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Research Article

RMS-sEMG AS A TOOL TO ANALYSE THE PERFORMANCE IN ISOMETRIC CONTRACTION

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ABSTRACT

The aim of this study is to investigate the behavior of depolarization of motor units in isometric contractions, according to the angles of the joint range of motion in the exercise of elbow flexion in Scott bench. This study consisted of 20 male volunteers with a mean age of 22.5 ± 3.5 years, no diagnosis of musculoskeletal diseases and physically active. We analyzed the values of electromyographic and isometric torque in external angles of 30°, 45°, 60° and 90°. Each subject performed using a repetition maximum strength for each range of motion for 10 seconds. The result of this study showed that the 90° angle isometric had a greater and greater depolarization of the motor units compared to most studied ranges of motion, thus making this position support a greater load imposed on the segment by a longer period of time.

INTRODUCTION

In human movement, strength is achieved through muscle contraction. For this to occur it is necessary that contraction depolarization occurs motor units until its threshold, as a result, takes place muscle contraction. This depolarization will depend on the size of the stimulus applied (1).

The muscle contractions can be classified as dynamic (concentric and eccentric) and isometric. A concentric contraction is performed when the applied force is somewhat larger than the external resistance occurs and the shortening of the muscles involved. The eccentric, the applied force is smaller than the external resistance and is used in the slowdown of the movement, as the isometric contraction is used as a lift where there is no difference in the length of the working muscle (2).

These contractions depend inter alia on the distance of application of the external force, called the torque or moment of force. The torque or moment of force can be defined as the fraction of the force applied to an object that is actually used to make it spin around an axis or center point, known as pivot point or pivot point (3).

The method that is being widely used for the study of these contractions is electromyography, which is a technique that evaluates the electrical discharges that occur in excitable membranes, thus showing each action potential. This in itself results from the change in membrane potential that exists between the internal and external environment of células4. From the moment that the EMG signal is collected it needs to be quantified for further analysis, quantification of this signal can be performed in the frequency domain or the time domain, in this case the measurement can be made by the Root Mean Square (RMS) and by Integral (IEMG) (4).

It is known that the magnitude of the EMG signal increases relative to the force during isometric contractions (5,6). Therefore when the maximum torque is also expected a greater depolarization of the motor units involved in the movement.

However Azevedo *et al* (7) reported that electromyographic signals do not have a directly proportional relationship with the external torque, because through their study that showed that even when the muscle begins to decrease the run strength, and hence the torque produced in a certain range of motion, electromyographic signal kept increasing.

Among the various resistance exercises torque is a primary variable in strength training. According to Santos, Silva and

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Loss (8), the joint angle can reveal the moment of maximum torque exerted on the proposed exercise, i.e., the period to which the individual will be performing the greatest strength to finish the movement.

The movement of elbow flexion is of extreme importance to human autonomy, as are movements needed to perform all daily activities as well as movements performed in several sports.

Thus the aim of this work was to examine the behavior of depolarization of motor units during isometric contractions, according to the angles of the joint range of motion in the exercise of elbow flexion on the bench Scott.

MATERIAL AND METHODS

This study consisted of 20 male participants with a mean age of 22.5 ± 3.5 years, no diagnosis of musculoskeletal diseases and physically active, according to American College of Sports Medicine (9). This sample was calculated by linear correlation sample (Statistica 6.0) testing a significance of $p < 0.05$.

To maintain the similarity between the participants was measured body mass (anthropometric scale, Filizola), height (stadiometer Wiso) and skinfold thickness (caliper, Cescorf) protocol Polock (10).

The exercise performed in this study was the elbow flexion at Banco Scott. The place used to carry out the collection was the Laboratory of Biomechanics and Kinesiology and Exercise Laboratory of Resisted the Sports Center of the Federal University of Ouro Preto.

For standardization of the execution of the movement, the individual sat in the Bank Machine Scott, in a way that his feet were flat on the ground, the trunk slightly bent forward, and the shoulder (approximately 60º flexion), in a way that the chest touches the bench Scott and get comfortable. Parallel arms resting on the bench Scott, hands in supination without locking the elbows.

The values of the electromyographic signals and isometric external torque at angles of 30º, 45º, 60º and 90º were analyzed. Each subject performed using a repetition maximum strength for each range of motion for 10 seconds. The results of three angles were collected on the first day and two on the second randomly in each individual, respecting the recovery time of five minutes between the angles and the 48 hours between collection days.

To capture the surface electromyographic signals (sEMG) electrodes surface (MedTrace) with silver coating were used - silver chloride (Ag / AgCl), respecting the distance between electrodes (center-center) 10mm, which were positioned about *biceps brachii* and *brachioradialis* muscles as recommended by the Surface Electromyography for the Non-Invasive assesment of Muscle.

