DELSYS

The following Delsys tutorial focuses on recording EMG and inertial measurements from concentric and eccentric upper limb tasks and in this case, elbow flexion and extension. It guides one through sensor setup, data collection and post-processing analysis of the recorded data sets.

HARDWARE PRESENT

Trigno™ IM sensors

SOFTWARE PRESENT

Delsys' EMGworks

C-Motion's Visual3D

We encourage users to recognize the useful principles present here and apply and expand them as needed to other tasks or applications.

Acknowledgement: Delsys thanks Professor Jim Richards and the University of Central Lancashire for creating this tutorial and providing permission to share on its website.

DELSYS-VISUAL3D TUTORIAL 1

Concentric/Eccentric Upper Limb Tasks

Contents

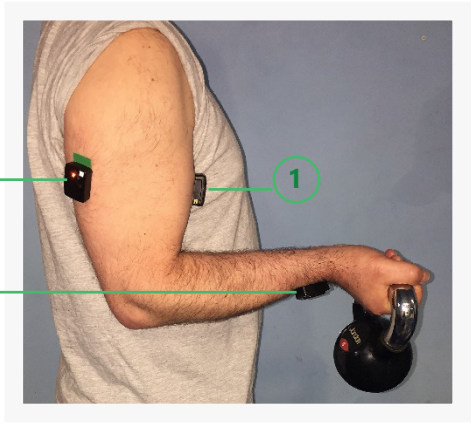
Data Collection
Elbow Flexion/Extension

SENSORS REQUIRED

Sensor 1 IMU/EMG on Biceps Brachii

Sensor 2 IMU/EMG on Triceps Brachii

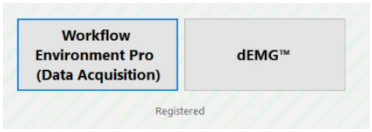
Sensor 3 IMU/EMG on Wrist



SETTING UP THE SOFTWARE

Open EMG works Acquisition

Open Workflow Environment Pro



Import note: Where does the data go?

Please follow the few points below to ensure you're able to locate the data sets after collection.

When starting a new session click on **"Application"** and **"Options"** under "**Default Sample Data Folder**" click on **"Browse"** and select where you want this project data to go.

c:\....\Delsys Tutorial\Elbow Flex Ext

For individual participants you will have the chance to make a folder within this later.

Open Test Configuration ConEcc Upper Limb IM only Sensors

Load the ConEcc Upper Limb IM only Sensors test configuration file from the download package of this tutorial in EMG-works.

After selecting the 'Workflow Environment Pro' option, load this test configuration file by clicking "Import" and locate the file "ConEcc Upper Limb IM only Sensors.emtc" then "Open"

EMG/IMU sensor 1 is to be placed on the Biceps Brachii, EMG/IMU sensor 2 is to be placed on the Triceps Brachii and EMG/IMU sensor 3 is to be placed on top of the wrist, with the long axis of the sensor parallel to one's hand when held straight.

If you wish to use standard EMG sensors on the Muscles then use Test Configuration "ConEcc Upper Limb EMG and IM Sensors .emtc"

It is worth reviewing the sensitivity settings of these sensors each time you use the Test Configuration. This is particularly relevant when you are recording IMU data (acceleration, angular velocity and magnetometer data).

Import note: sensitivity

For this Configuration, set these sensors to the least sensitive and therefore highest range, giving us the greatest range at the expense of sensitivity.

- Failure to select the correct sensitivity could reduce the sensitivity of the accelerometers (acceleration) and gyroscopes (angular velocity) measures
- Or worse clip the data so you do not record the full range, this data is then lost

EXPERIMENTAL WORKFLOW

Within Experimental Workflow there are several items we can do and display. Selected here is a "Signal Preview" template and a series of different "Plot and Store" experimental conditions.

Signal Preview

This is useful to check if you are getting signals from the sensors and to visually check a) the quality of the EMG signals, the sensitively setting of the IMU data (acceleration, angular velocity and magnetometer data). You have to select a sensor for feedback, however all channels will be displayed, FIGURE 1.

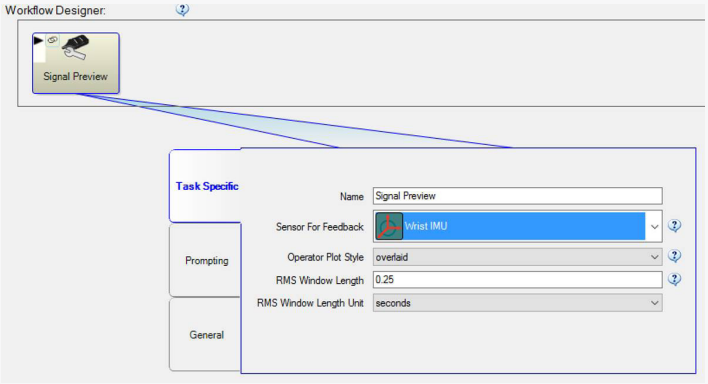


Figure 1: Setting up Signal Preview

Plot and Store

The next steps are to perform a series of experiments/ data collection. This workflow focuses on a simple elbow flexion/extension task using two different weights 3kg and 5kg.

