A FUZZY-APPROACH TO DIFFERENTIATE BETWEEN MUSCULAR CO-ACTIVATION AND CROSS-TALK

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INTRODUCTION

Muscular coordination represents the basis of every movement of the human body. Therefore, the evaluation of muscular coordination is important for clinical decision making in patients suffering from movement disorders. Bipolar surface electromyography (SEMG) is a frequently used methodology, which allows the noninvasive assessment of the muscular activation pattern. Although standards for electrode localization and signal processing have been developed (SENIAM), the problem of the occurrence of crosstalk in SEMG-signals have not been solved so far.

METHODS

A basic assumption in SEMG is that the recorded electric potentials originate from the muscle directly under the electrodes. However, crosstalk occurs as a result of the volume conduction properties of biological tissue. The contribution of the individual signal sources to the derived signal thereby depends on a multitude of different properties of the volume conductor. These properties are highly individual for each subject and in most cases they are not separately quantifiable. Therefore, it can be assumed that crosstalk also is an individual measure, which varies from one person to another.

Crosstalk Risk Factor-CRF

In order to be able to quantify the probability for the occurrence of crosstalk individually for each subject, we introduced a "Crosstalk Risk Factor" (CRF). It combines the high number of subject specific properties and integrates them into one objective variable. For that, SEMG were recorded on a muscle pair of each specific subject. Movements of such types in which physiologically no muscular co-activation takes place were used (Figure 1). Both SEMG signals have been rectified and smoothed. The ON-phases have been determined and if both muscles have been considered ON, the ratio of the signal energies has been calculated. Additionally, for all simultaneous detected ON-phases the maximum of the cross-correlation function between both signals has been calculated.

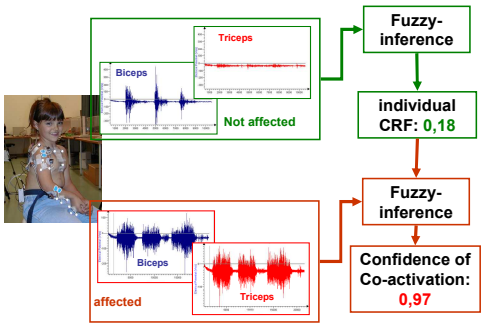

Figure 1 Calculation of the Crosstalk Risk Factor and the Confidence of Co-activation of a patient with plexus lesion.

The information about the cross-correlation and the energy ratio has been linked by fuzzy-inference, which is tolerant of imprecise data and, therefore, well suited to predict potential crosstalk. The out-put variable of the fuzzy-inference is the Crosstalk Risk Factor (CRF), which predicts the probability for the occurrence of crosstalk individually for each subject.

Confidence of Co-activation-CCA

To predict muscular co-activation, which is often essential in clinical applications the "Confidence of Co-activation - CCA" has been introduced which is, in contrast to the CRF, calculated for movements, in which muscular co-activation takes place potentially (Figure 1). Similar to the CRF the CCA is build by fuzzy inference. As input variables the CRF as well as the mean maximal cross-correlation coefficient of the measured SEMG signals is used. The CCA reflects likelihood that co-activation of the two muscles and not crosstalk occurs.

RESULTS AND DISCUSSION

The CRF as well as the CCA were calculated in a case study consisting of 20 children, suffering from a lesion of the plexus brachialis nerve and a resulting co-activation of the m. biceps brachii and the m. triceps brachii. The CRF has been calculated for each subject on the non-affected side. The measurements have been repeated two times between three and six month after the initial investigation. Figure 2 shows the calculated CRF of 6 subjects. The results show clearly the individuality of the CRF as well as a high intra-individual reproducibility (except of one) of the measure with time.

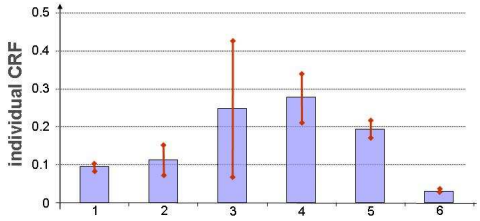

Figure 2 Intra-individual CRF of 6 exemplary subjects.

Within the group of healthy elbow flexion movements values lower than 0.4 on a scale from "0" to "1" have been calculated for the CCA, which means that there is only slight likelihood of co-activation between biceps and triceps. In contrast to that, the Confidence of Co-activation, was calculated very high (>0.8 on a scale from "0" to "1") on the affected side of the subjects suffering from a lesion of the plexus brachialis nerve. A double-sided t-test showed with a confidence < 0.01, that there was a significant difference between the healthy and affected subjects with respect to the calculated CCA.

CONCLUSIONS

The results show that by utilizing the procedure presented, discrimination between crosstalk and co-activation becomes possible and a prediction of muscular co-activation can be done. This is an important step to-wards clinical decision making based on SEMG.

REFERENCES

1. Disselhorst-Klug C, et al. *Clinical Biomechanics*, e-published 2008