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EFFECTS OF SEDENTARISM AND TRAINING IN MECHANICAL PROPERTIES OF MUSCLES OF OVARIECTOMIZED RATS WITH HIGHFAT DIET

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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 high fat diet (HFD) after ovariectomy (OVX). Eighty Wistar rats at 8 weeks of age and weight 200g were divided into 8 groups (n = 10) and treated for 12 weeks: GA: OVX + normal diet (ND), GB : OVX + ND + training, GC: sham + ND, GD: sham + ND + training, GE: OVX + HFD, GF: OVX + HFD + training, GG: sham + HFD, GH: sham + HFD + training. HFD consisting of standard ration for rats with addition of 30% lipids. In training groups, was conducted physical training 5 training /week on a treadmill with adaptation period of 3 weeks up to 18 m/s for 1h, training were performed for 12 weeks. The sedentary animals remained in individual box. To analyze the effects of training and diet were conducted tensile strength tests of the gastrocnemius muscles; 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), GH 56.67(5.87). There were differences for maximum load between surgeries (p=.004) and between treatments (p=.000). Differences were found also for the relationship surgery*diet*treatment (p=.007). For the variable stiffness (N/mm) were not statistically significant differences: GA 5.03(.72), GB 5.08(1.09), GC 5.17(.53), GD 5.35(.80), GE 5.52(1.20), GF 5.36(1.07), GG 4.83(1.03), GH 5.40(.73). The toughness (N.mm) there were differences between treatments (p=.010) and the ratio diet*treatment (p=.024): GA 455.00(107.2), 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); GH 481.26(129.45). Ovariectomy causes decrease in muscle maximum load; exercise treadmill provides increased muscular endurance, regardless of the diet and the ovariectomy in groups, the increased resistance observed in the groups submitted to high-fat diet can result in weight gain associated with the presence estrogen.*

Keywords:
physical training, ovariectomy, mechanical property, gastrocnemius muscles, high fat diet

1. INTRODUCTION

Healthy diets are based on qualitative and quantitative balance of nutrients required for the correct functioning of the body. One problem faced by public health overweight due to wrong diets. Studies conducted on mice showed that low levels of vitamin D and calcium, associated with a high-fat diet affects bone development. (Lac *et al*., 2008, Cao *et al.*, 2009). However, there are no reports in the literature describing the influence of a high-fat diet on muscle strength.

One of the major problems described in post-menopausal is the loss of muscle mass. Probably the health issue more important than human estrogen is related to potential differences in susceptibility to exercise-induced muscle damage in women in pre menopause and menopause. Studies by Amelink and Bar (1986) 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 (Tiidus, 2003). 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, studies on the influence of estrogen on the skeletal muscle system damage are deficient and additional research is required (Clarkson and Hubal, 2002).

Several studies have shown that exercise provides a better quality of life and enjoying different aspects of the body. In musculoskeletal aspect promotes muscle strengthening and greater strength and stability of the bones and joints, favoring the physical, mental and social well-being. Already the sedentary lifestyle is a risk factor for many diseases (Topp *et al.,* 2002;. Mellerowicz e Meller, 1979). Physical activity has been used in recent years as a method of analysis and prevention of muscular atrophy, for its beneficial effects (Tuukkanen *et al*., 1994, van der Wiel *et al*., 1995; Mathey *et al*., 2002). In addition, training controls the effects of ovariectomy on fat accumulation, lipid profile and lipid content of the tissue (Hao *et al*., 2010, Leite *et al*., 2009).

Thus, the study of mechanical properties of biological materials is of fundamental importance because it helps to characterize these elements, which is of great importance for absorption, transmission and resistance to physical efforts. However, there are few studies on the mechanical properties of skeletal muscle tissue determined by mechanical tensile test (Milani *et al*., 2008).

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The objective of the study was to investigate the effect of diet on muscle strength of female rats submitted or not to ovariectomy surgery and if physical training on a treadmill is able to prevent the loss of muscle strength.

2. METHODS

The study was conducted on 80 female Wistar rats (Rattus norvegicus albinus) with eight weeks of age and body mass ranging from 185 to 255 g (mean: 210.75 ± 16.15 g). The animals were maintained in cages located in the Laboratory of Bioengineering, with cycles of 12 h day / night, free access to water and food and humidity and temperature(21 ± 1) °C controlled. The study was approved by the Ethics Committee for the Use of Animals.

The animals were divided into 8 groups (n = 10) and treated for 12 weeks (Table 1)

Tabela 1 - Grupos experimentais

Grups	Surgery	Treatment	Diet
GA	Ovariectomia (OVX)	Sedentary (S)	Normal Diet (ND)
GB			High-Fat Diet (HFD)
GC		Training (T)	Normal Diet (ND)
GD			High-Fat Diet (HFD)
GE	Sham (SHAM)	Sedentary (S)	Normal Diet (ND)
GF			High-Fat Diet (HFD)
GG		Training (T)	Normal Diet (ND)
GH			High-Fat Diet (HFD)

In the trained groups was performed physical training on a treadmill with adaptation period of three weeks to reach speed of 18m/s during 01 hour. Five training sessions were held weekly for 12 weeks, totaling 60 training sessions. The sedentary animals remained in “reduced” cages, individually for a period of 12 weeks (Milani *et al*., 2008).

