SURFACE EMG AND MYOELECTRIC PROSTHESIS CONTROL

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Abstract— An electromyogram (EMG) signal is the signature of a muscle contraction by which our limbs can be moved. When part of a limb is lost, muscles used to move it can still be contracted. An amputee person can then used those muscular signals to activate a myoelectric prosthesis and produce some movements again. Newest myoelectric prostheses are capable of many degrees of freedom (DOF) and therefore many signals are required to fully benefit from their capabilities. In search of many muscle control sites to operate such prosthesis, muscle compartments, which are intra-muscular subdivisions innervated by individual muscle nerve branch, can be exploited. In order to explore if the compartments of those muscles could be voluntary controlled, we placed an array of 7 pairs of equally spaced surface electrodes across the biceps brachii (BB) of healthy subjects. EMG signals where collected while subject's hand was in different positions. Our preliminary results indicate that depending on hand positions, parts of the biceps muscle are more active than others. Such knowledge could be useful for the control of a modern myoelectric prosthesis.

Index Terms— Biceps brachii; Compartment; Electrode array; Surface EMG

I. INTRODUCTION

Upper and lower limb amputees can be associated to diseases, accidents and in recent years due to wars in Iraq and Afghanistan as bullet proof vests save lives but not limbs. Limb loss is a tragic event that has effect on entire life. Specially for young amputee persons, there is a need for a several DOF prosthetic device they could use in their daily life activities. With a myoelectric prosthesis, electromyographic (EMG) signals recorded over the muscles of the amputee stump are used to produce movements by activating an electric motor linked to the mechanical levers or cables.

Myoelectric control was introduced in the 1940s and considerable progress was made in the 1960s. Founded by the American Defense Advanced Research Project Agency (DARPA), one of the most advanced hand prosthesis with 22 DOF has recently been developed [1]. The problem that has now to be solved is how to activate it.

In large muscles, com partments innervated by an individual muscle nerve branch can exist [2]. Selective activation of such intra-muscular subdivisions has been observed in some animal muscles (e.g. cat sartorius and lateral gastrocnemius) during locomotion [3]. In humans, the ability of independently control of different subdivisions of the trapezius has been investigated with biofeedback guidance [4]. In the BB, neuromuscular compartments each innervated by a nerve branch have been found through dissection of a cadavers [5].

The project is aimed at determining if each of those compartments can be under our voluntary control. To do so, an array of equally spaced surface electrodes is placed across the BB, which is contracted while the hand is placed in different positions. Initially, normal subjects will be tested and the acquired knowledge will then be used to see if amputee persons can also activate those compartments with the objective of fitting them with a prosthesis which is best adapted to his/her abilities.

II. METHODS

A. Subject

Data gathered from four subjects; two males and two females for preliminary experiment.

B. Experimentation

After preparation of the skin with abrasive paper and cleaning with alcoholic pad, conductive gel put on the electrodes and an array of 7 pairs of gold coated electrodes (6 mm diameter) equally spaced 1.5 cm form both horizontal and vertical distance, is fixed around the arm above the middle of BB and below the estimated zone of the neuromuscular junctions. Exploratory experiments carried out to get the optimum electrode placement around the arm in order to detect muscle compartment activation while the hand is in different positions. With this information, data acquired from the healthy subjects while their hands are in the following positions: Neutral, Half-Supination, Supination, Half-Pronation, Pronation, Supination with wrist Flexion (S-F) and Pronation with wrist Flexion (P-F).

C. Instrumentation

An EMG amplifiers system (Grass, model 15LT) with a band pass of 3 Hz to 1 kHz is used and connected to an A/D converter (National instrument, NI USB-6225). The sampling rate is 2 kHz and the digitized signal is store on a computer for off-line processing with Matlab. LabView software is used to control the data acquisition. To monitor the level of isometric contractions at 10 % and 20% MVC (maximum voluntary contraction) during the 5 s of each acquisition, a strain gauge is used and its output is displayed on a monitor as a feedback signal to the subject and digitized in parallel with the EMG signals. For those acquisitions, the arm is close to the trunk and flexed at 110° with a hand cuff at wrist, linked to the strain gauge placed near the hand.

