Electromyography

I. Background

Skeletal muscle performs mechanical work. It is stimulated to contract when the brain or spinal cord activates motor units. An action potential in the motoneuron causes the activation of muscle fibres. The activation of motor units by action potentials generates a stochastic voltage signal in the muscle. The amount of work is proportional to the number of activated motor units. For weak contractions, only a few motor units need to be activated, while for stronger contractions, additional motor units can be activated. The maximum contraction strength occurs when all motor units are activated simultaneously (and repeatedly). The activation of increasing numbers of motor units to produce increasingly stronger contractions is known as *motor unit recruitment*.

Skeletal muscles are unable to maintain high rates of sustained or repetitive contraction indefinitely; they will eventually *fatigue*, that is, their ability to perform work will be reduced. *Physiological* fatigue results from the depletion of ATP at a rate faster than it can be replenished through respiration, as well as from a build-up of lactic acid (from anaerobic respiration). The effects of physiological fatigue can only be reversed by resting the muscles.

II. Measurement principles

The recording of changes in skin voltage produced by underlying skeletal muscle contractions is called electromyography (EMG). The electrical activity of a muscle can be recorded by measuring the voltage between two electrodes placed on the skin above the muscle (measurement instruments may also use a third electrode as a reference electrode).

III. Aims of the measurement

- Exertion of gradually increasing short-term grip force until the maximum attainable force is reached. The goal is to establish the relationship between the force maintained by the muscle and the electrical activity of the contracted muscle.
- Recording the force and the EMG activity whilst the maximum grip effort is maintained, until the force falls below ≈40% of the initial level. The goal is to characterise the development of muscle fatigue via the measurement of the EMG activity.

IV. Measurement

A. Basic functions of a data acquisition and processing computer system
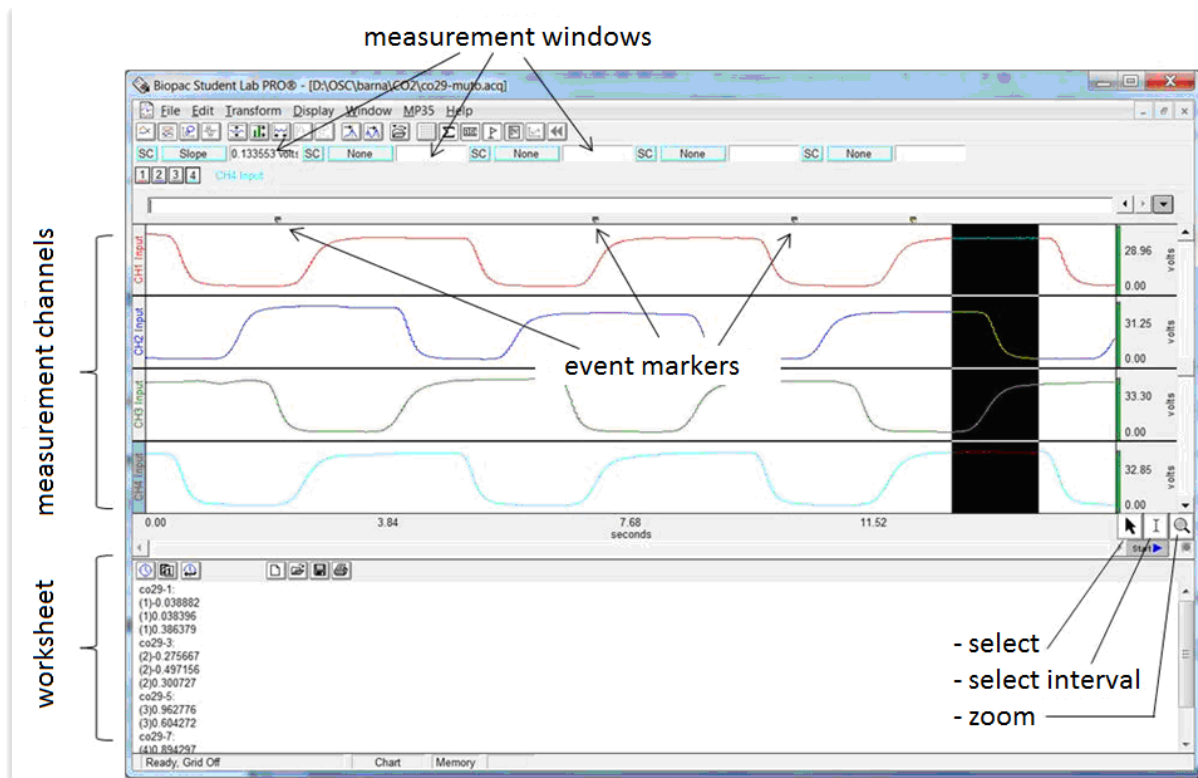
1. User interface of the Biopac Student Lab Pro program