We have selected an animal fat (AF) - enriched diet for this present study, which is widely used in western diets (Pinheiro *et al*., 2009). We fed a westernized diet containing 30% AF to 8-month-old female Wistar rats for 3 months.

The effects of surgery, treatments and diets offered were analyzed by tensile testing of the gastrocnemius muscles. The speed was 10mm/min with preload of 5 N for 60s in a universal testing machine (EMIC-DL ® 10000). We obtained the maximum load (N) - Fmax, stiffness (N/mm) and tenacity (N.mm).

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 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Differences were considered significant when $p < 0.05$.

3. RESULTS

Before applying ANOVA analysis was performed data normality test, it was possible to verify that all variables had a normal distribution. (Tab. 1).

Table 1 – Normality test

	Shapiro-Wilk		
	Statistic	df	Sig.
Fmax*	.981	80	.286
Stiffness	.982	80	.329
Tenacity	.978	80	.183

*maximum load

Figure 1 present the graphs for Fmax (N), for all the experimental groups, reported as means (SD).

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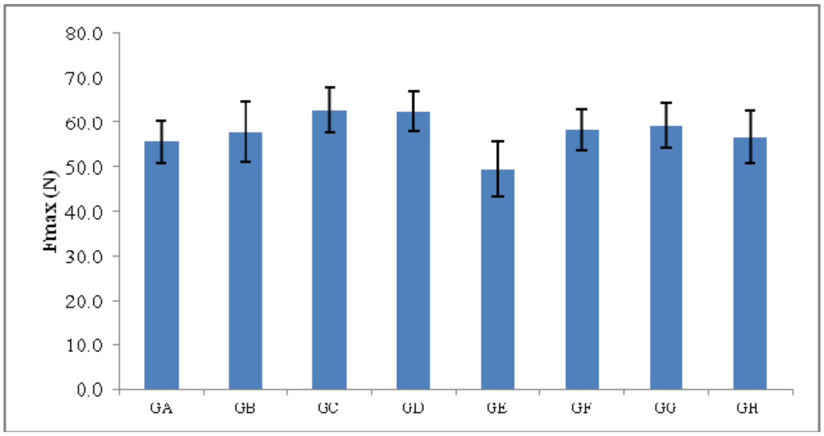

Figure 1. Means and standard deviation for maximum load (Fmax) (N)

When evaluating the influence of the type of surgery in maximum load (N) observed statistical differences between the OVX and SHAM groups (p =.004). No statistical differences were found in maximum load for the different diets (p=.413), but differences were found for the different treatments (p= .000). By comparing the effect of the interaction of the variables was observed differences for the relationship surgery * diet * treatment (p = .007), but not to surgery * diet (p = .072), surgery * treatment (p = .428) and diet * treatment (P = .054).

After identifying differences in the interaction surgery * diet * treatment was performed multiple comparisons in which it was observed that animals with high fat diet, treadmill-trained and under different surgery (GD and GH) showed statistical differences in relation to the maximum load (p = .018). Animals with standard diet, sedentary and subjected to different surgery (GA and GE) showed statistical differences with respect to maximum load (p=.001). SHAM animals, sedentary with different diets (GE and GF) showed statistical differences (p=.000). It was also observed that OVX animals, that receiving high fat diet and different treatments (GB and GD) showed statistical differences (p =.005) and SHAM animals with standard diet and different treatments (GE and GG) was statistically different (p =.000).

Figure 2 present the graphs for Stiffness (N/mm), for all the experimental groups, reported as means (SD).

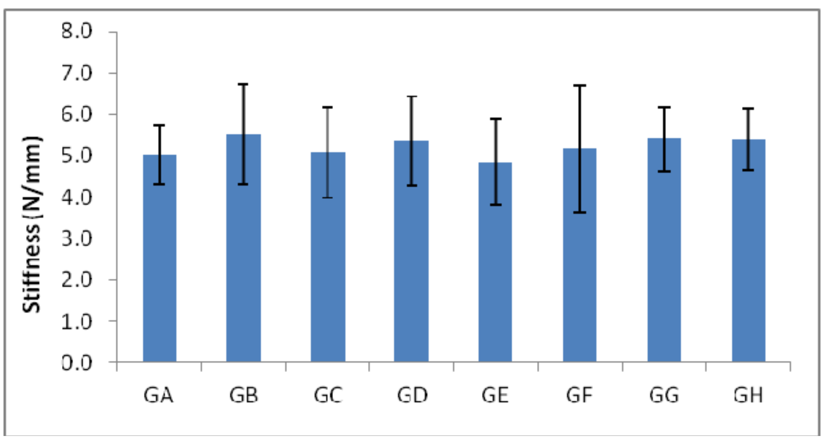

Figure 2. Means and standard deviation for stiffness (N/mm)

No statistical differences were observed in the stiffness (N/mm) for any of the variables or for the iterations (surgery: p =.853, diet: p = .657, treatment: p = .464, surgery * diet: p = .240, surgery * treatment: p = .333, diet * treatment: p = .905 and surgery * diet * treatment: p = .566).

