Eletromyography of the rectus femoris, vastus medialis and vastus lateralis muscles in women submitted to the knee extension movement with overload

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ABSTRACT

The aim of this work was to analyze the electromyography (EMG) data of the rectus femoris (RF), vastus lateralis (VL) and vastus medialis (VM) from trained and not trained women. The women performed the knee extension movement, with maximum speed, on a romam table, model Macieira Metais, with overload of 10% of body weight (BW). The analyses were done by observing the eletromyographics registers in the angular intervals from 0 to 70º, from 0 to 35º and from 35 to 70º. It were used electromyography LYNX Tecnologia Eletrônica Ltda., electrogoniometer, and mini-electrodes with surface model Beckman. The data demonstrated that electromyographics registers and movement speed (MS) aspects were similar in the trained and not-trained groups. The averages of the electromiographics results in microvolts of the muscles RF, VL e VM were: 1) interval de 0 a 70º, GT 83.71, 82.32 e 64.45; NTG 36.26, 33.37 e 31.48; 2) interval de 0 a 35º, GT, 95.11, 85.37 e 67.82, NTG 39.60, 33.25 e 32.60; e 3) interval de 35 a 70º, GT, 48.52, 69.53 e 52.44, NTG, 25.63, 29.88 e 25. The electromyographic (EMG)registers and the movement speed (MS) in trained women were significantly higher than in not- trained women.

Keywords: electromyography, muscles, knee.

INTRODUCTION

A human being needs a minimum of total physical fitness to comply with daily-life tasks. Such performance is a result of all human characteristics that includes the body activities, since the acquisition of physical fitness, gestual communication, general abilities and the typical overcoming of sporting stress.

The performance of an athlete or even a practitioner of regualr physical activities, as state Mellerowicz & Meller (1979); Hollmann & Hettinger (1983); Leite (2000) is the sum of factors such as: physical constitution, metabolic and coordination capacity, environmental and psychosocial influences, tactic and technical abilities to the selected sport.

With advances in science and technology, evaluations in the sporting practice has shown important progress in the last decade. The health area take as parameters for physical quality those of individuals that have regular physical training in order to appoint motor activities as therapy to sedentary people, compatible with their age and sex.

Human beings when adopting physical activity or competitive sporting practice need a systematic program to evaluate their evolution and responses from their organisms regarding the selected actions.

Mcardle, Katch & Katch (1992) state that electromyography (EMG) is able to study the complexity of muscle neurophisiology during various sorts of contraction. Literature shows that EMG may analyze both the quality and quantity of electric activity generated by muscles.

The analyzes of EMG is related to the rate of force that the muscle produces to overcome resistance. Gonçalves & Cerqueira (2000) have analyzed the electromyographic activity of the *rectus femoris* in individuals while elevating some load form the ground in the following postures: a) extended knees and trunk ; b) extended knees and flexed trunk. The authors concluded that this muscle participates in the stabilization of the knee joint in both postures since the electromyographic activities were more intense in the groups of the erector of the spine , *biceps femori* and abdominals.

Some studies have demonstrated that not always the increase in muscular strength is related to an increase of the cross-section. Ikai & Fukunaga (1970) have demonstrated in their studies on training, that initially there is an increase in the inervation and just after a long period of activity there appears the hypertrophy. Leong et al. (1999) have studied athletes in bodybuilding in the ages of 65 to 71 years, both trained and not trained, while practicing knee extension. Comparing both groups, they concluded that trained athletes showed a greater capacity of recruiting motor units and greater tension while using 50% and 100% of the maximum voluntary contraction (MVC).

In this connection this study aims to understand the electromyopgraphic responses of the *rectus femoris* (RC), *vastus lateralis* (VL) and *vastus medialis* (VM) of trained and non-trained women submitted to knee extension in the extensor table (roman table) with 10% of body weight.