Within Plot and Store you can choose what you would like displayed and how you would like it displayed.

If you click on options you can select which signals you would like displayed in the collection, although all channels will be collected so if you change your mind what you want to look at all the data will be available in analysis which we will come onto. This example has selected to show the data on 3 columns. Column 1 will have the EMG signal from Biceps Brachii, column 2 EMG signal from Triceps Brachii, column 3 will have the three axis of gyro (angular velocity) data, FIGURE 2.

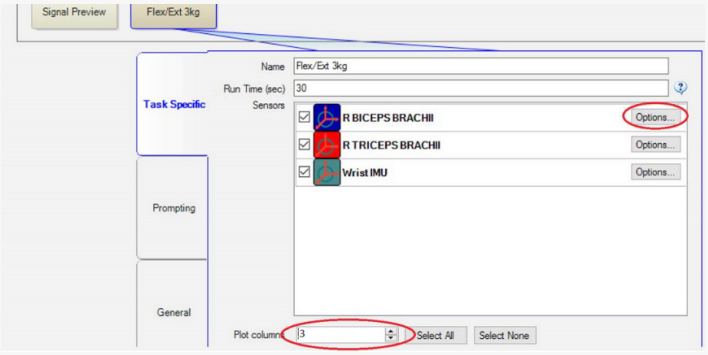


Figure 2: Display Settings

For these tasks EMG from Biceps Brachii and Triceps Brachii, and the angular velocity (Gryo) from the Wrist IMU were selected. As we're am interested in flexion extension of the elbow and concentric and eccentric muscle activity, FIGURE 3.

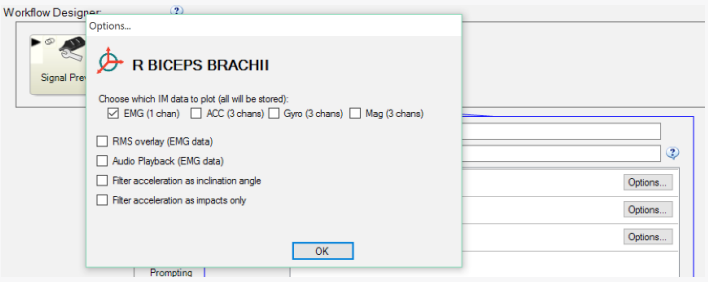
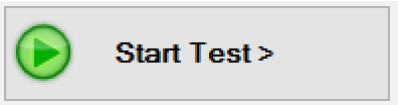


Figure 3: Setting up Plot and Store

STARTING A TEST

Click on



You now have a chance to name the data session, here we've called this "Participant1", FIGURE 4.

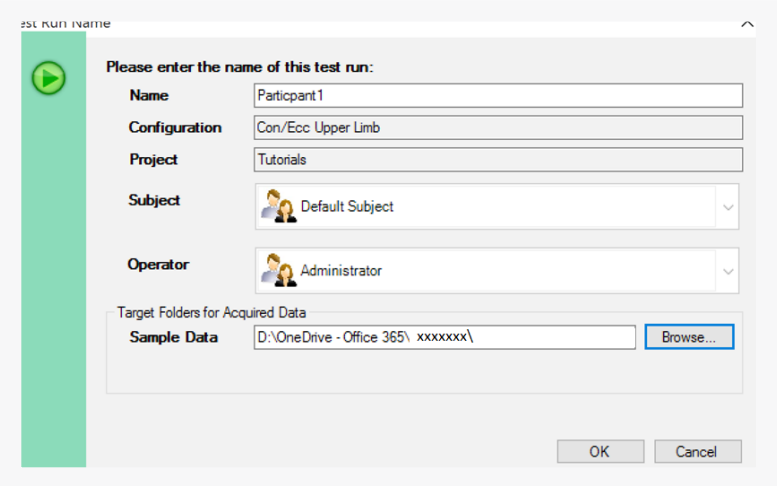


Figure 4: Session Data Name

Create a folder for that data session, by clicking on "**Browse**" and **"Make New Folder"** again making sure that you are selecting a sensible folder, FIGURE 5. In this case we've created a folder within ...\Delsys Tutorial\Elbow Flex Ext**Participant1**

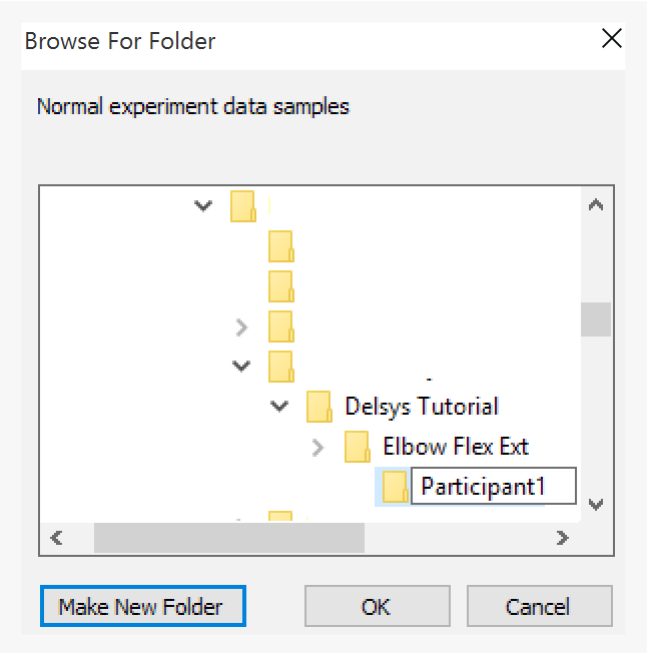


Figure 5: Session Data Name and Location

Import note: Return to Test Configuration

If you want to **"Return to Test Configuration"** this will now revert to the "**Default Sample Data Folder**" so you will need to point the data to the correct folder again when you click on **"Start Test"**

