Laboratory Exercise 1

Title: The effect of joint angle and fatigue on the relationship between joint torque and the integrated EMG from the Biceps Brachii and Brachioradialis muscles.

Objective: The intent of this exercise is threefold. The first objective is to quantify the relationship between excitation (EMG) of each of the two elbow flexors (Biceps Brachii and Brachioradialis) and joint torque. Second, the influence of joint angle on maximum excitation of each muscle will be quantified. Third, we will determine the effect of a prolonged fatiguing contraction of the excitation of each of these muscles at one joint angle.

Protocol: There are a number of steps that must be completed:

1. Calibrate the force transducer.
2. Select 90° at the elbow joint angle and record a series of contractions of increasing magnitude to the maximum possible.
3. For the 6 possible elbow joint-angle configurations, record the EMG for the maximum force at each joint angle.
4. Select one joint angle and have the subject provide a 35% MVC for as long as possible.
5. From the calibration data, compute the scaling factor for the transducer.
6. From item 2 above, determine the relationship between force (or torque) and EMG for each muscle.
7. From item 3 above, determine the effect of joint angle on the maximum EMG for both muscles.
8. From item 4 above, compute the time-related changes in excitation as the subject performed the prolonged contraction.

1. Calibration of Force Transducer: Before data collection can begin, it will be necessary to calibrate the force transducer. That means to determine the relationship between the actual load applied (in Newtons) and the voltage output of the transducer. This will be done by hanging a series of known weights from the transducer, collecting the electrical output from the transducer and then calculating a scaling and offset factor. The voltage output of the transducer is linearly related to the magnitude of the load. Thus, using a least squares algorithm it is possible to collect a series of measurements of voltage generated by the known applied load and compute an equation of the form y=mx+b, where y is the predicted output, m is the slope, x is the recorded voltage, and b the intercept.

   Using the available weights, in a random order hang 5 different loads from the transducer while it is supported from the stand. To do this, first hang the transducer by a wire from the support. Then hang the known weight from the transducer. Record the voltage. Once the 5 sets of data have been collected enter the data into an Excel spreadsheet and compute the slope and offset for the transducer. These values will be used to convert the transducer voltages to force in Newtons.

   Enter the values here: slope: _______________ intercept: _______________
2. Data Collection for EMG-Force relationship:

1. Affix the electrodes over the central portion of the Biceps Brachii and Brachioradialis muscles and the ground electrode over the wrist of the opposite arm. Plug these into the amplifier and observe your signals on the computer display.
2. Arrange the subject in the experimental position, wrapping the cuff around the wrist. Measure the distance between the centre of rotation of the elbow joint and the centre of the cuff. This distance is _________ meters.
3. Ask the subject to perform a series of contractions and set the appropriate gain.
4. With the force output displayed ask the subject to perform in sequence a series of contractions, beginning at a low level and proceeding to maximum. For each contraction the output of the EMG amplifiers and the force transducer will be recorded. Make sure that the subject has achieved a stable force output before you trigger the computer program. The subject will relax while the computer program saves the data. You should try to collect at least 6 - 8 sets of data.

3. Data Collection for EMG-joint angle relationship: With the force output displayed on the computer, ask the subject to perform in series of maximal contractions for each of the possible joint angle configurations displayed on the table. For each contraction the output of the EMG amplifiers and the force transducer will be recorded. Make sure that the subject has achieved a stable force output before you trigger the computer program. The subject will relax while the computer program saves the data.

4. Data Collection for effect of fatigue on the electromyogram:
1. With the force output displayed on the scope ask the subject to perform a maximal contraction. Use this value to compute the 25% target value.
2. Have the subject produce this target value. Make sure that the display is visible to the subject at all times. Record the force and EMG at 15-second intervals for 2 seconds. Continue this for as long as the subject can generate force at the required level.
3. After the subject has stopped and is fatigued, have him/her produce a maximal contraction. Record the force and the EMG.

**Data Processing:** The EMG and force data are stored on the Biomechanics Lab computer. Each student should have brought a blank 3.5" floppy disk onto which the data will be copied or we can move the data to the School’s computers in the micro computer lab. Analysis should be done within Microsoft Excel, which is also available in the School Microcomputer Lab. A final report will be submitted two weeks after the lab for assessment. You will have to consider the best method for analysing the EMG such as computing the integrated value or averaging the peak value. It would be best to examine the force trace at the same time as you examine the EMG trace.

**Discussion hints:** You have collected some useful data and are now in position to describe the relationship between torque/force and EMG for each muscle, torque/force and the effect of joint angle for each muscle, and how fatigue might alter the excitation. What influence did varying the joint angle have on this relationship and, of course, why (or why not). Was there any evidence of shifting activation that could be attributed to load sharing? What was the effect of fatigue on the frequency spectrum of each muscle? Some suggested references are;