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MATERIAL AND METHODS

1. Studied population

This study analyzed 21 women divided in two groups, trained and non-trained. The trained group (TG) was constituted by 10 athletes of the Brazillian Basketball Team which were under technical and physical training for specific high performance. This group was intentionally selected. The non-trained group (NTG) was constituted by 11 volunteer and sedentary women with no habit for systematic physical activity (TABELA 1).

All procedures of the study were fully explained to the participants, which accepted the conditions.

TABLE 1 - Mean and standard deviation of anthropometric variables for the trained and non-trained groups

Variables	Trained	Non-trained
Age	25.10 ± 4.33	22.00 ± 4.77
Height	180.20 ± 4.44	166.22 ± 8.43
Weight	70.41 ± 11.31	67.52 ± 6.45

2- Equipment used

2.1. Electromyograph LYNX[1] connected to a PC/AT with an model CAD10/26 AD conversion board and specific software for acquisition and analysis of signals. The equipment was calibrated to catch signals with amplitude of 500 microvolts.

2.2. Electro goniometer[2] with a potentiometer of 4k 7lin 011volts connected to the roman table by means of two shafts, being one attached to the mobile part and the other to the superior extremity of the roman table in a base without mobility. The electrogoniometer was adjusted to continuous register in a standard amplitude of 0 to 120 degrees.

2.3. Roman table (Macieira Metais) with a mobile arm with angular amplitude of 120°. In the mobile arm there was a support for the accommodation of overloads adjustable to the length of the leg. The height of the support in the leg of participants was 8cm above the lateral maleolus. The seat place was also adjustable in order to make the knee rotation center coincident with the center of the electrogoniometer and with the axis of movement of the roman table.

2.4. Surface minielectrods (Beckman).

3. Methodology

The study was based in the register of:

1. LYNX Tecnologia Eletrônica Ltda. Donated bya FUNDUNESP (proc. 076/90/DFP/F/CBS e 384/90-DPE to the Laboratory of Electromiography of the Department of Physical Education, UNESP Campus of Rio Claro)

2. This equiment was made at the Center for Biomedic Engeenering (CEB) - UNICAMP

1. electromyographic activity of *rectus femoris* (RC), *vastus lateralis* (VL) and *vastus medialis* (VM), with surface minielectrods type Beckman and positioned according to the technique reported by Delagi et al. (1975);

2. Maximum movement velocity (MV) for knee extension of the right leg. The volunteers were seated with the thigh stabilized by means of a nylon strip to prevent displacement at the end of extension.

Testes were standardized according to the following steps:

a) movement with maximum velocity and overload of 10% of the body weight (BW);

b) movements were repeated thrice and the mean was calculated at the end.

4- Procedures for the analyzes

The study was conducted taking into consideration the maximum velocity of extension of the right knee recorded in milliseconds by the software for acquisition of electromyopraphic signals in three angular intervals with 10% of the body weight. The standardization from 0° to 70° started with seated position and knee bent at 90°. Angles and intervals were as follows:

a) complete movement, angle ranging from 0° to 70° (MT10% 0-70º);
b) movement from 0° to 35° (ML10% 0-35º);
c) movement from 35° to 70° (ML10% 35 -70º).

5. Statistical treatment

For the study of the variables: 1) electromyographic record of the *rectus femoris* (RC), *vastus lateralis* (VL) and *vastus medialis* (VM); 2) velocity of movement with 10% of body weight in the group of trained (TG) and non-trained women (NTG) it was calculated the descriptive values for position (mean) and variability (standard deviation). The comparison of these two groups were made with the test t of Student for two independent samples (Vieira 1991).

Conclusions in this study were drawn at a level of 5% of significance.

RESULTS

The electromyographic patter of the studied muscles and the velocity of movements with overload of 10% of the body weight, in both groups, were similar.

The statistical analyzes of means comparing trained and non-trained women revealed a significant difference of electromyographic activity between the groups. It was possible to verify in all variables that results for trained women were more intense than those for non-trained women.