Data Collection

RUNNING A TASK

A task is part of the test configuration and in this case we have **"Signal Preview"**, **"Flex/Ext 3kg" and "Flex/Ext 5kg"**

If you click on **"Run Task"** the software will increment through the tasks one by one, alternatively you can Double Click on the test Icons and do in any order which is usual if you are wanting to randomise the conditions.

In "Signal Preview" you will need to click stop before you can run the next task.

PROTOCOL

This test protocol aims to look at the concentric versus eccentric muscle activity for the biceps whilst also looking at any co-contractions of triceps.

Ask your participant to hold the 3 kg weight and flex and extend their elbow in a continuous smooth movement avoiding any rapid changes in acceleration and ideally with similar angular velocities during the concentric and eccentric phases.

Saving the Data

The data is automatically saved one the completion of each task in the location selected above. This can now be analysed in a number of ways including EMGworks Analysis and Visual3d.

Data Analysis
Elbow Flexion/Extension in EMGworks Analysis

CREATING A WORKSPACE

Open **EMGworks analysis**

Select **"Create new workspace"**

The workspace name usually suggest this is the same as the participant data file, in this case **Participant1** and Browse to the **Participant1** folder.

You can now add the different trial files to this workspace

For the purpose of this tutorial we will consider one file **Participant1_Flex_Ext_5kg**

Plotting the data

At this point we have to be clear on what we are trying to achieve. For this test, we're interested in:

1) Flexion extension angular velocity
2) Biceps Brachii EMG data during concentric and eccentric phases of movement
3) Co-contractions from Triceps Brachii

The first thing to do is visually inspect the data. To do this we need to select the channels we are most interested in, namely **R BICEPS BRACHII: EMG 1 (IM)**, **R TRICEPS BRACHII: EMG 2 (IM)** and **Wrist IMU: Gyro X 3 (IM)**.

To select hold down the **Ctrl key** and **select the channels**. Then **right hand mouse click** and select plot as **Subplots**. Then unlock the screen by clicking the icon in the red circle, FIGURE 6.

