

CORRELATION BETWEEN ELECTROMYOGRAPHIC ACTIVITY AND STRENGTH OF THE FLEXOR MUSCLES OF THE WRIST

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INTRODUCTION: It is well documented in the literature that electromyography (EMG) is an important instrument not only for studying the normal functioning of muscles, but also to analyze muscular responses to specific tasks or therapeutic regimes. Besides this, according to SODEBERG & COOK (1983) therapists may use EMG to evaluate the effectiveness of exercises in facilitating or inhibiting specific muscular activity, thus enabling them to check whether therapeutic goals are being reached. However, in the face of the increasing need for validating therapeutic effectiveness, EMG represents an objective means of scientific documentation (PORTNEY, 1993).

According to BASMAJIAN & De LUCA (1985) the strength developed by a muscle depends on various factors, such as the alpha neuron firing rate, the number of motor units active in the muscle, the size and type of motor units of the muscle and the duration of the contraction.

The EMG signal is affected by anatomical and muscular properties, through a controlling scheme of the peripheral nervous system, by instrumentation used for collecting and processing signals. Besides this, there are more muscles than are necessary to perform a specific motor task, so that the EMG signal shows a high intra- and inter-subject variation, the normalization of the EMG signal being crucial for the comparison of various subjects, measuring days, muscles or studies; the most common procedure for such normalization is the maximum voluntary isometric contraction (ERVILHA et al., 1997).

PORTNEY (1993) observed that frequently professionals who use EMG to study muscular functions are tempted to make assertions concerning the strength of the muscle. Although this term is used clinically, it should be used with caution, as strength is a term which must be defined as torque or potency produced under a specific set of conditions. The referenced author also considered the influence of muscle length in the correlation of EMG and strength, as revised studies affirm that an increase is observed in the EMG response as muscular tension is increased, as long as muscular length does not undergo alterations, i.e., during isometric contraction. This is one of the reasons for using isometric contraction in the referenced experiment.

RAY & GUHA (1983) observed that the majority of theoretical studies of the EMG and strength correlation suggest that the amplitude of the EMG signal should increase proportionately with the square root of tension, and that direct experiments, however, demonstrated a linear correlation.

According to GERTZ et al. (1997), the strength developed by a contracting muscle depends on the neural excitation which is applied to it; thus on measuring the level of excitation, the EMG may be used as a strength indicator, but it is impossible to use EMG to estimate the strength applied; it is possible to determine with high accuracy only the difference in the level of myoelectrical activity and, consequently,

the variation in the level of strength applied. In the face of the considerations and controversies expounded in the literature, the object of this paper was to establish the possible correlations between EMG activity and the strength of the flexor muscles of the wrist.

METHODS AND PROCEDURES: The flexor muscle of the wrist of the non-dominant member was analyzed in 21 female volunteers with an average age of 21 years ($s \pm 1.5$), with no any clinical history of skeletal muscle dysfunctions in the segment to be analyzed. The volunteers were recruited by verbal invitation and signed a research authorization before the experiments were carried out.

For collecting the electromyographic signal, a surface bipolar active electrode (DELSYS) was used, having a gain of 10 Hz, coupled to a 16 channel 12/36 electromyograph (AqDados - LYNX TECNOLOGIA ELETRÔNICA LTDA), which permitted a gain of 50 Hz. The system bandwidth was 10 to 500 Hz, with an overall gain of 1,000. The data acquisition rate was 1,000 Hz. The EMG signal was expressed in microvolts (μV), thus permitting a reading of RMS which, according to BASMAJIAN & De LUCA (1985), is the parameter which best comprehends the EMG signal variables.

The surface electrode was positioned on the midline of the muscle belly between the myotendinous junction and the nearest innervation zone perpendicularly to the length of the muscle fibers, this being the place where the signal shows the greatest amplitude (De LUCA, 1997). In order to eliminate possible interferences, a ground electrode was coupled to the third distal of the forearm.