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TABLE 2 - Mean and standard deviation for results of the statistical test for comparison between groups of the rectus femori (RC), vastus lateralis (VL) and vastus medialis (VM) in the angular intervals of 0 to70º, 0 to 35º, 35 to70º with 10% overload body weight (BW)

Variable		Groups		Resullt of the statistical test
		Trained	Non-trained	
	MT10% 0-70º	83.71 ± 33.31	36.26 ± 16.88	t= 4.18 (p<0.01)
RC	M10% 0-35º	95.11 ± 38.57	39.60 ± 21.21	t= 4.14 (p<0.01)
	M10% 35-70º	48.52 ± 27.49	25.63 ± 15.44	t= 2.38 (p<0.05)
	MT10% 0-70º	82.32 ± 40.14	33.37 ± 8.14	t= 3.97 (p<0.01)
VL	M10% 0-35º	85.37 ± 41.95	33.25 ± 10.03	t= 4.01 (p<0.01)
	M10% 35-70º	69.53 ± 45.98	29.88 ± 12.41	t= 2.76 (p<0.01)
	MT10% 0-70º	64.45 ± 23.06	31.48 ± 16.94	t= 3.76 (p<0.01)
VM	M10% 0-35º	67.82 ± 25.30	32.60 ± 20.85	t= 3.49 (p<0.01)
	M10% 35-70º	52.44 ± 28.69	25.68 ± 14.79	t= 2.73 (p<0.01)

In the knee movement, with maximum velocity and overload of 10% of the body weight, the trained group (TG) presented higher speed than the non-trained group (NTG) in the three given intervals. Results for TG showed significant differences if compared to those of the NTG (TABLE 3).

TABLE 3 - Mean and standard deviation for the velocity of movement in milliseconds in the angular intervals of 0 to70º, 0 to 35º, 35 to70º with 10% overload body weight (BW) and result of the statistical test for comparison among groups.

Variable	Groups		Result of the statistical test
	Trained	Non-trained	
VMT10%PC-0-70º	216.675 ± 24.950	264.244 ± 31.502	t= 3.81 (p<0.01)
VM-10% PC-0-35º	140.775 ± 17.607	169.175 ± 18.653	t= 3.58 (p<0.01)
VM-10%PC35-70º	75.900 ± 8.161	95.069 ± 14.896	t= 3.60 (p<0.01)

VMT-10% 0-70º - Velocity of complete movement in angle of 0° to 70°
VM- 10% 0-35º - Velocity of movement in the angel interval of 0° to 35°
VM- 10% 35-35º - Velocity of movement in the angel interval of 35° to 70°

The electromyographic results for movement with 10% of body weight, analyzed in the angle interval of MT10% 0-70º, demonstrate the RC and VL more active than the VM. The pattern of the action potential of muscles has shown similar characteristics in both groups.

In the TG the percentage of variation of the electromyographic for RC in relation to the VL was 1.66% superior and in relation to the VM it was 23.00% more intense. The action of the VL in the angular interval was 21.76% more active than the VM. In the NTG the *rectus femoris* was more active with a percentage variation of 13.18%. On the other hand the percentage variation among the RC *versus* VL and the VL *versus* VM was circa 7% (TABLE 4).

Observing the results in the angular interval M10% 0-35º the RC in the trained group (TG) continued to preset strong electromyographical activity being, in percentage, 10.24% superior in relation to VL and 28.69 in relation to VM. In this angular interval the VL was 20.55% more active than the VM.

Analyzing the NTG the muscular activities, concerning the participation profile, was similar to the TG, that is, the *rectus femori* was 16.03% more active than the *vastus lateralis* and 17.67% in regards the *vastus medialis*. The *vastus lateralis* was 1.95% superior to the *vastus medialis* (TABLE 4).

