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A PROBABILISTIC APPROACH TO ASSESS ACTIVITY DURING DYNAMIC ECCENTRIC AND CONCENTRIC CONTRACTIONS

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SUMMARY

Purpose of this work is to present a probabilistic approach to assess the muscular activity during eccentric and concentric contractions in specific joint angle positions out of series of movements. The method is utilized to exemplarily retrieve an individualized relationship of surface electromyogram (sEMG) and elbow joint angle in elbow flexion during dynamic movements to finally show the differences in the muscular activation patterns. The setup includes series of elbow flexion movements, which are performed in a motion analysis lab. Through a probabilistic approach, the most probable sEMG amplitude out of all trials is assigned to the elbow joint angles. The differences of concentric and eccentric contractions can be clearly observed from the sEMG results and so the contribution of the elbow flexor muscles during movement becomes clear.

INTRODUCTION

The dependency of effectively performed motion and the underlying muscular activation is investigated in a wealth of literature.

But in the human motor system, there are redundant activation strategies for performing single joint or even complex movements. Since there are an infinite number of combinations of the level of activation of the muscles required generating a specific joint torque resulting in a movement, it is difficult to determine which movement is depending on the relative contribution of the activity of each muscle [2].

Many authors have given conflicting results from the examination of sEMG activities during elbow flexion movements. Numerous studies have been conducted comparing sEMG amplitudes and motor unit activity during maximal and sub-maximal concentric and eccentric movements, with the bulk reporting lesser sEMG amplitude and motor unit activation during eccentric contractions [5,6,7].

Most of the presented approaches only use deterministic methods in single measurements, not taking into account full series of dynamic movements. The accuracy of repetition is not sufficient, especially because the sEMG signals are not properly reproducible from one trial to another. So consequently the full series of movement have to be considered.

To get an improved dependency of sEMG amplitude in specific joint angle positions and get insight into the underlying activation patters, a probabilistic approach is utilized to specify the most probable sEMG amplitude in a joint angle position during movement out of series of movement.

METHODS & SUBJECTS

A convenience sample of data of 10 healthy male subjects (age 23 (±3) years; height 179 (±9) cm; body mass 75 (±8) kg) was used in the present study. No subject had any known symptoms of neuromuscular disorders or orthopedic surgery or symptoms in upper extremity. Subjects avoided strenuous exercises in the day prior to the measurement. All subjects were right handed. Subjects were measured in standing position with anatomical hand posture with shoulder nor flexed or abducted.

In the motion analysis laboratory measurements of series of elbow flexion and extension movements were performed in a constant speed of 25°/s. The elbow joint center and subsequently the elbow flexion angle were determined by a biomechanical model based on marker positions recorded by the motion analysis system [8].

Synchronizely bipolar sEMG signals of biceps brachii and brachioradialis muscle are recorded and processed according to standard protocols developed with the SENIAM project [3]. Since sEMG amplitudes vary for different elbow angles, sEMG signals are normalized to the maximal amplitude in 90 degrees elbow flexion maximum voluntary contraction (MVC) out of three trials for each muscle.

A minimum of 20 repetitions of full flexion and extension movements of the elbow joint were performed to gather enough data for the probabilistic analysis [1,4]. Between each trial there was a minimum rest of 120 seconds.

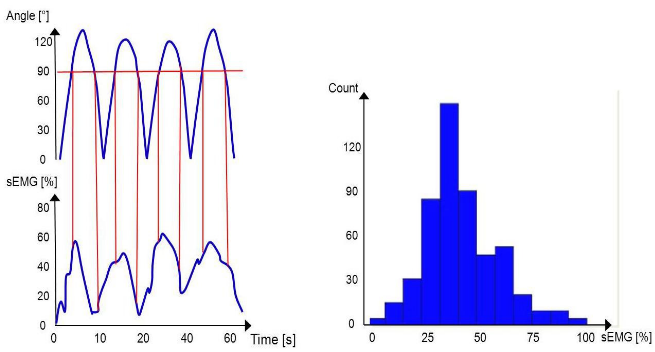

Figure 1: Calculation of the most probable sEMG amplitude of biceps brachii in an elbow joint angle of 90 degrees

With an accuracy of ± 2° the elbow angles and the associated sEMG signals were determined in steps of approximately 5° from full extension to maximum elbow flexion. Every time the specific angle is reached the sEMG amplitude is assigned and added to the distribution, see Figure 1 on the left. The distribution in Figure 1 on the right shows the counts how often a sEMG amplitude appears in a specific joint angle position, here 90 degrees.