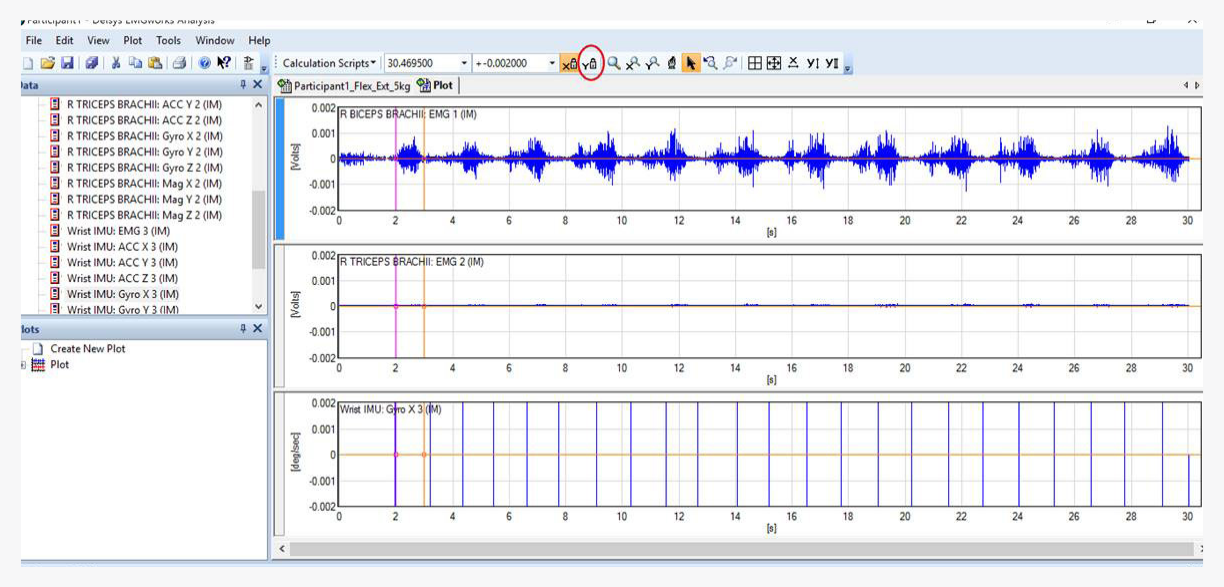


Figure 6: visual inspection of the data

Now **right hand mouse click** and **Auto Scale All Y**, FIGURE 7

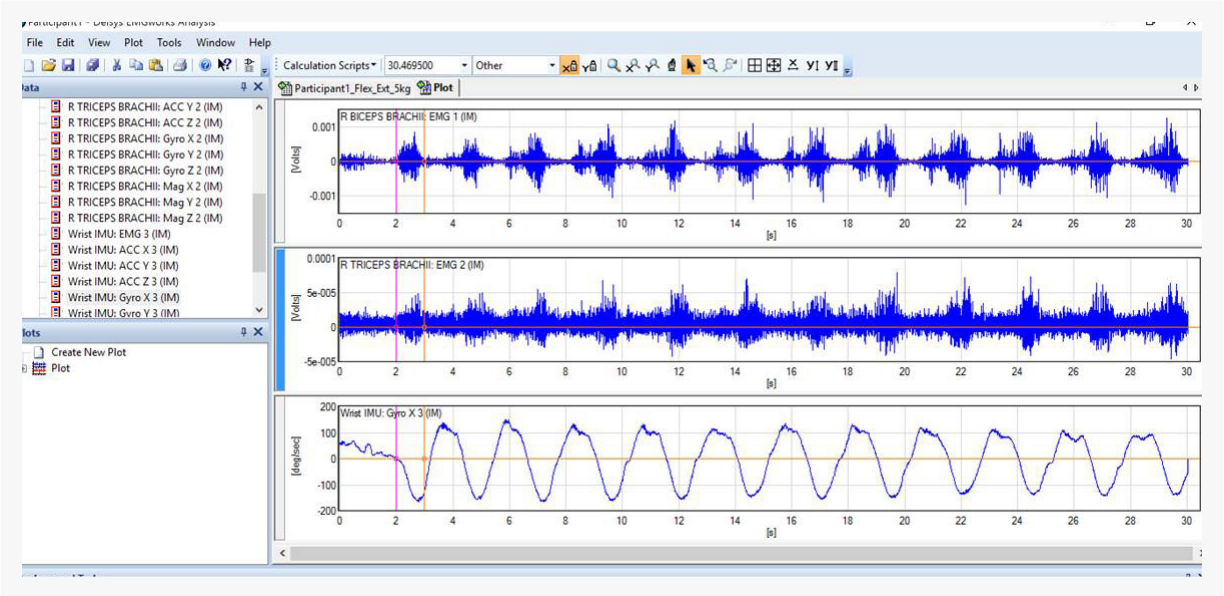


Figure 7: Rescaling the Y axes

Removing offsets on EMG signals

You should be able to see there is a slight (DC) offset on the EMG that we need to get rid of.

To do this hold down the **Ctrl key** and select the channels **R BICEPS BRACHII: EMG 1 (IM)** and **R TRICEPS BRACHII: EMG 2 (IM)**

Then **right hand mouse click** and select **Calculation Scripts** and **Remove Mean** and plot as **Subplots**, FIGURE 8