In the last phase of the movement, that is, M10% 35-70°, results for muscle potentials showed different values as compared to the previously analyzed intervals.

In the TG, for the angular interval M10% 35-70º, the RC showed diminished electromyographic potential in 43.30% in relation to the VL and 8.07% in relation to the VM. Analyzing the action of the VL it was noted that it has maintained more activity that the VM in 24.57%. In the NTG the electromyographic record for the RC wasi 16.58% smaller than that of the VL and 0.19% in comparison to the VM. Observing the VL it was noted that, in percentage, it was 14.05% superior to VM (TABLE 4).

TABLE 4 - Percentage difference of electromyographic records (EMG) in microvolts for mucles rectus femori (RC), vastus lateralis (VL) and vastus medialis (VM) in the movement with overload of 10% of the body weight in the angular intervals MT10% 0-70º, M10% 0-35º e M10% 35-70º in the trained and non-trained groups.

Variables	Groups			
	Trained		Non-trained	
	Diff. EMG	%	Diff. EMG	%
MT10% 0-70º				
RC x VL	1.39	1.66	2.89	7.97
RC x VM	19.26	23.00	4.78	13.18
VL x VM	17.87	21.76	1.89	5.66
M 10% 0-35º				
RC x VL	9.74	10.24	6.35	16.03
RC x VM	27.29	28.69	7.00	17.67
VL x VM	17.55	20.55	0.65	1.95
M 10% 35-70º				
RC x VL	-21.01	-43.30	-4.25	-16.58
RC x VM	-3.92	-8.07	-0.05	-0.19
VL x VM	17.09	24.57	4.20	14.05

DISCUSSION

In the present study it was possible to observe the synchronization of muscles RC, VL and VM during knee extension. Being this extension the one directly responsible by the performance of the proposed movement, it will be discussed the electromyographical profile of the studied muscles in three routes as well as the velocity of the knee extension movement.

In the interval MT10%0-70º the *rectus femori, vastus lateralis* and *vastus medialis* showed an increase in the electromyographic activity although some minor percentual difference was noted between the *rectus femoris* and *vastus lateralis.* With *vastus lateralis* it was possible to observe a greater actuation as regards the *vastus medialis,* although the latter has also showed some increased activity. These findings are similar to those reported by Cintra & Furlani (1981) studying the *rectus femoris* and *vastus medialis* submitted to resistance and high velocity. On the other hand, the *vastus lateralis*, in the present study, showed an effective participation which did not occur in the study by the mentioned authors. Such difference could be explained by the methodology employed that consisted in fixation of the overload in the form of a shoe directly in the foot of the participant. Differently, in the present study the overload was moved by pushing the shaft that was in contact with the anterior aspect of the tibia.

Santos & Avela (1991) reported increase in the electromyographical activity in the *rectus femoris* when 10% of the body weight was added during vertical jump. The same behavior was observed to the *rectus femoris* in the present study when 10% of body weight was added. Bosco & Viitasalo (1982), while studying individuals practicing vertical jump of various heights, observed that during concentric contraction there were more participation of *vastus medialis* in comparison to *rectus femoris* and *vastus lateralis.* These authors have confirmed the efficient participation of the *quadriceps femoris* in explosive activities. Therefore, the results of this study to the *rectus femoris* in relation to the *vastus medialis* are not coincident as those found in the work of the latter authors. The lack of similarity may be due to the employed methodology. In the present study the methodology included pushing the overload while seated and in the work of the mentioned authors, this occurred after the rest of the foot in the ground in continuity to the vertical jump.

In the angular interval M10%0-35º the difference for the *rectus femoris* in relation to the *vastus lateralis* was 10.24% superior being, however, 9% greater than that of the angular interval MT10%0-70º. In comparison to the *vastus medialis,* the *rectus femoris* was 28.69% more active. In the other hand, the difference between *vastus lateralis* and the *vastus medialis* has decreased to 20.55%. The greater electromyographical activation was viewed in his angular interval with overload of 10% of the body weight. This observation is in accordance to Bobbert & Harlaar (1993) that reported, in their studies on activity with overload, that such occurrence in due to the an increased neural activation as regards the elastic component of the muscles.

