

Effects of Sedentarism and Treadmill Training in Mechanical Properties of Muscles of Ovariectomized Rats with High-Fat Diet

Ana Paula Macedo¹, Débora Taffarel Ferrari¹, Roberta C Shimano¹, João Paulo Mardegan Issa^{1, 2}, Alceu Afonso Jordão³ and Antônio Carlos Shimano¹

1. Department of Biomechanics, Medicine and Rehabilitation of the Locomotor System, Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto 14049-900, Brazil

2. Departament of Morphology, Physiology and Basic Pathology, School of Dentistry of Ribeirão Preto, University of São Paulo, Ribeirão Preto 14040-904, Brazil

3. Department of Internal Medicine, Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto 14049-900, Brazil

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Abstract: The aim of this study is to evaluate the ability of physical training in the maintenance of muscle strength in rats with HFD (high-fat diet) after OVX (ovariectomy). Eighty Wistar rats are at eight weeks of age and weight 200 g which divided into 8 groups (n = 10) and treated for 12 weeks: GA: OVX + ND (normal diet), GB: OVX + ND + training, GC: sham + ND, GD: sham + ND + training, GE: OVX + HFD, GF: OVX + HFD + training, GG: sham + HFD and GH: sham + HFD + training. HFD consists of standard ration for rats with addition of 30% lipids. In training groups, physical training five training/week was conducted on a treadmill with adaptation period of three weeks up to 18 m/s for one hour, training were performed for 12 weeks. The sedentary animals remained in individual box. To analyze the effects of training and diet, tensile strength tests of the gastrocnemius muscles were conducted: the speed of 0.1 mm/min. Analysis of variance was performed to compare groups. The mean (SD) obtained for the maximum load (N) were: GA 57.77 (6.89), GB 62.74 (5.07), GC 49.45 (6.06), GD 59.42 (5.26) and GE 55.58 (4.72), GF 62.50 (4.56), GG 58.35 (4.54) and GH 56.67 (5.87), respectively. There were no differences for maximum load between surgeries (p =0.004) and between treatments (p = 0.000). Differences were found also for the relationship surgery diet treatment (p = 0.007). For the variable stiffness (N/mm), there were not statistically significant differences: GA 5.03 (0.72), GB 5.08 (1.09), GC 5.17 (0.53), GD 5.35 (0.80), GE 5.52 (1.20), GF 5.36 (1.07), GG 4.83 (1.03) and GH 5.40 (0.73). For the toughness (N/mm), there were differences between treatments (p = 0.010) and the ratio diet treatment (p = 0.024): GA 455.00 (107.21), GB 541.96 (126.80), GC 394.97 (84.67), GD 566.90 (157.07); GE 424.63 (113.03), GF 478.07 (106.03); GG 517.44 (98.65) and GH 481.26 (129.45). OVX causes decrease in muscle maximum load; exercise treadmill provides increased muscular endurance, regardless of the diet and the OVX in groups, the increased resistance observed in the groups submitted to HFD can result in weight gain associated with the presence estrogen.

Key words: Physical training, ovariectomy, mechanical property, gastrocnemius muscles, high-fat diet.

1. Introduction

The intake of micronutrients (vitamins and minerals) and macronutrients (carbohydrate, lipid and protein) are directly related to growth, physical development, cognitive and motor of the individual. A deficiency or excess of these nutrients in childhood can cause serious diseases in adulthood [1]. Nutrition is based on quantitative and qualitative balance necessary for healthy function of the organism. Another problem faced by the public health is overweight due to wrong diets. Surveys conducted in rats showed that low levels of vitamin D and calcium are associated with a

Corresponding author: Ana Paula Macedo, Ph.D., research fields: bioengineering. E-mail: anapaula@forp.usp.br.

HFD (high-fat diet) affect bone development [2, 3]. However, we found no reports in the literature describing the influence of a HFD in muscle strength.