Figure 1. The user interface of *Biopac Student lab Pro.*

2. Defining the input channels (*MP36 » Set up channels...*)

In the Biopac data acquisition system, we can choose between three types of input channels. There are four **analogue** channels associated with the analogue-to-digital converters; through these, we can acquire electrophysiological signals, pressure or flow signals, or the signals of dynamometers or analogue microphones. **Digital** input channels receive digital signals directly. In **calculation channels,** we can record signals derived from the signals of primary input channels (such as the heart rate derived from an ECG recording).
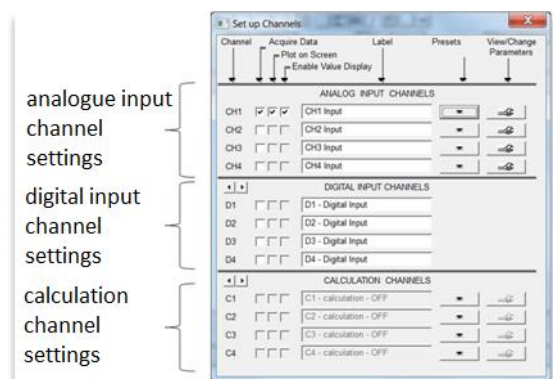
3. Setting up data acquisition parameters (*MP36 » Set up acquisition*)

- Data storing mode: in memory or on hard disc.
- Sample rate: should be greater than twice the maximum frequency within the signal.
- Acquisition length (data acquisition can be aborted before its completion).
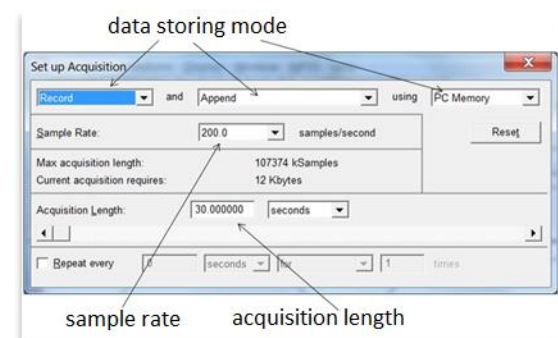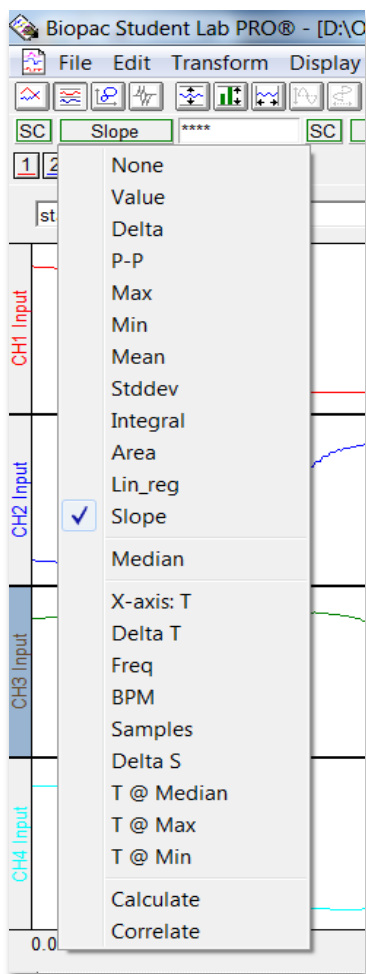
4. Starting data acquisition

