where an ES of 0.20–0.49 was considered as small, 0.50–0.79 as moderate and ≥0.80 as large[15]. The level of significance was set at $P < 0.05$. The data were stored and analyzed using STATISTICA software version 10.0 (StatSoft Inc., Tulsa OK, USA).

RESULTS

The general characteristics of participants at baseline are presented in Table 1.

Table 1. General characteristics of participants at baseline (n = 14).

Variables	Minimum	Maximum	Mean	Standard deviation
Age (years)	62	71	68.7	4.8
Body mass (kg)	51.9	103.6	71.3	14.8
Height (cm)	148	170.5	156.3	7.2
Body fat (%)	30.2	51.5	44.3	4.4

Table 2 presents information on muscular strength, body composition and oxidative stress in different moments of the study. A significant

increase in muscular strength ($P < 0.05$) was observed after 12 weeks of RT (chest press = + 17.9%, ES = 1.02; knee extension = + 13.6%, ES = 0.47). Although muscular strength has been significantly reduced after 12 weeks of detraining ($P < 0.05$), the results were higher than those found at baseline in chest press (10.6%), while a decrease was identified in knee extension (-5.5%). A significant decrease in relative body fat ($P < 0.05$) was observed with RT (1.3 percentage points), which remained below baseline values even after detraining (0.4 percentage points). On the other hand, a gain in SMM (+5.2%, $P < 0.05$) was observed in RT and part of this change was retained after detraining (+3.7%). AOPP was not changed by RT or detraining ($P = 0.31$). Furthermore, TRAP increased after RT (+15.1%, ES = 0.94; $P < 0.001$) and remained high even after a 12-week detraining period (+10.5%; $P < 0.001$).

Table 2. Body composition, muscular strength and oxidative stress indicators in pre- and post-training periods (12 weeks) and after a 12-week detraining period in obese older women (n = 14).

Variables	Pre	Post	Detraining	P
Muscular strength				
Chest press (kg)	39.7 ± 5.4	46.8 ± 8.5*	43.9 ± 7.3*†	< 0.001
Knee extension (kg)	47.1 ± 13.2	53.5 ± 13.9*	44.5 ± 13.9†	< 0.001
Body composition				
Body fat (%)	44.3 ± 4.4	43.0 ± 4.8*	43.9 ± 4.1†	< 0.01
Muscle mass (kg)	19.0 ± 3.5	20.0 ± 4.2*	19.7 ± 4.1*†	< 0.01
Oxidative stress				
TRAP (µmol Trolox)	688.6 ± 90.3	792.6 ± 130.8*	761.2 ± 120.2*†	< 0.001
AOPP (µmol/L)	95.6 ± 22.0	90.0 ± 21.0	86.8 ± 25.2	0.31

Note. Values are presented as mean and standard deviation. * $P < 0.05$ vs. Pre. † $P < 0.05$ vs. Post. TRAP = total radical-trapping antioxidant potential. AOPP = advanced oxidation protein products.

Figure 2 illustrates the relative changes observed in each dependent variable examined in this study.

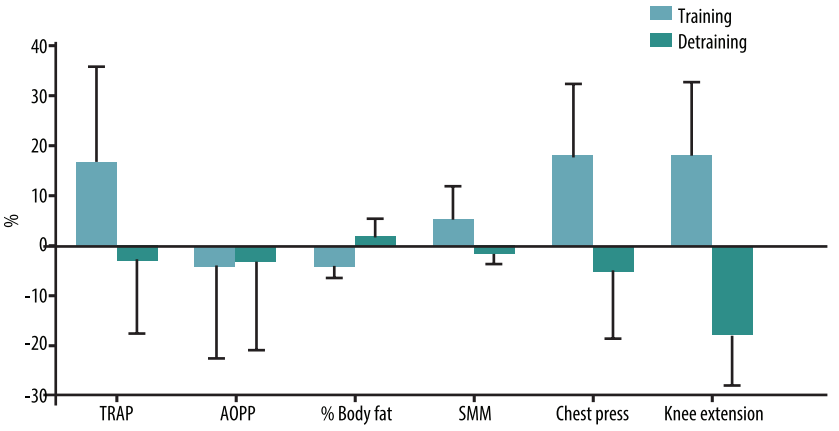

Figure 2. Relative changes in oxidative stress markers, body composition, and muscular strength after 12 weeks of resistance training followed by detraining (12 weeks) in obese older women (n = 14). TRAP = Total radical-trapping antioxidant potential. AOPP = Advanced oxidized protein products. SMM= Skeletal muscle mass.