RESULTS AND DISCUSSION

From the sEMG activation distributions calculated by the probabilistic approach it can be observed that the activation patterns of the biceps brachii clearly differ in concentric and eccentric contractions. The peaks of activation can clearly be separated during movements, see Figure 2. In the lower joint angles (0°-30°) activation is quite similar, but especially in the maximum of the biomechanical lever arm (70°-90°) the peaks can clearly be separated, finally leading to a closer value in the higher joint angles (100°-120°).

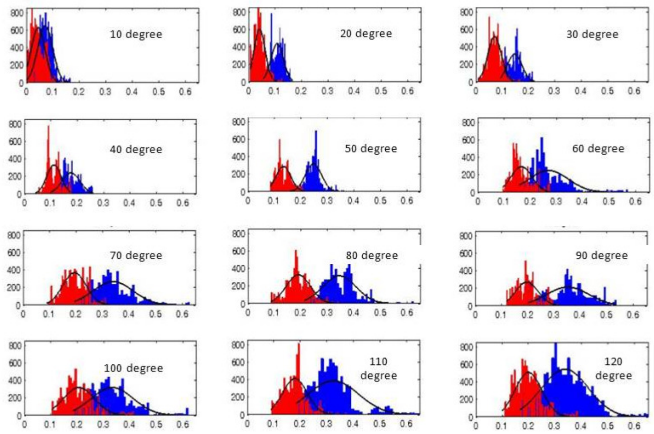

Figure 2: Exemplary activation profiles of concentric (blue) and eccentric (red) contractions in biceps brachii during elbow flexion calculated from the probabilistic approach.

Combining the single activation profiles from the probabilistic approach in several joint angles leads to a characteristic curve representing the sEMG-joint angle relationship shown in Figure 2. Therefore the distributions are taken in mean to get the most probable sEMG amplitude value.

The resulting characteristic curves show similar activation patterns with a maximum close to 90 degree in dynamic movement, both concentric and eccentric, but with a strongly increased amplitude in the concentric contraction [6,7]. Especially in the lower and higher flexion angles the activation profiles seem similar, while the peaks in 70°-90° show clear differences in amplitude. These differences can only be partially explained because the biomechanical conditions match in both conditions

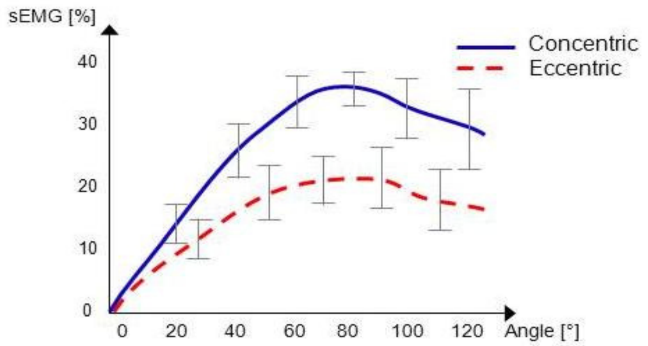

Figure 3: Characteristic curves representing the mean of all subjects of the sEMG-joint angle relationship during elbow flexion in concentric and eccentric contractions.

CONCLUSIONS

The chosen probabilistic approach is a proper method to assess the muscular activation level in different elbow angle positions during continuous elbow flexion movements. From the results it can be observed that the sEMG amplitudes in concentric an eccentric contractions clearly differ from each other

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