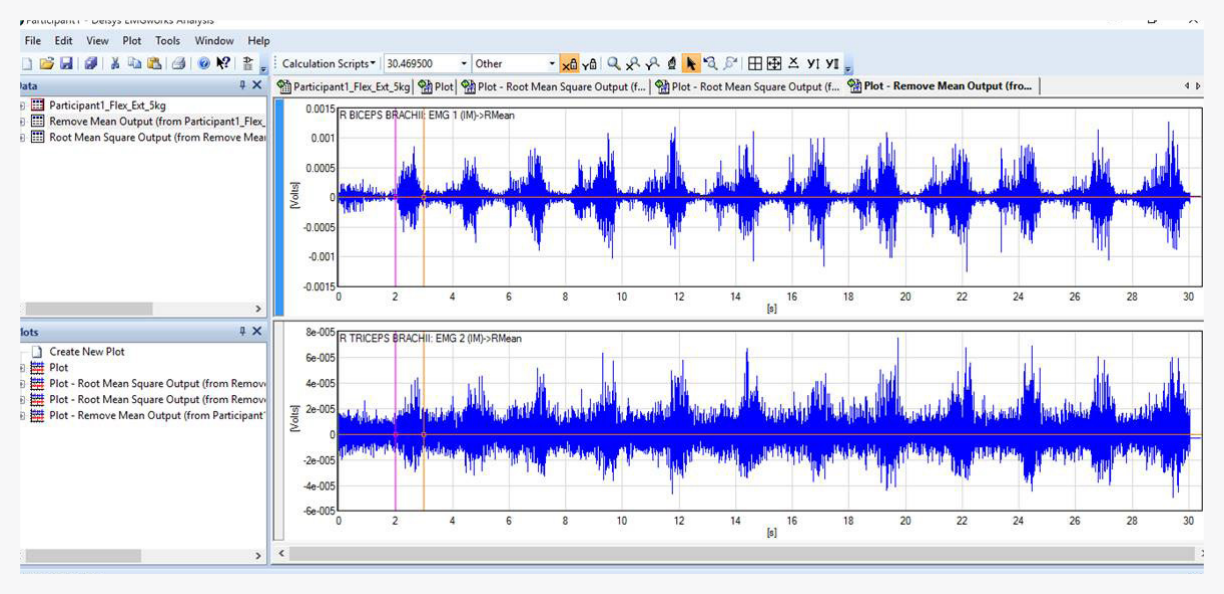


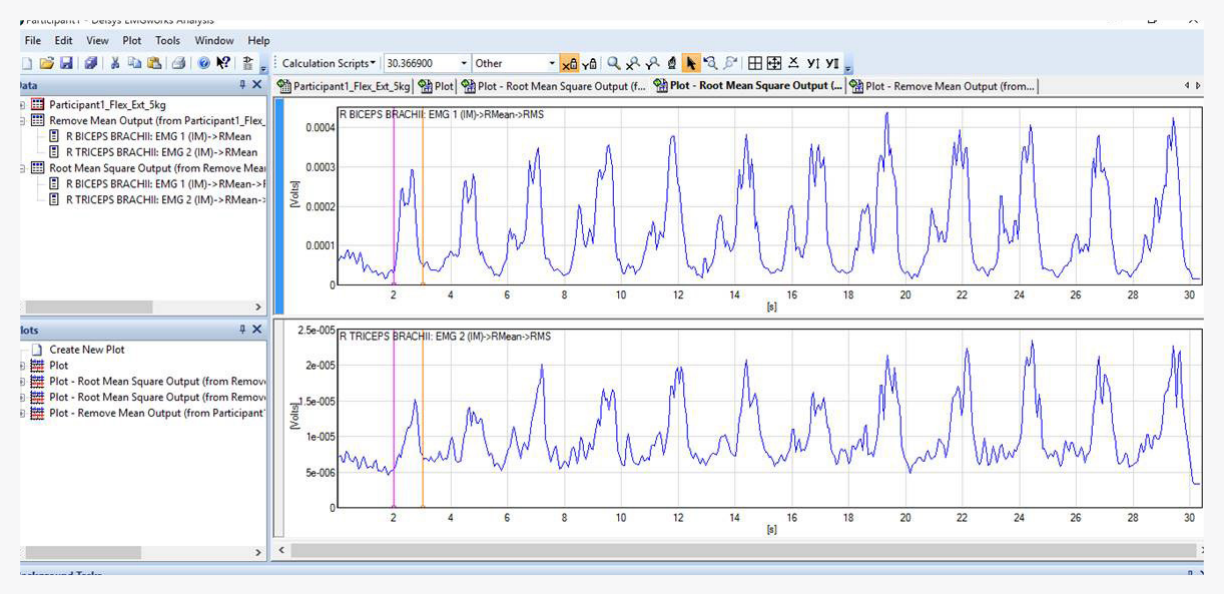
Figure 8: Plotting remove mean data

Enveloped EMG signals

To produce an Enveloped EMG we will now run a Root Mean Square (RMS) calculation. To do this hold down the **Ctrl key** and select the channels in **Remove Mean Output**

Then **right hand mouse click** and select **Calculation Script** then **Root Mean Square**

And then plot **Root Mean Square Output** as **Subplots**, FIGURE 9.



Cyclical Analysis

Cyclical analysis is a way of defining events which can then be used to plot the mean and standard deviation of multiple cycles. In this case flexion extension.

Select the signals you wish to include. Here, we've included the GyroX (forearm angular velocity) and the RMS of the Biceps and Triceps EMG signals, FIGURE 10.

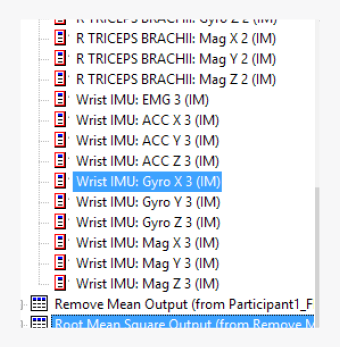


Figure 10: Selecting Wrist GyroX (forearm angular velocity) and the RMS of the Biceps and Triceps EMG signals

Then **right hand mouse click** and select **Calculation Script** then **Cyclical Analysis**

For this data we've selected Peak find for Wrist GyroX. I have set the cycle start at 2 seconds with an estimated cycle length of 2 seconds and a scanning window length of 1 second, FIGURE 11.

