ELECTROMYOGRAPHIC ACTIVITY OF THE *Bicceps brachii* AND *Brachiorradialis* MUSCLES UNDER INFLUENCE OF STATIC STRETCHING AFTER EXHAUSTIVE EXERCISES

ATIVIDADE ELETROMIOGRÁFICA DOS MÚSCULOS Biceps brachii E Brachiorradialis SOB INFLUÊNCIA DE ALONGAMENTO ESTÁTICO APÓS EXERCÍCOS EXAUSTIVOS

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ABSTRACT: The aim of this work was to study the electric activity of the motor unit action potential of the *biceps brachii* and *brachiorradialis* muscles produced just after exhaustive exercise of forearm flexion, considering the influence of static stretching on this activity. Ten volunteers performed a series of exhaustive exercises with 80% maximum voluntary load using a double-pulley apparatus. The subjects were divided in experimental group that performed static stretching post-exercise and control group that did not perform any stretching. Electromyographic signals were captured by surface electrodes and recorded using a computerized electromyograph and an acquisition system of data (Alc-EMG). Statistically significant differences were not found for the electric activity of the studied muscles, with or without stretching post-exercise. The results suggest that once the effort stimulus to the muscle ceases, its electric activity returns at levels similar to resting position, with or without stretching. Thus, the muscular electric activity seems be not influenced by the static stretching following exhaustive exercise.

UNITERMS: Electromyography, Uper limb muscles, Sretching, Ehaustive exercises.

INTRODUCTION

The electric activity that emanates of the muscle provides not only responses with regards to muscular function but also is able of supplying the degree of muscular tension through the action potential of the muscle. Accordingly, the electromyography is likely the most relevant method for researchers interested in measuring the muscular tension through the muscle action potential (ALTER, 1999).

A number of electromyographic studies (STEWART et al., 1981; BASMAJIAN; DE LUCA, 1985; BUCHANAN et al., 1986; MOJICA et al., 1988; BOMPA et al., 1990; CALDWELL; LEEMPUTTE, 1991; PÉROT et al., 1996; SOUSA et al., 2000) have been specifically correlated to functional analysis of the muscles that act on the forearm flexion. Nevertheless, some studies (DE VRIES, 1961, 1966; McGLYNN et al., 1979; JONES et al., 1987; LUND et al., 1991) have correlated the flexor muscles of the forearm to the degree of muscular tension post-exercise. Among these latter, divergent results are found with regards to electromyographic response of the muscle during the recovery, being considered as the main factor of divergence the degree of action potential generated by its motor units when using static stretching during the pause of the muscular work.

De Vries (1961, 1966) and McGlynn et al. (1979) observed that an increase of the degree of muscular tension caused by an enhanced degree of activity of motor units occurs after the muscular exercise and that the static stretching promotes the reduction of this electric activity and consequently induces to a better muscular recovery and significant diminution of the pain post-exercise.

Other studies (JONES et al., 1987; LUND et al., 1991) demonstrated that in the injured muscle due to the exercise, its electric activity is diminished during the recovery even without the use of stretching.

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The aim of this work was to study the degree of electric activity of the action potential of motor units of the *biceps brachii* and *brachiorradialis* muscles generated just after exhaustive exercise of forearm flexion in concentric and eccentric phases through electromyography, considering the influence of the static muscular stretching on this electric activity.

MATERIAL AND METHODS

1. Volunteers

This study was carried out in 10 male volunteers (age: 18-25 years old) selected among the students of the Institute of Biomedical Sciences of the Federal University of Uberlândia, to evaluate the electromyographic activity of the *biceps brachii* and *brachiorradialis* muscles in forearm flexion movements. The subjects were divided into 2 groups (experimental and control), containing 5 individuals per group, and received instructions about the exercises to be performed and signed a consent term agreeing with their participation in the study.

2. Electromyography

The electromyographic signals were recorded using a computerized electromyograph developed in the Biomedical Engineer Laboratory, Electric Engineer Faculty, Federal University of Uberlândia, Brazil, with the following characteristics: simultaneous acquisition of up to 8 differential channels with 10 GΩ input impedance, 93 dB at 60 Hz CMRR (common mode rejection ratio), ground electrode common to all channels, filters set at 20 Hz (low pass) and 5 kHz (high pass), and three amplification stages - the first supplying gains of 1, 2 or 5 times, the second gains of 82, 10, 22, or 39 times, and the third 10, 100 or 1000 times – thus making possible a gain of at least 100 times and at most 4960 times. In addition, the system possesses optical isolation – 1.5 KV (RMS) at 60 Hz – between the electronic circuit and the stage that is in contact with the volunteer. The gel-anointed ground electrode was used to eliminate external interferences to the electromyographic signs.