At the end of the movement, that is, in the interval M10% 35-70º , it was observed an increase in the electromyographical activity for *vastus lateralis* and *vastus medialis* in regards the *rectus femoris*, showing the *vastus lateralis* circa 43.30% more activity and the *vastus medialis* 8.07%. The same was observed for the non-trained women although the percentage for differences was smaller, that is, for the *vastus medialis* was 16.58% more active than the *rectus femoris* and the v*astus medialis* 0.19% superior to the latter.

The differences of potentials between athletes and non-athletes, as observed in the present study, may be explained by the ability of neuromusclar mobilization. Weineck (1991) reports that in maximum muscle tension the synchronization of the activity of the motor units has an important role to play. He also states that non-trained persons present more than 20% of the total of motor units that are not synchronized during exercise with overload. On the other hand, for trained persons, less than 10% of the total are not synchronized. This may clarify the reason for the pattern of the electrical potential of the trained group to be more intense than that of the non-trained group.

The *vastus lateralis* and the *vastus medialis* showed decreasing of activity in the final interval of the angular amplitude. However, if compared to the initial interval, this decreasing was not important, which demonstrates that these two muscles are adapted to effectively work in the greatest possible trajectory of knee extension. Works by Basmajian & De Luca (1985), Monteiro Pedro & Vitti (1989), Bobbert & Harlaar (1993) have already explained this behavior. Results in the present study, supported by the above mentioned authors, indicate the influence of angulation of the knee in the activity of the *vastus* muscles. Mcardle, Katck & Katch (1992) admit that the first explosion of the agonist create the propelling force capable of starting movement at the limb with high speed. However, the antagonists in the posterior aspect of the thigh tend to participate restraining such speed next to the final point of the amplitude of movement. Results reported in this study confirm this fact. However, as the studied movement was observed between 0º and 70º and not the maximal amplitude of the extension of the knee, this fact was understood by means of the activity of the *rectus femori* taking into consideration its high participation in the beginning of the movement and marked diminution at 70° established as final. Banjkoff; Moraes & Pellegrinotti et al. (2000) reported a low electromyographical participation of the *rectus femori* in the kicking movement when the amplitude of this action was greater than 90°. It is possible that this action aims to protect the knee since Van Eijdem et al. (1987) state that the quadriceps press the patela against the femoral condile while the knee is close to its maximum extension (180°). These authors clarify that in this amplitude that quadriceps muscle shows less strength.

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CONCLUSION

It was possible to conclude:

1. The electromyographical activity of the msucle *rectus femori* (RF), *vastus lateralis* (VL) and *vastus medialis* (VM) of the trained women was significantly more intense than in the non-trained women.

2. Electromyographical data of muscles in all angle intervals (0-70º, 0-35º and 35-70º), with overload (10% BW), allowed the conclusion that the *rectus femori* (RF) has a strong action during the initial degrees of the extension movement of the knee as regards the *vastus lateralis* (VL) and *vastus medialis* (VM).

3. The *vastus lateralis* (VL) and the *vastus medialis* (VM) has participation in the extension of the knee since its initial steps. However, from 35°and on, wtih overload (10% of the body weight), the participation of both *vastus* (VL and VM) is greater in regards the *rectus femori* (RF).

4. The muscles *vastus lateralis* (VL) and *vastus medialis* (VM) showed diminution of their activity in the 35-70º interval when compared to the 0-70º and 0-35º interval.

5. The velocity of movement (Vm) of knee extension in the three intervals (0-70º, 0-35º and 35-70º), with overload of 10% of the body weight, was significantly faster in trained women than in non-trained women, demonstrating a superior performance of those women undergoing physical training.

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