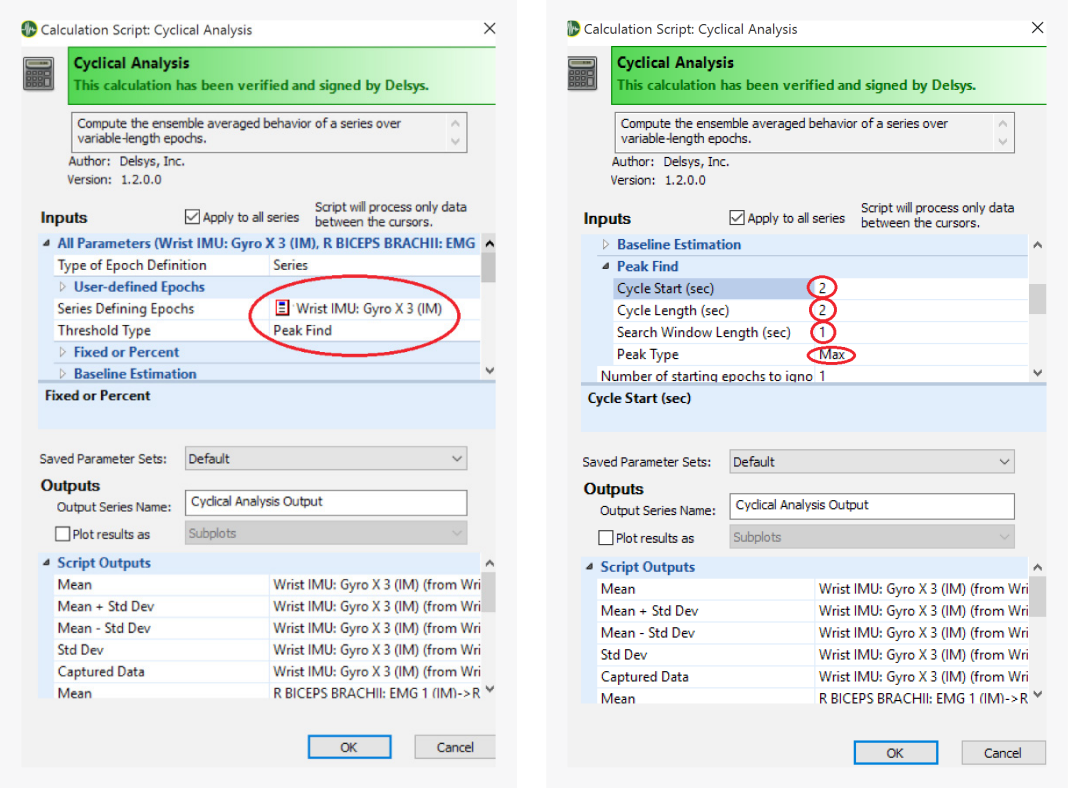


Figure 11: Cyclical Analysis set up

It is now possible to plot the mean and standard deviations of these signals, by selecting and then **right hand mouse click** and select **Plot Overlaid**, FIGURE 12-14.

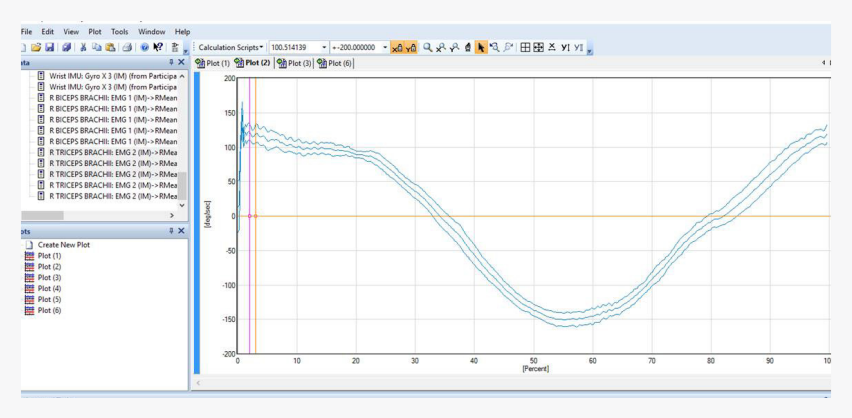


Figure 12: Forearm Angular Velocity mean and standard deviation (Concentric negative, Eccentric positive)

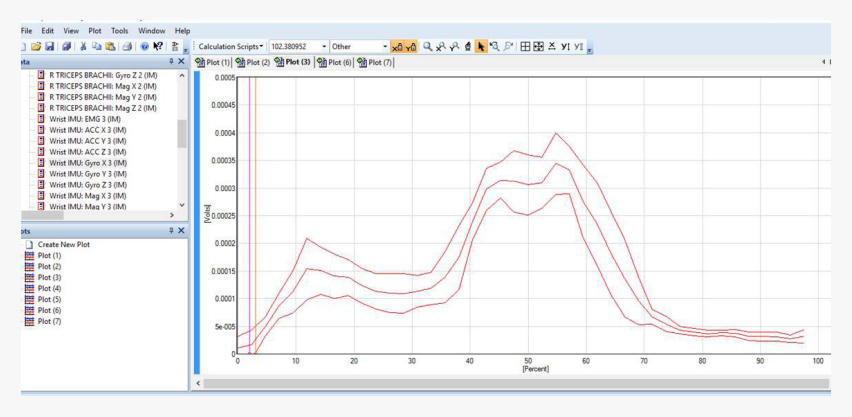


Figure 13: Biceps RMS mean and standard deviation (Eccentric-Concentric)

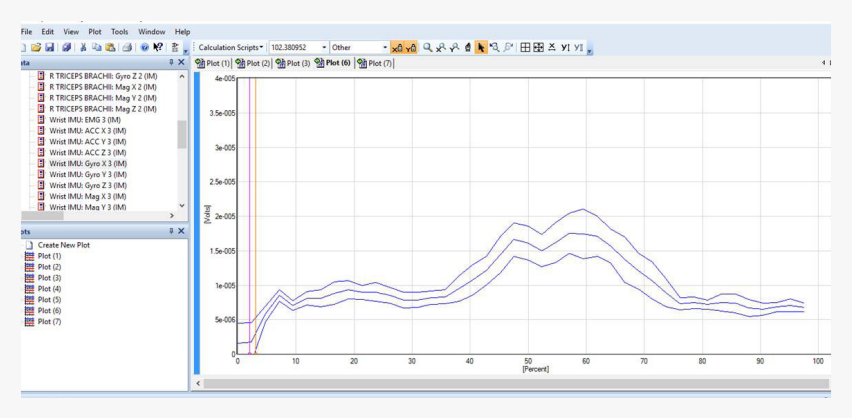


Figure 13: Triceps RMS mean and standard deviation co-contractions (Concentric-Eccentric)

Data Analysis
Elbow Flexion/Extension in Visual3d

EXPORTING THE DATA

Open the Delsys File Utility – this is a separate program that can be found in your program list, FIGURE 14.