Figure 3 present the graphs for Tenacity (N.mm), for all the experimental groups, reported as means (SD).

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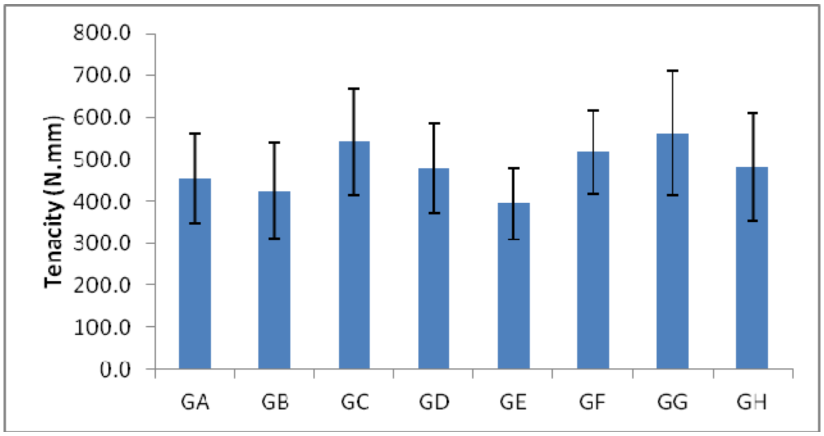

Figure 3. Means and standard deviation for tenacity (N.mm)

When evaluating the effect of treatments on tenacity (N.mm) were observed statistical differences (p = .010), with greater maximum load observed in trained animals. There were no statistical differences in tenacity for different surgeries (p = .582) and diet (p = .605). By comparing the effect of the interactions between variables was possible to observe differences in diet * treatment (p = .025), but not to surgery * diet (p = .197), surgical * treatment (p = .936) and treatment * diet * surgery (p = .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 = .001), with higher values in animals receiving high-fat diet.

4. DISCUSSION

Several studies have evaluated the influence of high fat diet on bone quality, obesity and body composition (Pinheiro *et al*., 2009, Jen *et al.*, 2003; Feoli *et al.*, 2003, Gaíva *et al.*, 2003). Reduction of ovarian hormones 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 (Vasconcellos *et al*., 2004).

However there are no studies that evaluate the influence of a high fat diet in endurance muscle after ovariectomy. The aim of this study was to evaluate the influence of high fat diet on muscle strength in ovariectomized rats. Furthermore, this study aimed to assess the influence of exercise on the mechanical property of the gastrecnemio muscle.

In a study of healthy and diabetic rats undergoing treadmill training for 89 days Mathey *et al.* (2004) evaluated the maximum load during the three points test of the femur. In this study the researchers showed that lower values of maximum load were observed for diabetic and sedentary animals. There is no difference between the other groups. In the analysis of muscle in our study it is possible to observe lower maximum load values for the sedentary groups, compared to the trained on treadmill. Thus, we believe that treadmill training brings benefits to the musculoskeletal system, with increased maximum load for the bone (Mathey *et al*., 2004) and muscle.

Unlike expected, OVX animals had higher maximum loads when compared to SHAM. We believe that ovariectomy may cause a different response in the muscle compared with that observed in the bone (Peng *et al*. 1996). As the immobilization (Jozsa *et al.*, 1990), the absence of estrogen could cause a decrease in capillary density of the muscle to increase the volume of tissue intramuscular and this feature may entail increasing the maximum force in the muscle.

When assessing the stiffness was not observed differences. This way, none of the variables was able to influence the ability of muscle deformation. Some studies report that preserve this property is very important, since this decrease might indicate that muscle stretching, and is more susceptible to injury (Jarvinem *et al.*, 1992). In study by Peng *et al*. (1996), the researchers report different intensities of treadmill training provide different percentages of bone loss.

In a study by Jozsa *et al*. (1990), the authors observed the effect of immobilization on the structure of the soleus muscle and gastrocnemius. Their findings show that the effect of immobilization is checked more quickly in the soleus muscle, by its oxidative metabolism when compared with the gastrocnemius glycolytic capacity. Thus, we believe that the characteristics of muscle gastroecnemio, this takes longer to show the effects of a sedentary lifestyle, and even the OVX stiffness.

Tenacity represents the energy absorbed to failure during the tensile test muscle. In our study, statistical differences were observed between trained and sedentary groups. We observed lower tenacity values for the sedentary animals, so we believe that treadmill training provides increased muscle's ability to resist, reducing the risk of injury.

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The effect of diet on muscle can be observed in sedentary SHAM groups in which high values were attributed to animals that received high-fat diet. As there are no reports in the literature on similar studies believe that these results may be related to a higher weight observed in OVX compared to SHAM (Hao *et al.,* 2010) and animals that received high-fat diet compared with those receiving the 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. These results corroborate the finding Milani *et al*. (2008), the authors found improvement in mechanical strength in the muscles of trained rats.

5. CONCLUSION

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

6. ACKNOWLEDGEMENTS

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8. RESPONSIBILITY NOTICE

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