To reduce possible interferences in the passage of electrical stimulation was performed prior to placing the electrodes, shaving and cleaning the skin with alcohol, the level of the muscle studied. The reference electrode was placed on the patella.

To obtain the surface electromyographic signals used a (EMG System, Brazil) acquisition module biological signals from eight (08) calibrated channels with a gain of 1000 times, with a high pass filter to 10Hz and 500Hz low-pass with a sampling frequency of 2000Hz and common module rejection of 120dB. For the record of maximum voluntary isometric contraction (MVIC) used a load cell (EMG System, Brazil), with a capacity of two thousand Newton (2000N), positioned perpendicular to the direction of the mechanical axis (tensile strength).

After it was done the digital processing of the sEMG data that provided the RMS (root mean square) of each record obtained during exercise, as well as analysis of the fast Fourier transform (FFT). The digital signal processing were made using MatLab®.

RESULTS

The relative values of the external torque at angles of 30º, 45º, 60º and 90º in the initial, middle and final fragments show an increasing behavior of the moment of force (Figure 1) where the initial fragments, middle and end in angles 30º showed significant differences ($p \leq 0.05$) compared to other angle and their fragments.

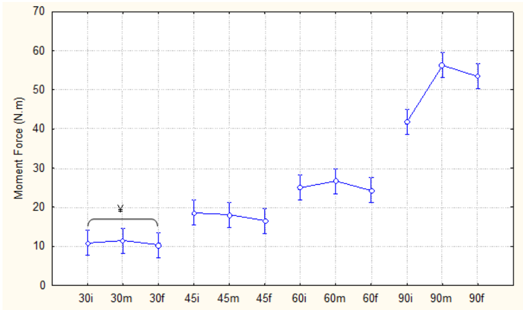

Fig 1 Values of the relative torque (Moment Force) in Newton meters (Nm) of isometric pulls fragments in the initial (i), medium (m) and final (f) the angles of 30º, 45º, 60º and 90º of external torque isometric (¥: $p \leq 0.05$ compared to the other moments of force).

Figure 2 shows the values of the brachial biceps long head of the angles 30º, 45º, 60º and 90º where the value of 30i has significant difference compared to 45i.

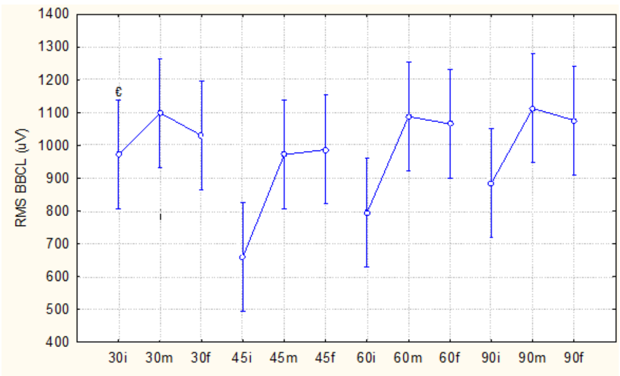

Fig 2 Values of the root mean square (RMS) in microvolts (uV) of the brachial biceps long head (BBCL) fragments in the initial (i), medium (m) and final (f) at angles of 30º, 45º, 60º and 90º isometric external torque. €: $p \leq 0.05$ compared to 45i.

Analyzing the RMS values of the biceps brachii short head (Figure 3) there is a significant difference ($p \leq 0.05$) in the 45m compared to 90m and 45f values compared to the values of 90f.

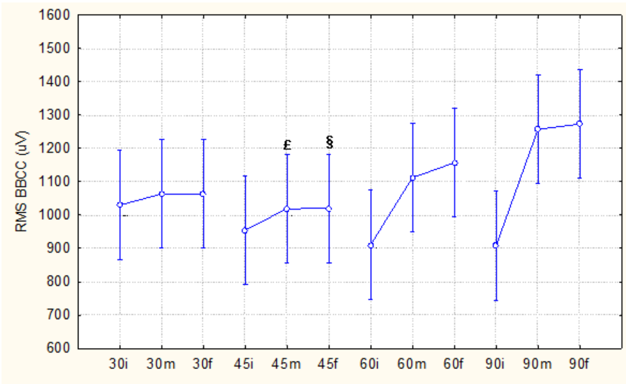

Fig 3 Values of the root mean square (RMS) in microvolts (uV) of the brachial biceps short head (BBCC) in the initial fragments (i), medium (m) and final (f) the angles of 30º, 45º, 60º and 90º isometric external torque. £: p ≤ 0.05 compared to 90m; §: p ≤ 0.05 compared to 90f.

The RMS values of the brachioradialis muscle showed no significant difference from those angles and fractions (Figure 4).