Select the .hpf file that you are wanting, in this case "Participant1_Flex_Ext_5kg.hpf"

Tick C3D and UPSample hpf to .c3d, this will up sample all channels to the highest recorded in this case 1111 Hz as this is the highest frequency from the EMG from the Delsys IM sensors.

This will generate a file "Participant1_Flex_Ext_5kg_1111_111Hz_part1.c3d"

You could shorten this name without affecting the files in EMGworks, but we'll continue to use as is for consistency.

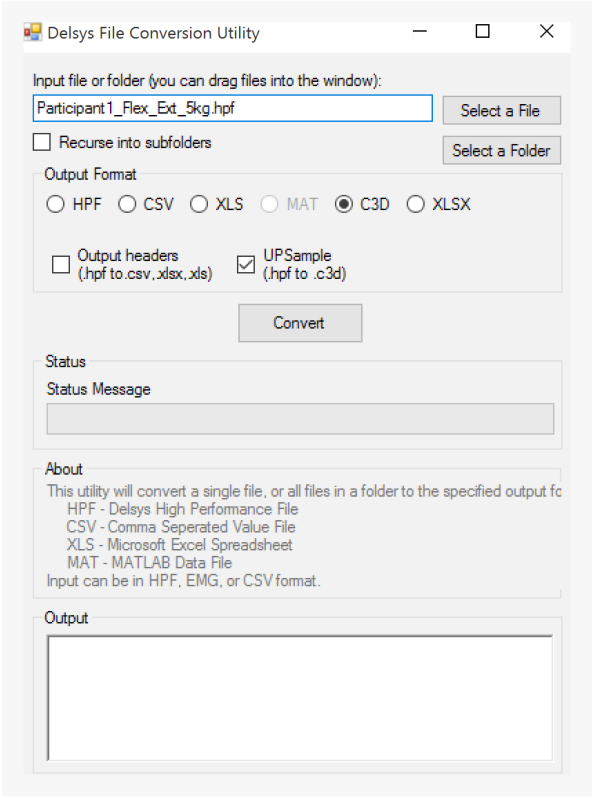


Figure 14: Export to c3d using Delsys File Utility.

BRINGING THE DATA INTO VISUAL3D

Open Visual3D

Go to – **File** – **Open** – and select "Participant1_Flex_Ext_5kg_1111_111Hz_part1.c3d".

RUNNING A PIPELINE IN VISUAL3D

A "pipeline" which contains a series of operations.

Click on **Pipeline** – Open Pipeline... – and click on "**flex ext pipeline.v3s**", FIGURE 15A.

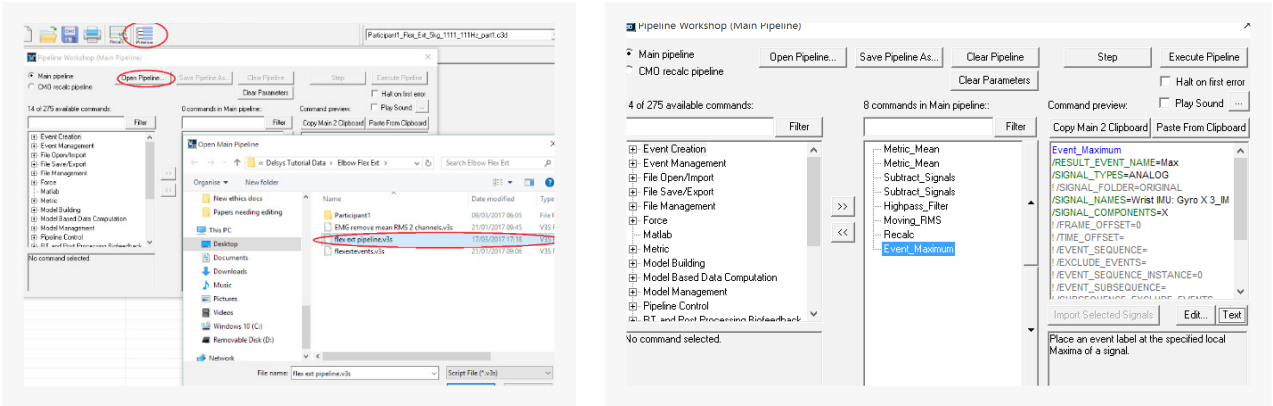


Figure 15: a) Opening a Pipeline, b) Running a pipeline in Visual3D

FIGURE 15B shows a pipeline to calculate the mean values "**Metric_Mean**" for the two EMG channels, in this case Biceps and Triceps, then subtracts the mean from these "**Subtract_Signals**" signals which performs the same operation as remove mean in EMGworks.