One of the major problems reported postmenopausal is the loss of muscle mass. Probably a more important than human estrogen health issue is related to potential differences in susceptibility to exercise-induced muscle damage in women of premenopausal and postmenopausal. Studies by Amelink et al. [4] showed a primary effect of estrogen may be to protect muscle membranes from muscle damage induced by exercise. The reduction of muscle membrane disruption may also be important in the inflammatory and muscle repair [5]. It has been reported that the loss of estrogen after menopause may result in more power loss associated with aging and a reduced rate of gain of strength in older women. Thus, although some information is available, definitive studies on the influence of estrogen on skeletal muscle damage are deficient and additional research is needed [6].

Several studies have shown that exercise provides a better quality of life and benefiting various aspects of the organism. In this aspect, musculoskeletal promotes muscle strengthening and greater strength and stability of the bones and joints, also favoring one physical wellbeing, mental and social. Already, a sedentary lifestyle is a risk factor for several diseases [7, 8]. Known for their beneficial effects, physical activity has been used in recent years as a method of prevention and analysis of muscle atrophy [9-11]. In addition, training controls the effects of ovariectomy on fat accumulation, lipid profile and lipid content of the tissue [12, 13].

The mechanical test is a standardized technique as used in the evaluation of mechanical properties of materials in different applications, using specimens or experimental models. The tests allow knowing the response of the material by applying different loads. Among the destructive testing has the tensile test, bending, torsion, impact, and fatigue among other nondestructive testing, has ultrasound, x-ray [14].

The aim of this study is to evaluate the ability of physical training in the maintenance of muscle strength in rats with HFD after OVX (ovariectomy).

2. Material and Methods

Eighty Wistar rats, eight weeks of age and weight (200 ± 5) g were ovariectomized and divided into eight groups (n = 10) and treated for 12 weeks: GA: OVX + ND (normal diet), GB: OVX + ND + training, GC: sham + ND, GD: sham + ND + training, GE: OVX + HFD, GF: OVX + HFD + training, GG: sham + HFD and GH: sham + HFD + training.

The diet consists of standard ration diet to rats with addition of 30% lipids [15].

In the trained groups, physical training was performed on a treadmill with adaptation period of three weeks until reaching a speed of 18 m/s during one hour. Five training sessions were conducted per week for 12 weeks, totaling 60 sessions of training.

The sedentary animals remained in "reduced" cages, individually for a period of 12 weeks, according to the guide for Care and Use Laboratory Animals [16].

To analyze the effects of diets and treatments offered, tensile test of the gastrocnemius muscles were performed. The speed was 10 mm/min with preload of 5 N for 60 s in a universal testing machine (EMIC-DL® 10,000). We obtained the maximum load (N)- F_{max} , stiffness (N/mm) and tenacity (N.mm).

To evaluate the effect of training and diet at mechanical proprieties, the statistical analysis was performed using a mixed linear model, which is a generalization of the standard linear model (ANOVA) with Bonferroni's complementary test using the statistical software SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA). Differences were considered significant when p < 0.05.

3. Results

Table 1 shows the results of the Shapiro-Wilk test for the evaluation of the normality of the variables.

The results obtained after analysis are shown in Table 2.

When evaluating the influence of the type of surgery in maximum load (N) observed statistical differences between the OVX and SHAM groups **Table 1** Normality test.

		Shapiro-Wilk		
	Statistic	df	Sig.	
F _{max}	0.981	80	0.286	
Stiffness	0.982	80	0.329	
Tenacity	0.978	80	0.183	

(p = 0.004). No statistical differences were found in maximum load for the different diets (p = 0.413), but differences were found for the different treatments (p = 0.000). By comparing the effect of the interaction of the variables, differences for the relationship surgery diet treatment (p = 0.007) was observed, but not to surgery diet (p = 0.072), surgery treatment (p = 0.428) and diet treatment (p = 0.054).

After identifying differences in the interaction surgery, diet treatment was performed multiple comparisons in which it was observed that animals with HFD, treadmill-trained and under different surgery (GD and GH) showed statistical differences in relation to the maximum load (p = 0.018). Animals with standard diet, sedentary and subjected to different surgery (GA and GE) showed statistical differences with respect to maximum load (p = 0.001). SHAM animals, sedentary with different diets (GE and GF) showed statistical differences (p = 0.000). It was also observed that OVX animals, that receiving HFD and different treatments (GB and GD) showed statistical differences (p = 0.005) and SHAM animals with standard diet and different treatments (GE and GG) was statistically different (p = 0.000).