To analyze muscular strength, a device was designed and built which permitted the forearm to be fixed in a supine position and the wrist at 45° flexion and 45° extension, allowing the charge cell (model MM, KRATOS - Dinamômetros) of a capacity of 0-50 kg to be fixed perpendicularly to the resistance arm and parallel to the potency arm. The charge cell was coupled to the electromyograph, its signal amplified and calibrated, enabling the strength to be evaluated in kilograms-strength (Kgf) concomitantly with the myoelectrical signal.

The volunteer remained seated, with the upper non-dominant member supported, and was instructed to concentrate on the command "Attention, now!" given by the electromyograph operator to indicate the concentration and "strength, strength,.... strength," emitted vigorously and quickly, apart from the visual stimulation represented by a computer screen, where both the EMG and STRENGTH graphs were being developed, in order to maintain maximum strength and modulate the duration of the contraction at 4", the pre-established period for capturing the signal. The EMG signal was captured during a maximum voluntary isometric contraction (MVIC) obtained in 2 positions of the wrist: 45° flexion and 45° extension with the member supine. In each of these positions the contractions were repeated 3 times, with an interval of 1 minute of rest between each test. The examinations were always carried out in the same period, in an air conditioned room ($23^{\circ} C \pm 1$) For the statistical analysis of the data, the correlation coefficient was calculated.

RESULTS AND DISCUSSION: The results show a positive correlation between electromyographic activity and strength ($r = 0.76$) in the 45° flexion position, while for the 45° extension position the correlation was not significant ($r = 0.23$) considering the sample analyzed.

The relationship between the strength exercised by and EMG activity recorded for a muscle, has been a controversial subject since the advent of EMG recording techniques (PHILIPSON & LARSSON, 1988).

BASMAJIAN & De LUCA (1985) undertook a broad revision of the literature on the correlation between the amplitude of the EMG signal and strength. They observed that there is no consensus and that this is mainly due to the considerable variability of the muscles examined, to the detection site, to the type of contraction performed and to the detection techniques and data processing. Even so, the authors recognize that the amplitude of the EMG signal may reflect the generation of strength by the muscle, and resuming the correlation characteristics between EMG and strength during an isometric contraction in the following manner: 1) is dependent on the muscle, as it is almost linear for the small muscles of the hand and non-linear (EMG increasing more than strength) for the large muscles of members; 2) this different behavior of the muscles, could possibly be the reflection of the difference in the firing index and the recruitment properties of the small and large muscles, as well as other electrical and anatomical considerations.

On the other hand, STOKES & YOUNG (1984), consider the level of muscular activation to be the result of the number of motor units recruited and their firing rate and that alterations in these factors may alter the strength of contraction.

Another factor which could interfere with the strength developed by the muscle, according to BASMAJIAN & De LUCA (1985), is the duration of the contraction. This factor, however, was controlled in the experiment, seeing that the contractions had the same period of 4 seconds of maximum voluntary isometric contraction (MVIC) in the 45° flexion and extension positions.

When a muscle in isometric contraction maintains a constant length, the result of the EMG varies directly with muscular tension (EDWARDS & LIPPOLD, 1956) The results of the experiment showed a positive correlation between EMG and strength, when the articulation of the wrist was at 45° flexion, therefore, shortened. This correlation was lower in the lengthened position (articulation of the wrist at 45° extension), this may be explained as a result of the fact that, according to LIPPOLD (1952), when the muscular length varies in this position, less activity is observed in the EMG in the lengthened muscles, and conversely, greater activity in the EMG as the muscle length diminishes. Theoretically, therefore, it can be assumed that fewer motor units are needed to produce the same level of tension in the lengthened position (PORTNEY 1993).

Besides the factors quoted in the literature, which interfere with the relationship between EMG and strength, the results suggest that the position of the articulation also influences this relationship.

CONCLUSIONS: Considering the sample and the experimental conditions used, the data of this research permit the conclusion that there is a positive correlation between EMG and strength of the flexor muscles of the wrist when these are in a shortened position (flexion 45°), while in the lengthened position (extension 45°), this correlation was not significant. This being so, the correlation between EMG and strength appears to depend, among other factors, on the position of the muscle.

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