Signals were captured using differential surface electrodes with 4.75 mm in diameter. The detection surface was standardized at 2.5 mm in diameter and the distance between the electrodes was 2 cm. An acquisition system of data (Alc EMG) was used to quantify the electromyographic sign amplitude, transforming the action potential in the root mean square (RMS), expressed in microvolts (μV), thus representing the best parameter to evaluate the variables of the electromyographic sign, according to Basmajian; De Luca (1985).

3. Procedures and Exercises

The movements were performed using a double-pulley apparatus (Vitally - Indústria de Aparelhos para Ginástica Ltda, São José do Rio Preto, SP, Brazil) designed for muscular exercises of the upper and lower members. The volunteers were sat down in the bank coupled to the apparatus with the erect trunk and the feet supported in the soil.

Initially, the subjects of both groups performed the exercises to accustom with them, thus avoiding possible failures during the experimental test. Then, tests for evaluating the maximum voluntary load (MVL) were done and consisted of complete forearm flexion movements of the dominant member (concentric and eccentric phases), beginning with load of 15 kg with increasing loads of 2 kg for each series of exercises, in 3 replications, up to reach the overload, in which the volunteer did not get anymore to support the resistance. Thus, the immediately previous load was considered as being its MVL.

The skin where the electrodes were to be placed was then shaved and cleaned with an ether/alcohol solution to remove superficial fat and any other substance that eventually could interfere in the results. Specific maneuvers of maximum voluntary contraction were done to guarantee the exact location of the muscles.

The first captured electromyographic signs were obtained from the muscles in resting position. The volunteers of the control group performed a series of exercises involving complete forearm flexion movements during 6 sec (3 sec for concentric phase and 3 sec for eccentric phase) with 80% of MVL until exhaustion, that is, when the volunteer was unable to accomplish the complete cycle. After reaching the exhaustion, a rest of 2 min was given and the electromyographic sign of the *biceps brachii* and *brachiorradialis* muscles was collected.

The same procedure was applied to the experimental group, except for the resting period, when the volunteers performed a static stretching of the exercised musculature during 30 sec, then a rest of 1 min, and again the stretching for more 30 sec. Next, the electromyographic signs were captured as described for the control group.

4. Statistical analysis

Since the distribution of data was non-Gaussian as determined by the variance analysis for normality (SHAPIRO; WILK, 1965), the results were analyzed using non-parametric methods. The differences in the RMS values obtained in resting and post-exercise conditions between the experimental and control groups were analyzed by the Mann-Whitney "U" test (SIEGEL, 1975). Comparisons between the RMS values obtained in resting and post-exercise conditions in both groups were analyzed by the Wilcoxon test (SIEGEL, 1975). A significance level of $P < 0.05$ was chosen.

RESULTS AND DISCUSSION

Table 1 shows the RMS values of the electromyographic activity obtained from the biceps brachii and brachiorradialis muscles in resting condition and after 2 min of exhaustive exercises of forearm flexion with 80% MVL without using the stretching. In the volunteers 1 and 5, an increase of RMS values obtained from the biceps brachii and brachiorradialis muscles was observed after the effort, but this was not statistically significant (P = 0.6015 and P = 0.4647, respectively). This increased electric activity might have been captured during a muscle contraction in the resting position. On the other hand, in the volunteer 4, a decrease on the electric activity of the biceps brachii muscle was observed after the induced effort, probably due to either a fatigue of a higher number of motor units or a muscle contraction performed by the volunteer during the resting period.

The values of the electromyographic activity of the *biceps brachii* and *brachiorradialis* muscles obtained in resting position and after 2 min of exhaustive exercise of forearm flexion with 80% MVL, using static stretching of the referred muscles, are demonstrated in Table 2. An increase of RMS values of the *biceps brachii* (volunteers 8, 9, and 10) and *brachiorradialis (*volunteer 10) muscles was observed, but this was not statistically significant ($P = 0.7540$ and $P = 0.8340$, respectively).