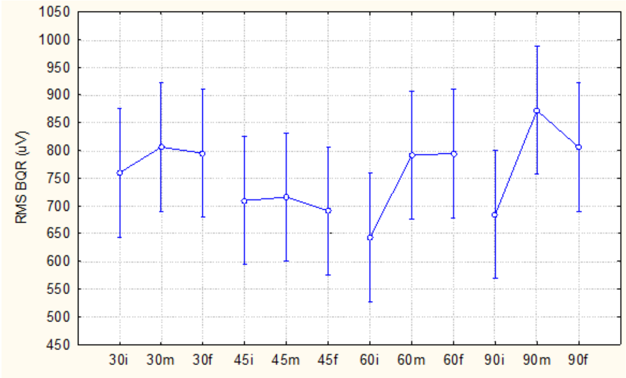

Fig 4 Values of the root mean square (RMS) in microvolts (uV) of the brachioradialis muscle (BQR) fragments in the initial (i), medium (m) and final (f) at angles of 30º, 45º, 60º and 90º isometric external torque.

DISCUSSION

For data analysis, an initial, middle and end of the EMG signal incision was made. The first piece was cut from 25 to 35% and the central and end sections were cut into 55-65% and 85-95%, respectively.

When comparing the results of torque at 30º, 45º, 60º and 90º, as shown in (Figure 1), the torque value takes on a character directly proportional to the angles, it results from this study demonstrated that in a bending Scott elbow on the bench, the range of motion at 90º has a value greater isometric torque, thus confirming the findings of Carpes *et al* (12).

Santos Silva and Loss (8) found in their study a larger external torque at 60 ° of elbow flexion in Scott bench, but in dynamic contractions, which may be an important factor in the difference found, because according to Neumann (13) some variables can change the value of torque, for example, the speed of execution of the movement the angle of insertion of the muscle, and thus change its perpendicular distance, the length of the muscle, the muscle actions and speed of muscle activation, as isometric contractions in the internal torque is similar to the external torque.

The figure 2 shows the value of the electromyographic signal in *biceps brachii* Long Head (BBCL) muscle. In the range of motion of 30º (point A), its value is greater than 45º original (C), which in turn is less than 45m, 45f, 60m, 60f, 90m and 90f, as in point b which corresponds to 60i, depolarization is considerably smaller than average 30º, 60º east, 60º and 90º average end.

This reveals that in 30º, 45º, 60º and 90º, in the middle and late times the muscle is very driven and has no significant statistical difference between them. In the initial 45º, there was a smaller depolarization of the motor units.

The figure 3, which are related electromyographic signals regarding the range of motion in muscle BBCC, reveals that in 30i depolarization of the motor units is lower than in 90f already in 45i, 45m, 45f, 60i and 90i, as well as demonstrating a smaller value compared to 90f, it is less depolarization of the motor units than 90m.

Thus, we hypothesize that many points have differences with the 90m and 90f, and it may be responsible for higher torque at 90 °, as one notes a large depolarization of the motor units mainly these points, which confirms studies Marson (5,6) which showed a greater depolarization of motor units in the range of greater torque.

The figure 4 is related to the amount of depolarization of muscle motor units *brachioradialis* (BQR) studied the four corners where notices a significant difference between the points 45f, 60i and 90i, as compared to 90m.

The fact that the depolarization of the motor units had few points with BQR and all differences relative to 90º, one can assume that the BQR would also be important to determine the largest torque observed at 90º.

In the results we can observe a difference between the values of the electromyographic signal of BBCL BBCC and muscles regarding BQR, where greater depolarization of motor units in muscles and BBCL BBCC was found, this can be explained by the BBCC be BBCL and muscles biarticular because research shows that there is variation in force production between mono-and biarticular muscles, possibly caused by the difference in the activation of motors units (14, 15).

Silva *et al* (16) in his analysis of electrical activation of the *rectus femoris, biceps femoris and semitendinosus* long with the external torque of the hip extension movement performed with the spring set in two different positions in a pilates exercise found that head the magnitude of the electromyographic signal accompanied the external torque, the same found by Marson (5,6).

Already in the present study cannot say the same, because, to the angle of 30 ° we note a difference between the torque value, which was the lowest result found in comparison with the other ranges of motion studied with depolarization motor units responsible for the elbow flexion muscles, which in turn did not show a lower value of the electromyographic signal. This leads us to believe there may have been some movement accessory with shoulder or hip, because according to Fields (17) exercise bench Scott, is an exercise that can easily occur in this type of movement. This can be considered a limitation of the study.

It can be concluded that in an elbow flexion performed on Scott bench, the time when there will be a better mechanical advantage is 90º range of motion, it is this position that we find a larger external torque or moment of force, and a greater depolarization of motor units compared with most other amplitudes, therefore, in a position of approximately 60º of flexion and 90º of elbow flexion, individuals bear a greater burden imposed on the segment for longer period of time.

However, it is suggested that the new studies related to maximal voluntary isometric contraction of the elbow flexion exercise on bench Scott, some adjustments in procedures, such as a fixation device in the trunk, so that accessory movements do not interfere in results.

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