D. Analysis

Mean RMS values of EMG signals for each 7 channels were calculated from the 3 repetitions of best recording trials in each hand positions. Slow drift in the signal due to instability of the half-cell potential of the electrodes was removed when present.

III. RESULT

Fig.1 illustrated the results obtained from 3 subjects for 3 hand positions. As it can be seen, for each subject, some parts of the biceps muscle are more active than others and that distribution is changes as the hand position is changed. Differences are also noted among the subjects. It can be observed that the signal at electrode #2 displays important changes between the different positions. Activity of the segment of the biceps under electrode #4 increases as the wrist position is moved from neutral to Supination and

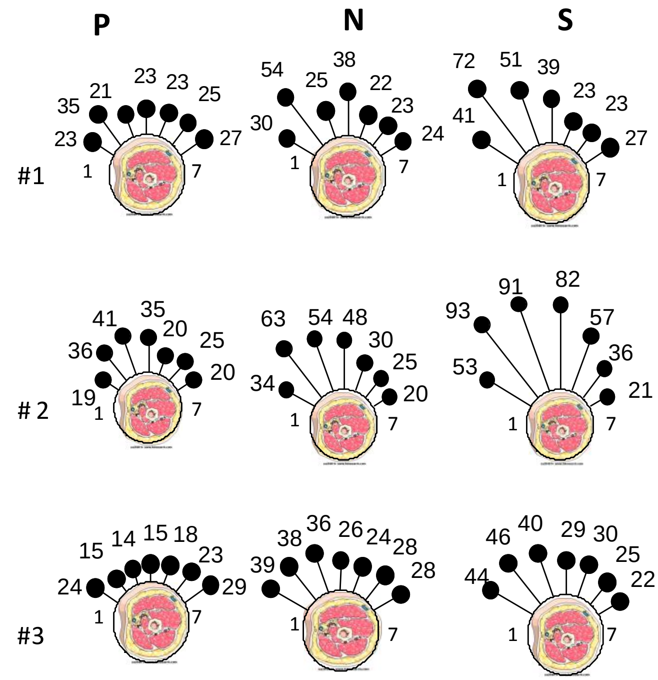

Fig.1. Illustration of the EMG signals distribution (mean RMS values in µv) over the biceps brachii (electrode 1 to 7) vs. different hand positions. P;Pronation, N;Neutral, S; Supination. Subject#1: 10% MVC, subject #2, #3: 20%MVC.

reduced when wrist is put in Pronation. The pattern of the activity of the BB were found to be similar for all the other positions tested but not displayed here i.e.; Neutral, Half-Pronation and Half-Supination. In general more activity is observed on the medial side of the BB in Supination compared to the lateral side which indicate that short head of the BB was more activated than the long head in the supination position.

Patterns of BB's activity for Supination and Supination with wrist Flexion (S-F) were found to be the same. This was also observed for Pronation and Pronation with wrist Flexion (P-F).

IV. DISCUSSION/CONCLUSION

The main objective of this study is to see if the anatomical com partments of upper arm biceps (and eventually the triceps) can be used to control a prosthetic hand capable of many DOF. From our preliminary results on the biceps, there is indication that some zones are more active depending on the hand position. Romeny et al [6] found that during elbow flexion, motor units in the lateral portion of the long head of the biceps are preferentially activated, whereas in forearm Supination, motor units in its medial portion are more activated. Our results show the same finding if we just look at the electrodes #4, 5 we see more activity in medial portion of the long head of the BB.

According to our results, more activity was found in the medial portion of BB which could be related to the short head of the BB and lateral portion of the BB had less contribution for keeping the arm at Supination position. This finding is in accordance with Brown et al. [7] experiment in which it was found that short head of BB has more contribution than long head in Supination motion when the elbow is in 120° of flexion.

In future work, the triceps could be investigated and we will try to locate the zones of tension within a contracted muscle with ultrasound imaging.

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