MEMO

Subject: Electromyography 2

Synopsis:

This lab is continuous on the previous electromyography lab. The purpose of this lab is to obtain abilities to acquire and analyze biomedical signals, electromyography (EMG) and pressure data are chosen for this lab with various muscle situations, such as, muscle fatigue, injuries, etc. The objective of this lab is to distinguish the effects of fatigue during isometric contraction on the EMG signal as well as due to changes in muscle length and dynamic loading conditions. This lab is designed after the previous lab so the detailed procedure involved in the processing of the EMG data will not be included except where it is deemed necessary. Previous settings of gain, filter frequency, mode, positions of electrodes, and holding position of pressure transducer are same. However, this lab performs isometric fatigue testing, dynamic testing, and muscle length variation testing. First, for isometric fatigue testing, sampling rate is 500Hz for each channel, 1000Hz combined for the two channels, and sampling period is 5 seconds. Make sure to check the log data before start and subject is well rested between trials. The different procedure from the previous lab is that students collect three sets of data for two different trials. One has 30 seconds, another has 60 seconds for the interval between sampling periods. Record peak frequency, (make sure 60Hz is noise not peak frequency), mean pressure, and standard deviation. Second, for dynamics testing, no pressure transducer is needed and make sure that subject can lift 20lb weight. Subject should stand and begin flexing his/her arm at a relatively constant slow rate without weight. Then repeat flexing arm with 20lb weight. Generate power spectrum and record the peak EMG frequency. Third, for muscle length variation, the pressure transducer is need and subject creates 90 degrees of elbow flexion and full elbow extension. The subject should maintain contraction until the 5 second sampling period is finished. Obtain power spectra of tests and record the mean pressure and standard deviation. Finally, performs LabView analysis which includes low pass filtering to create a linear envelope for each all of the data sets. The integral of the signal will be obtained from the LabView window. According to results, mean pressure and peak EMG frequencies of first trial (30 seconds duration) of the isometric fatigue testing have a trend of decreasing. However, the second trial (60 seconds duration) of the isometric fatigue testing does not have a clear trend for both mean pressure and peak EMG frequencies. With 20lb weight, rectified EMG signal reached to 6.0V but with no weight, rectified EMG signal reached to 1.5V. Mean pressure are similar in both cases with 90 degrees elbow flexion and 180 degrees elbow flexion. Even though both cases have similar mean pressure, muscles get fatigue with 180 degrees elbow flexion due to low frequency presence for peak EMG signal.

Results:

Table 1. Summary of Experiments

Trial Name	EMG Peak Frequency(Hz)	Mean Pressure(psi)	Pressure Standard Deviation (psi)
Isometric Trial 1 – 1	38	81.755	1.084
Isometric Trial 1 – 2	45	71.1	2.5
Isometric Trial 1 – 3	52	74.3	16.8
Isometric Trial 2 – 1	39	55.7	0.9
Isometric Trial 2 – 2	49	57.0	0.7
Isometric Trial 2 – 3	43	53.1	0.5
Dynamic (No weight)	38	N/A	N/A
Dynamic (20lb weight)	70	N/A	N/A
90 degrees elbow flexion	76	73.3	3.1
Full elbow flexion	37	72.0	4.0

**graphs are attached as appendix.

For isometric fatigue testing trial 1, (Isometric trial 1-1 to 1-3 has 30 seconds duration between collecting data sets) EMG peak frequencies and mean pressure are decreasing due to fatigue of biceps. Pressure standard deviation is increasing and isometric trial 1-3 value is 16.8 psi which is very scattered data. This indicates that biceps are fatigue. Pressure standard deviation for isometric trial 1-1 is very high due to subject did not apply force and contract biceps before start. The maximum EMG peak frequency among three data sets is 52 Hz and maximum mean pressure is 81.755 psi.
For isometric fatigue testing trial 2, (Isometric trial 2-1 to 2-3 has 60 seconds duration between collecting data sets) EMG peak frequencies and mean pressure do not show a trend as trial 1.

For dynamic testing, EMG peak frequency increased when the subject flexed elbow with 20lb weight.

For muscle length variation, EMG peak frequency decreased when the subject had full elbow flexion (180 degree). At 90 degree elbow flexion has higher mean pressures but both values of 90 degrees and 180 degrees elbow flexion are very close. Full elbow flexion has 0.9 psi higher standard deviation than standard deviation of 90 degrees elbow flexion.

Discussion/Conclusion:

1. Mean pressure of first trial (30 seconds duration) of the isometric fatigue testing has a trend of decreasing. However, the second trial (60 seconds duration) of the isometric fatigue testing does not have a clear trend. The decreasing trend of mean pressure is expected so the second trial includes some errors. For examples, the subject might not give 100% effort at trial 1 or was not familiar to the procedure at the beginning. Also, the subject might use different hand position to press the press transducer. Also, the pressure standard deviation for isometric trial 1-1 is very high due to subject did not apply force and did not contract biceps before start.