DISCUSSION

The main finding of this study was that oxidative stress can be improved by RT and the 12-week detraining period does not seem to be enough to reverse adaptations induced by RT in obese older women. To the best of our knowledge, this is the first study that examined the effect of RT followed by a detraining period on OS indicators in obese older women. However, our findings corroborate results previously found in exercised older women with respect to increased antioxidant capacity[16] and reduced OS markers[17].

The potential mechanism for the increase in TRAP is not yet fully elucidated, although the OS modulation caused by RT may be related to some known mechanisms[18]. Thus, if physical exercise can stimulate the synthesis of reactive oxygen species through the activation of the electron transport chain, the predominantly anaerobic exercise such RT can increase the synthesis of xanthine oxidase and NADPH oxidase enzymes, additionally the synthesis of lactic acid, catecholamines and inflammation, factors that contribute to the production of reactive oxygen species[18]. In response to this process, the antioxidant system triggers adjustments favorable to the endogenous antioxidant system, thus increasing the body's defense capacity. It is noteworthy that among antioxidant defense indicators, TRAP has been the most widely used indicator[19].

Another interesting point of this experiment is the exclusive participation of obese older women, given that excess of body fat is an important factor in the production of ROS / RNS[4]. Thus, based on the results found in this investigation, we believe that RT has indirectly favored the improvement of OS by a reduction body fat. However, as the ES for TRAP was of great magnitude and of low magnitude for fat, it is possible that other mechanisms are involved in the improvement of OS revealed in this study.

With the detraining period, TRAP suffered a significant reduction, an expected response due to the removal of the training stimulus[20]. Nevertheless, the 12-week detraining period was not enough to reverse all benefits promoted by RT.

The AOPP was analyzed in this study as an oxidant biomarker because it is considered a reliable marker to estimate the levels of protein damage, the OS intensity and inflammation that is closely related to cardiovascular diseases, inflammatory processes, and obesity[12,16]. The oxidative protein damage is caused by the action of free radicals and other oxidizing compounds[21]. Physiologically, AOPP is formed in small amounts during the life and increases with age[22]. Therefore, the absence of changes in this marker throughout the experimental period suggests that RT can probably to attenuate the deleterious effects of the aging process.

Regarding muscular strength, our findings are consistent with previous results reported in literature, indicating that elderly have reduced muscular strength after a detraining period, although part of the gains from RT can be retained over shorter (four weeks), similar (12 weeks) or longer (48 weeks) detraining periods[23-25], compared to the period analyzed

in this study. However, a more detailed comparison with findings from literature is not simple, mainly due to methodological differences among experiments with respect to intensity, volume, type of exercise, training and detraining periods.

The SMM gains observed in this study are quite relevant, given the importance of this body composition component, mainly for its close relationship with mobility and function of the locomotors system in the elderly[26], being considered an important predictor of longevity in this population[27]. Furthermore, reductions in SMM caused by the detraining period were not enough to achieve the values identified at baseline, demonstrating the importance of RT to attenuate the sarcopenia process in the elderly[28].

This study has some limitations. The results found should not be extrapolated to other populations, and results are limited to the time period, exercise protocols and markers used. In addition, the lack of control group and information on dietary habits should be considered when extrapolating the results. On the other hand, the information produced by this study encourages future investigations involving periodization, training volume and frequency, or even other practices that may be more effective for the OS control in obese older women. Also, there is need for studies aimed at analyzing the possible mechanisms involved with these adaptations. The clinical relevance of the results found in this study should be highlighted, since improvements in the antioxidant capacity can be an important protective factor against the development of many degenerative processes associated with age and excess body fat.

CONCLUSION

The results suggest that 12 weeks of RT appear to be sufficient for the modulation of the antioxidant capacity in obese older women. Additionally, the benefits obtained with RT may be largely retained after a 12-week detraining period.

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