Investigation of the EMG-time relationship of the biceps Brachii muscle during contractions

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Abstract. [Purpose] This study investigated the changes in the slope of EMG-time curves (relationship) at the maximal and different levels of dynamic (eccentric and concentric) and static (isometric) contractions. [Subjects and Methods] The subject was a 17 year-old male adolescent. The surface EMG signal of the dominant arm’s biceps brachii (BB) was recorded through electrodes placed on the muscle belly. [Results] The results obtained during the contractions show that the regression slope was very close to 1.00 during concentric contraction, whereas those of eccentric and isometric contractions were lower. Significant differences were found for the EMG amplitude and time lags among the contractions. [Conclusion] The results show that the EMG signal of the BB varies among the three modes of contraction and the relationship of the EMG amplitude with a time lag gives the best fit during concentric contraction.

Key words: EMG, Biceps brachii muscle, Contraction

INTRODUCTION

Electromyography (EMG) is a recognized recording tool that is commonly used for measuring the electrical activity of a contracting muscle1. A number of research studies have investigated the relationships between EMG and other parameters. Before conducting this study, we conducted a review of the literature concerning relationships regarding EMG activities of the upper limb muscles. Commonly assessed relationships are those of: EMG-force, EMG-torque, EMG-time, EMG-angle and EMG-other parameters. For example, Munteanu et al. studied the relationship between EMG and muscle temperature during dynamic contraction of the forearm muscles2. Rantalainen et al. examined the EMG-force/torque relationship in the BB. These researchers found that the disruption of the physiological signal (EMG) caused by the innervation zone alters the reliability of the force-EMG relationship on a single bipolar channel level3. Similarly, Doheny et al. examined the effect of the joint angle on the relationship between the force and EMG amplitude and the median frequency in the BB, brachioradialis and triceps brachii muscles4. Some other EMG studies have also examined force, exercise and movement. According to the definition by previous gerontological studies, the age range of adolescence is 13 to 19. In the literature we reviewed, most of the previous studies had investigated the EMG signal of subjects older than 20 years of age. We could not find any report of the EMG-time relationship during MVC of adolescent’s muscle. The major goal of this study was to fill this gap by analyzing this relationship in order to characterize the BB muscle activity of adolescents. In other words, to investigate the EMG-time relationship in order to evaluate the endurance time of an adolescent’s BB using EMG under three contraction conditions.

SUBJECTS AND METHODS

A male adolescent (age=17 years, weight=60 kg, height=171 cm) participated in this study and provided written informed consent prior to the experiment. All of the experimental procedures conformed to the principles of the Declaration of Helsinki and were approved by the local Human Research Ethics Committee of the University. Be-
fore the test, the subject was told to sit in a chair and relax as much as possible. Dynamic (concentric (up) and eccentric (down)) contractions were then induced by lifting and lowering a weight. During the dynamic contractions, the subject was instructed to move his forearm between elbow angles of 0° and 90°. In contrast, during static (isometric) contractions, the subject was instructed to hold the same load with an elbow angle fixed at 90°. Three trials of each type of contraction were performed for 10 s with a rest period of 5 min provided between each trial.

A wireless sensor was used to record the EMG signal at the belly of the BB muscle using two foam adhesive electrodes (Ag/AgCl). The inter-electrode distance, electrode placement procedure and skin preparation followed the descriptions of SENIAM\(^7\). The raw signals were recorded at a sampling rate of 1 kHz before analog to digital conversion. Fourth-order bandpass Butterworth filter was used to remove skin movement artefacts and high-frequency noises (cutoff frequency between 10 and 500 Hz). The digitized EMG datasets were processed offline (filtering, windowing, and signal extraction) using Matlab software. The EMG signals were divided into four parts and analyzed as 2,500-ms time windows. EMG amplitude data were normalized to the root mean square (RMS) values: i.e., the individual RMS values during the contraction were considered 100% MVC. The filtered EMG activity was normalized by dividing the observed EMG value by the maximum value recorded during the three MVC trials. The mean (RMS) normalized EMG activity was then calculated as the mean of the sum of the muscle during the early stage of the contraction. This study had some limitations. Like, only a single muscle was selected, and the EMG data were recorded from a single subject. Future research should focus on defining the relationship between the EMG-moment, EMG-force and other parameters of the BB muscle of individuals in different age groups.

ACKNOWLEDGEMENT

The authors extend their appreciation to the College of Applied Medical Sciences Research Center and the Deanship of Scientific Research at King Saud University for funding this research.

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