No statistical differences were observed in the stiffness (N/mm) for any of the variables nor for the iterations (surgery: p = 0.853, diet: p = 0.657, treatment: p = 0.464, surgery diet: p = 0.240, surgery treatment: p = 0.333, diet treatment: p = 0.905 and surgery diet treatment: p = 0.566).

When evaluating the tenacity (N.mm) their

differences statistically significant between treatments (p = 0.010) and the ratio diet treatment (p = 0.024).

When evaluating the effect of treatments on tenacity (N.mm), statistical differences were observed. between groups (p = 0.010). There were no statistical Table 2 Mean (standard deviation) of maximum load (F_{max}), stiffness and tenacity.

Groups	$F_{\max}(\mathbf{N})^*$	Stiffness (N/mm)*	Tenacity (N.mm)*
GA	57.77 (6.89)	5.03 (0.72)	455.00 (107.21)
GB	62.74 (5.07)	5.08 (1.09)	541.96 (126.80)
GC	49.45 (6.06)	5.17 (0.53)	394.97 (84.67)
GD	59.42 (5.26)	5.35 (0.80)	566.90 (157.07)
GE	55.58 (4.72)	5.52 (1.20)	424.63 (113.03)
GF	62.50 (4.56)	5.36 (1.07)	478.07 (106.03)
GG	58.35 (4.54)	4.83 (1.03)	517.44 (98.65)
GH	56.67 (5.87)	5.40 (0.73)	481.26 (129.45)

*standard deviation.

differences in tenacity for different surgeries (p = 0.582) and diet (p = 0.605). By comparing the effect of the interactions between variables was possible to observe differences in diet treatment (p = 0.025), but not to surgery diet (p = 0.197), surgical treatment (p = .936) and treatment diet surgery (p = 0.103).

After identifying differences in diet treatment interaction was performed multiple comparisons in which it was observed that animals with standard diet, subjected to different treatments (GA, GC, GE and GG) showed statistical differences in relation to tenacity (p = 0.001).

4. Discussion

Several studies have evaluated the influence of high-fat diet on bone quality, obesity and body composition [15, 17-19]. However, there are no reports on the influence of diets rich in lipids in muscle strength after OVX. The objective of this study was to evaluate the influence of HFD on muscle strength in ovariectomized rats.

In the present study, less muscular strength was observed for animals submitted to OVX. This is an important result because reduced ovarian levels leads to endocrine and functional disorders, such as loss of libido, increased risk of osteoporosis and heart disease, abnormal levels of lipoproteins and weight gain [20]. Differences were found between treatments for maximum load and tenacity.

When evaluating the difference between groups observed that animals with standard diet, sedentary and undergo different surgeries (GA and GE) had statistical differences with respect to maximum strength and toughness. Being that OVX had higher values for both variables. SHAM animals underwent surgery, sedentary and with different diets (GE and GF) showed statistical differences for maximum strength. The highest values were assigned to animals receiving fat diet. It was observed that OVX animals undergoing surgery, receiving HFD and different treatments (GB and GD) showed statistical differences in maximum strength, with higher values in the trained animals. SHAM animals underwent surgery, standard diet and different treatments (GE and GF) are statistically different with respect to maximum strength and toughness, with higher values in the trained animals.

As there are no reports in the literature on similar studies, it is believed that these results may be related to greater weight observed in OVX compared to SHAM animals and animals that received HFD compared to those who received standard diet. As for the differences observed between the groups trained or sedentary, we believe that the best results were observed for animals trained to be a result of muscle strengthening arising from treadmill training applied. In Ref. [16], the authors found improvement in mechanical strength in the muscles of trained rats.

Analyzing the results obtained in static tests, we observed differences between the OVX and SHAM groups for maximum strength, but not for stiffness and toughness. However, the different diets resulted in no statistical differences for the variables of the static test. Differences were found between treatments for maximum strength and tenacity.

5. Conclusions

OVX causes decrease in muscle strength; exercise treadmill provides increased muscular endurance, regardless of the diet and the OVX in groups, the increased resistance observed in the groups submitted to HFD can result in weight gain associated with the presence estrogen.

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