5. Data display settings

6. Data evaluation

1. Channel selection (1, 2, etc, or SC: selected channel)
2. Evaluation of parameters:
   - *None*: no parameter read
   - *Value*: the value at the position of cursor I
   - *Delta*: the difference between the endpoints of the interval
   - *p-p*: peak-to-peak value within the selected interval
   - *Max*: maximum value within the selected interval
   - *Min*: minimum value within the selected interval
   - *Mean*: mean of the values in the selected interval
   - *Stddev*: standard deviation of the values in the selected interval
   - *Integral*: area under the curve between the endpoints
   - *Area*:the area above the line connecting the endpoints
   - *Lin_reg*: the slope of the best fit line
   - *Slope*: the slope of the line connecting the endpoints
   - *Median*: the median of the selected interval
   - *X-axis T*: the position of the cursor along the time axis
   - *Delta T*: the length of the selected interval
   - *Freq*: the frequency of a periodic signal
   - *BPM*: recurrences per minute
   - *Samples*: cursor position expressed as a sample index
   - *Delta S*: the length of the selected interval as sample count
   - *T @ Median, Max, Min*: the times associated with the median,
   - maximum or minimum, respectively
   - *Calculate*: calculation using a custom formula
   - *Correlate*: correlation between channels

B. Measurement protocol

1. Start the BSL PRO® 3.7.3 program and resume the recording named *Template-2014.acq*.
2. Connect the dynamometer to CH1 and the EMG electrodes to CH2.
3. Place the EMG electrodes:
   - Red: wrist, thumb side
   - Black: wrist, little finger
   - White: arm
4. Calibrate the dynamometer (ensure that it reads zero if there is no force applied).

5. Record the forearm EMG for the dominant arm:
   - Increase the grip force gradually in short (≈2-s) intervals (eg. in steps of 50, 100, 150, 200, 250, 300 N) up to the maximum grip force, with 2-s breaks inserted.
   - Maintain maximum effort until the force falls below ≈40 % of the initial level.
6. Save the recording (*Save as...*) with the ETR code (less .SZE) of the subject.