2. Peak EMG frequencies of first trial (30 seconds duration) of the isometric fatigue testing has a trend of decreasing. However, the second trial (60 seconds duration) of the isometric fatigue testing does not have a clear trend. The decreasing trend of peak EMG frequencies is expected so the second trial includes some errors which are similar to the mean pressure of first trial in the above.

3. Force, which caused by the 20lb weight and rectified EMG data in the dynamic testing show correlation. With 20lb weight, rectified EMG signal reached to 6.0V but with no weight, rectified EMG signal reached to 1.5V. EMG signal through the linear envelope portrays the EMG signal without noise which is dynamic representation than isometric trial signals. The linear envelope acts as a low-pass filter to cut off noise and high frequencies.

4. Mean pressure are similar in both cases with 90 degrees elbow flexion and 180 degrees elbow flexion. However, the frequency was much lower when it was 180 degrees elbow flexion. This situation was occurred due to fatigue. It represents that 180 degrees elbow flexion needs more effort to have same output due to the body mechanics.

Free body diagram

5. According to Chaffin, localized muscle fatigue is characterized by a progressive increase in discomfort arising from an active muscle during a prolonged constant force contraction at a moderate load level (Maniar). Another past muscle theory is that fatiguability is dependent on motor unit type 1 or type 2. More recently, fatigue has been related with shift of the EMG signal toward low frequencies (De Luca). This shift has been measured using median frequencies (Maniar). Motor unit also influenced by muscle fiber conduction velocity and tissue filtering properties. According to Maniar, a decrease in conduction velocity produces a more dispersed waveform which will have more low frequency and fewer high frequency components (Maniar). Maniar expected the opposite from the observation that the triceps fatigues less than either the biceps or deltoids. This analysis is useful to evaluate patients with fatigue producing diseases such as chronic fatigue syndrome, multiple sclerosis, myopathies, neuropathies, and motor neuron disease by comparing the median frequency values with the normal. Also this will lead to new technique to study fatigue by testing muscles using a hand held dynamometer, and standard processing equipment (Maniar).

Mean pressure and peak EMG frequencies of first trial (30 seconds duration) of the isometric fatigue testing have a trend of decreasing. However, the second trial (60 seconds duration) of the isometric fatigue testing does not have a clear trend for both mean pressure and peak EMG frequencies. The decreasing trend of mean pressure is expected so the second trial includes some errors. For examples, the subject might not give 100% effort at trial 1 or was not familiar to the procedure at the beginning. Also, the subject might use different hand position to press the press transducer. Also, the pressure standard deviation for isometric trial 1-1 is very high due to subject did not apply force and did not contract biceps before start. It is also possible that the subject has very strong muscles which did not get fatigue during collecting data. Force, which caused by the 20lb weight and rectified EMG data in the dynamic testing shows correlation. With 20lb weight, rectified EMG signal reached to 6.0V but with no weight, rectified EMG signal reached to 1.5V. EMG signal through the linear envelope portrays the EMG signal without noise which is dynamic representation than isometric trial signals. The linear envelope acts as a low-pass filter to cut off noise and high frequencies. Mean pressure are similar in both cases with 90 degrees elbow flexion and 180 degrees elbow flexion. Even though both cases have similar mean pressure, muscles get fatigue with 180 degrees elbow flexion due to low frequency presence for peak EMG signal. This experiment is successful to obtain abilities to acquire and analyze biomedical signals, EMG and pressure data with various muscle situations, such as muscle fatigue. Students also understood EMG signals as well as due to changes in muscle length and dynamic loading conditions.

**Please see the appendix A for designed EMG.

References

[1] Maniar. “Normal Values for Median Frequency in Upper Extremity Muscles During Isometric Contraction at 50% of Maximal Voluntary Contraction”. IEEE, 1995. 38-40.

[2] De Luca, C.J., M.A. Sabbahi, F.B Stulen, and G. Brilotto. 1983. “Some Properties of the Median Frequency of the Myolectric Signal during Locallized Muscular Fatigue” Chicago IL. 175-186.

[3]Winters, *David. Biomechanics and Motor control of human movement*. Chapter 9.

APPENDIX A.

** Design a system component or process to meet desired meds with realistic constraints

Figure 2. Single-ended amplifier showing lack of rejection of present on non ground active terminal.

Figure 3. Biological amplifier showing how the differential amplifier rejects the common signal by subtracting the signal that is present at an equal amplitude at each active terminal. Different EMG signals are present at each electrode thus, the subtraction does not result in a cancellation.

Figure 4. Electrode design with data storage

Once the EMG signal has been amplified, it can be processed for comparison or correlation with other physiological or biomechanical signals. The need for changing the EMG into another processed form is caused by the fact that the raw EMG may not be suitable for recording or correlation. This can be a constraints for signal processing. (Winters)