Our results are disagreeing with the findings of De Vries (1961, 1966) when studying on the theory of muscular spasm to justify the muscular pain post-exercise, who found a significant increased electric activity in the period of muscle recovery post-effort and significant decreased electric activity of the studied muscles when using static stretching during the muscular recovery. Similar results were also found by McGlynn et al. (1979) who investigated the effect of static stretching in the period of recovery post-exercise, observing a decreased muscular electric activity with the use of static stretching.

These divergent results can be related to the adopted methodology, since both above mentioned authors captured the muscular electric activity after 24 hours of execution of the exercise, time in which the muscular pain appeared. According to the same authors, the pain induced to an increase of the muscular electric activity, which in turn, was decreased with the use of static stretching.

On the other hand, previous studies (JONES et al., 1987; LUND et al., 1991) have shown that there is no any increase of the muscular electric activity in the recovery period after effort, therefore it would not be necessary the use of some stretching type with the purpose of decreasing the muscular electric activity. Thus, these studies are agreeing with our findings since no significant difference was found between the electric activity of the studied muscles in resting and after exhaustive exercise, whether with or without the use of static stretching. As demonstrated in table 3, there was not a pattern of significant decrease of the electric activity of the studied muscles, confirming that the static stretching does not have any influence on the level of the muscular electric activity.

Our results are consistent with the muscle physiology (POWERS; HOWLEY, 2000) since the accentuated electric activity is generated when the muscle is under some stimulation, taking it to develop certain degree of tension. Considering that after stopping of the stimuli, consequently it also occurs a fall of the muscle tension, a high electric activity of the muscle in resting would not be generated. This can also be justified by the fact that the number of recruited motor units is smaller when the muscle is not developing a significant tension as compared to a concentric, eccentric or isometric developing work.

CONCLUSION

Taken together, it can be concluded that once the stimulus of the effort to the muscle ceases, its electric activity returns at levels similar to resting position, with or without the use of stretching. Thus, the stretching has shown to be an efficient approach during the muscular recovery, but without any influence on the muscular electric activity.

RESUMO: O objetivo deste trabalho foi estudar a atividade elétrica do potencial de ação das unidades motoras dos músculos *biceps brachii* e *brachiorradialis* produzidos logo após exercício exaustivo de flexão do antebraço, considerando a influência do alongamento estático sobre esta atividade. Dez voluntários realizaram uma série de exercícios exaustivos com 80% da carga voluntária máxima usando um aparelho de polia dupla. Os indivíduos foram divididos em grupo experimental que realizaram alongamento estático pós-exercício e grupo controle que não realizaram qualquer alongamento. Sinais eletromiográficos foram capturados por eletrodos de superfície e registrados usando um eletromiógrafo computadorizado e um sistema de aquisição de dados (Alc-EMG). Diferenças estatisticamente significantes não foram encontradas para a atividade elétrica dos músculos estudados, com ou sem alongamento pós-exercício. Os resultados sugerem que uma vez que o estímulo do esforço para o músculo cessa, sua atividade elétrica retorna a níveis similares à posição de repouso, com ou sem alongamento. Assim, a atividade elétrica muscular parece não ser influenciada pelo alongamento estático após exercício exaustivo.

UNITERMOS: Eletromiografia, Músculos do Membro Superior, Alongamento, Exercícios Exaustivos.

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Table 1. Electromyographic activity (RMS) of the *biceps brachii* and *brachiorradialis* muscles in resting and post-exercise conditions without stretching in volunteers of the control group.

Volunteer	*RMS (V)*			
	Bíceps brachii		Brachiorradialis	
	Resting	Post-exercise	Resting	Post-exercise
1	22	35	33	36
2	46	40	49	45
3	20	21	19	20
4	37	23	16	14
5	29	34	29	62

Table 2. Electromyographic activity (RMS) of the *biceps brachii* and *brachiorradialis* muscles in resting and post-exercise conditions with stretching in volunteers of the experimental group.

Volunteer	*RMS (V)*			
	Bíceps brachii		Brachiorradialis	
	Resting	Post-exercise	Resting	Post-exercise
6	19	18	32	28
7	17	19	16	11
8	34	95	26	13
9	49	61	20	21
10	31	47	45	85

Table 3. Probability values obtained using the Wilcoxon test in the comparison between RMS values in resting and post-exercise conditions for the *biceps brachii* and *brachiorradialis* muscles in both groups (experimental and control).

Muscles	Group	*P* values
Biceps brachii	Control	0.8972
Brachiorradialis	Control	0.6858
Biceps brachii	Experimental	0.0796
Brachiorradialis	Experimental	0.6858