C. *Signal processing and data analysis*

- Open the file recorded by the subgroup with BSL PRO® 3.7.3.
- Reduce the noise of the EMG activity signal with a 300-point running average (Figure 2):
  - select the channel *EMG activity*
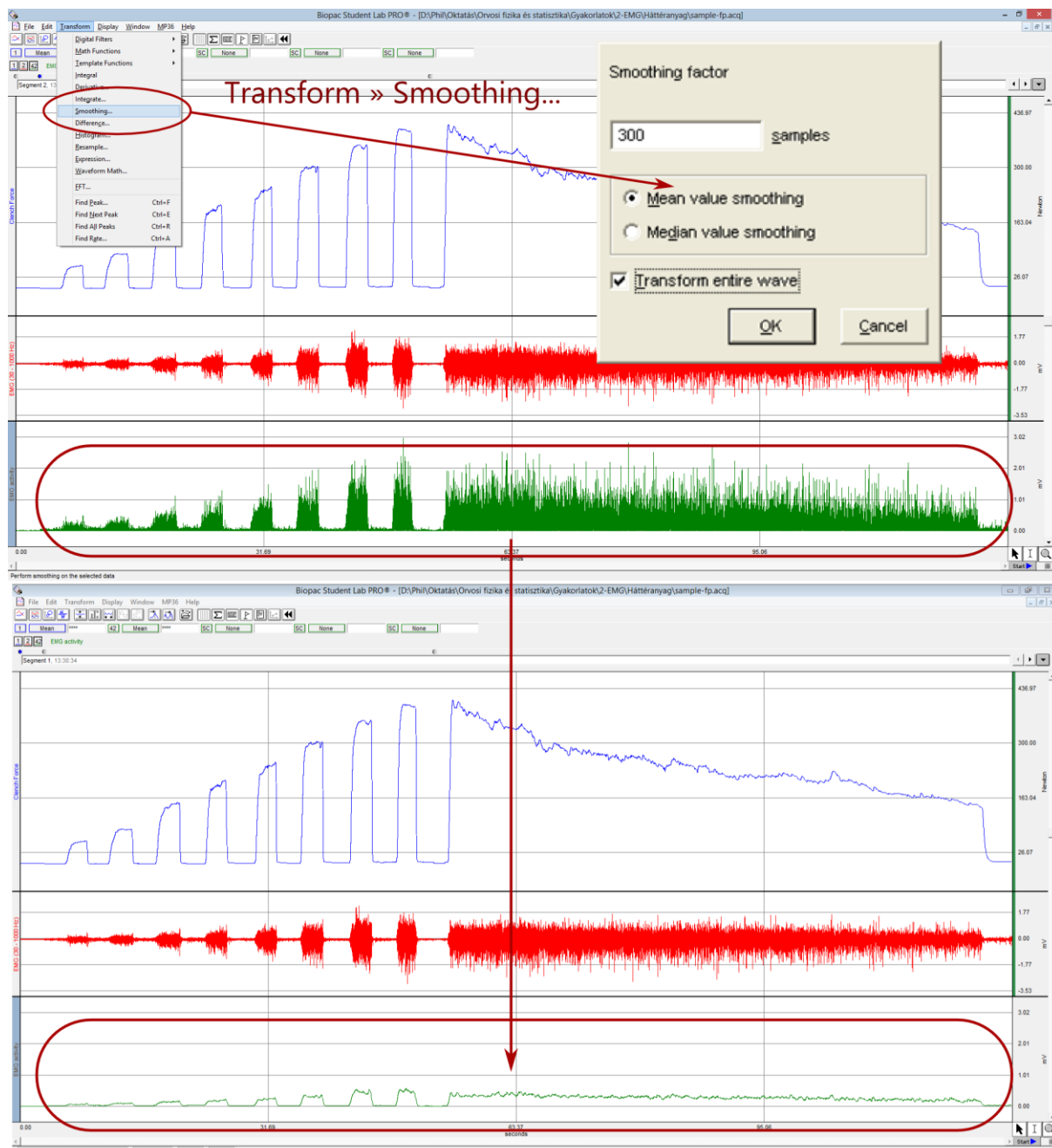 - apply *Transform » Smoothing*

Figure 2. Reducing the noise of the EMG activity signal using smoothing.

- Establish the relationship between the grip force and the smoothed EMG activity from at least 4 successive short grip manoeuvres of ≈2-s length: select the grip force plateaus and read the plateau mean values of the force and the EMG activity (see Figure 3).
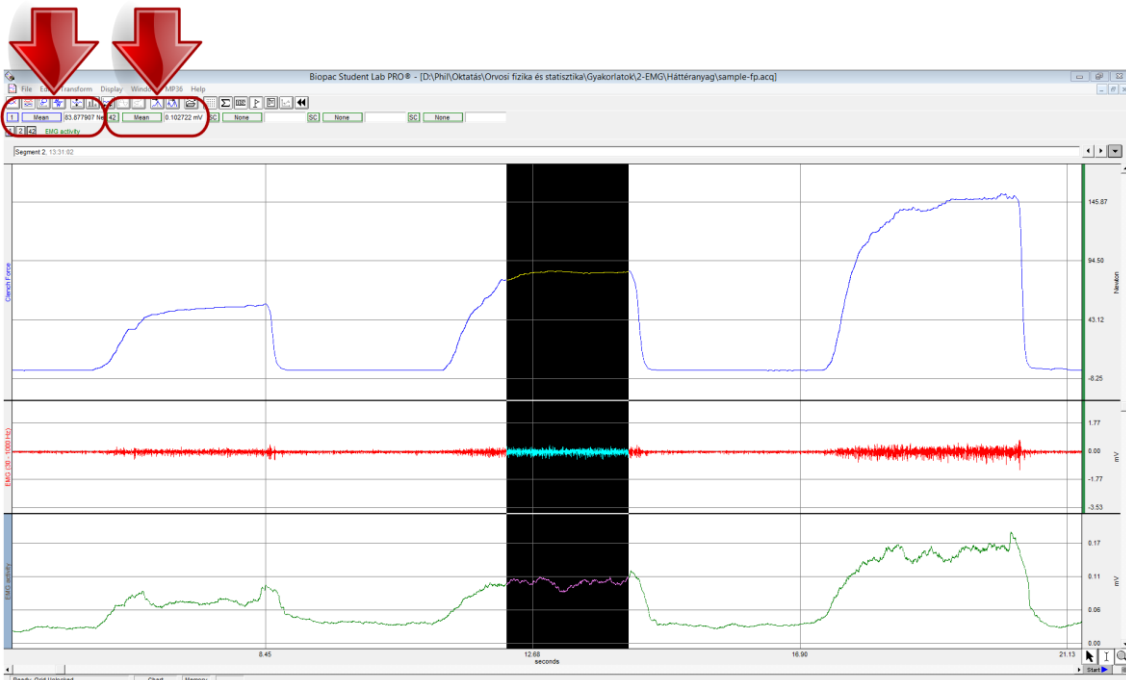

Figure 3. Selecting a grip force plateau and determining the relevant mean values.

- Measure the mean values of the force and the EMG activity at the initial maximum (100%) effort and the ≈50% end-manoeuvre level (see Figure 4):
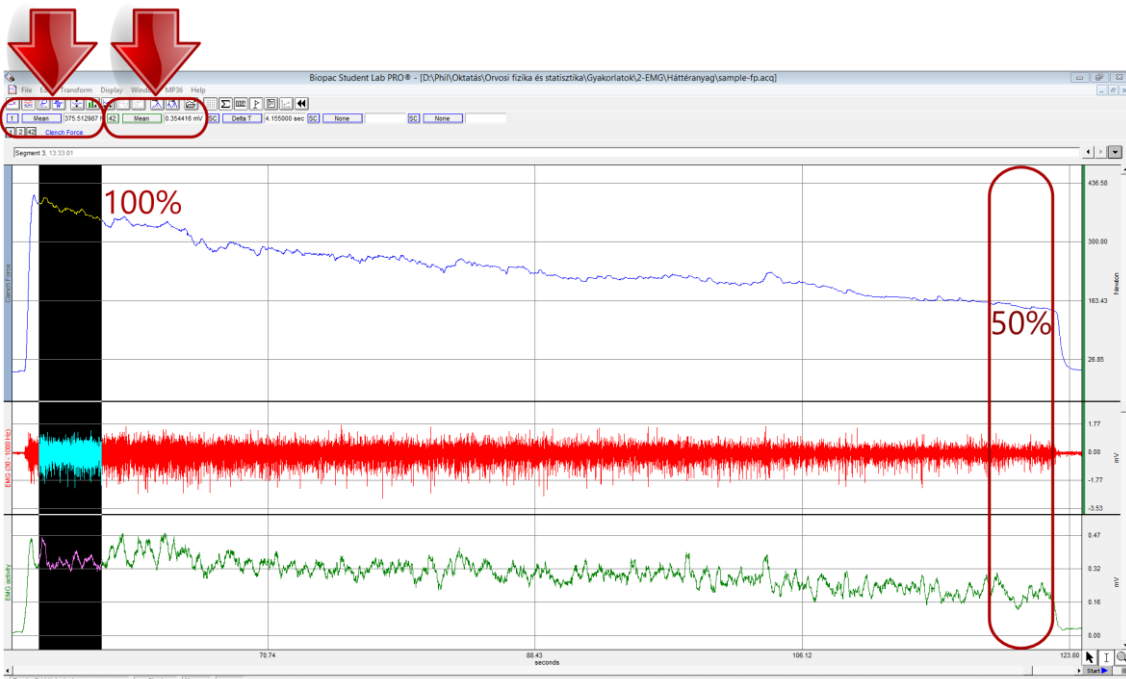

Figure 4. Determining the mean values at the initial maximum (100%) and at the ≈50% end-manoeuvre level.

- Fill in the Report, display the force – EMG activity diagram and comment on the results.