Next, we've applied a "**Highpass filter**" with a cut off frequency of 20 Hz which can be increased if you have

any movement artefacts, and a "**Moving RMS**" in this case with a window length on 23, or 0.021 seconds. This performs the same operation as RMS in EMGworks.

Finally, and most importantly we've created "Events". In this case, we've used the Maximum sagittal plane segment angular velocity of the wrist "Wrist IMU: Gyro X 3_IM".

This creates an event "**Max**" which is midway through the eccentric phase of the cycle.

Click on "Execute Pipeline"

RUNNING A REPORT TEMPLATE IN VISUAL3D

We are now able to bring in a report.

Click on the **Reports** tab, then and select "flex ext report.rgt", FIGURE 16.

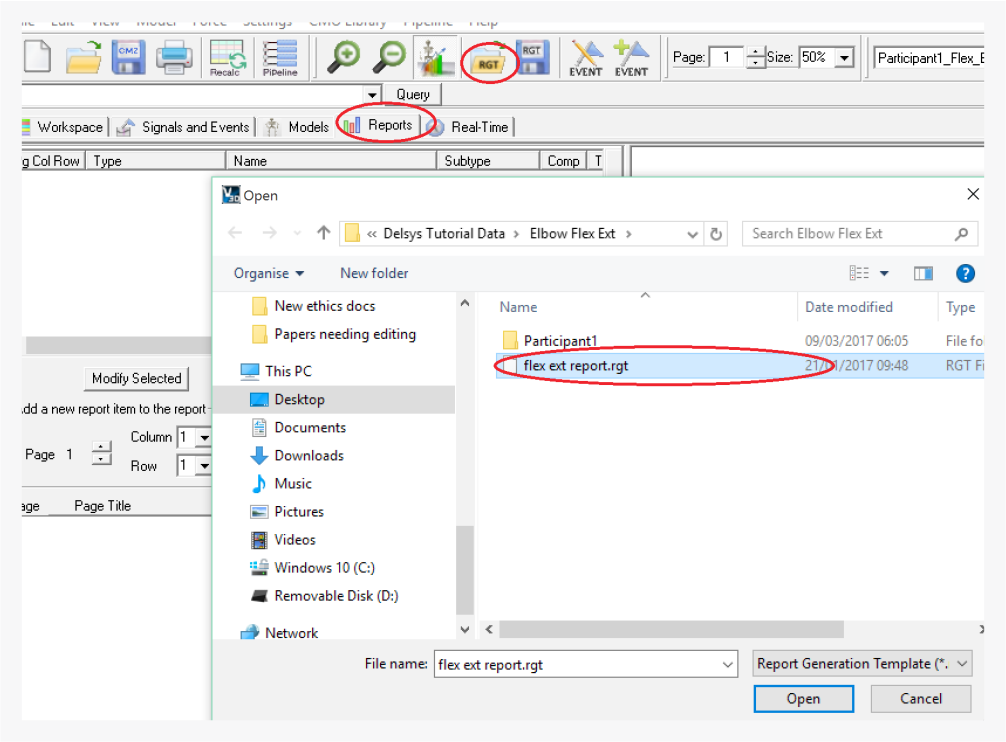


Figure 16: Running a Report Template in Visual3D

This is a simple report that will use the "Max" events

Page 1: Forearm Angular Velocity with individual repetitions

Page 2: Mean and Standard Deviation Forearm Angular Velocity with Raw EMG from Biceps and Triceps

Page 3: Mean and Standard Deviation Forearm Angular Velocity with Mean and Standard Deviation RMS EMG from Biceps and Triceps

If we review page 1 of the report we can see that we have three lines that do not agree with the rest, FIGURE 17.

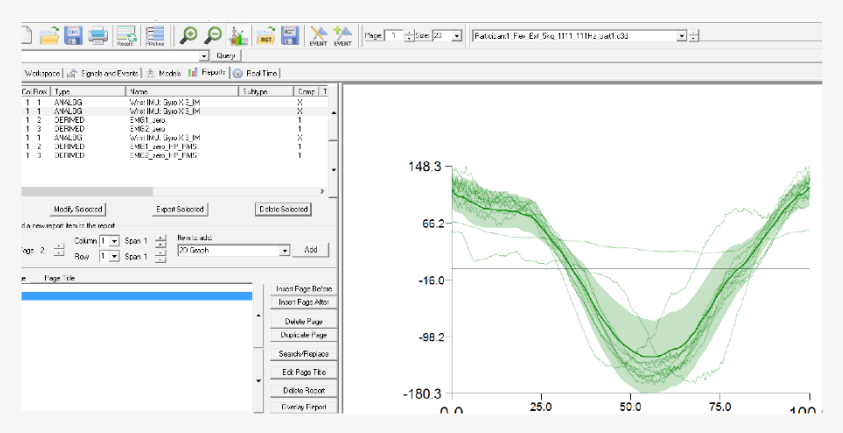


Figure 17: Inspection of Forearm Angular Velocity data

We can examine the events under **Signal and Events** and we can see the first two have been incorrectly identified, it is also often a good idea the remove the last event in the sequence as the person could be slowing down. To bring the data graph up right hand mouse click on the signal "Wrist GryoX" and plot as a new graph, FIGURE 18.

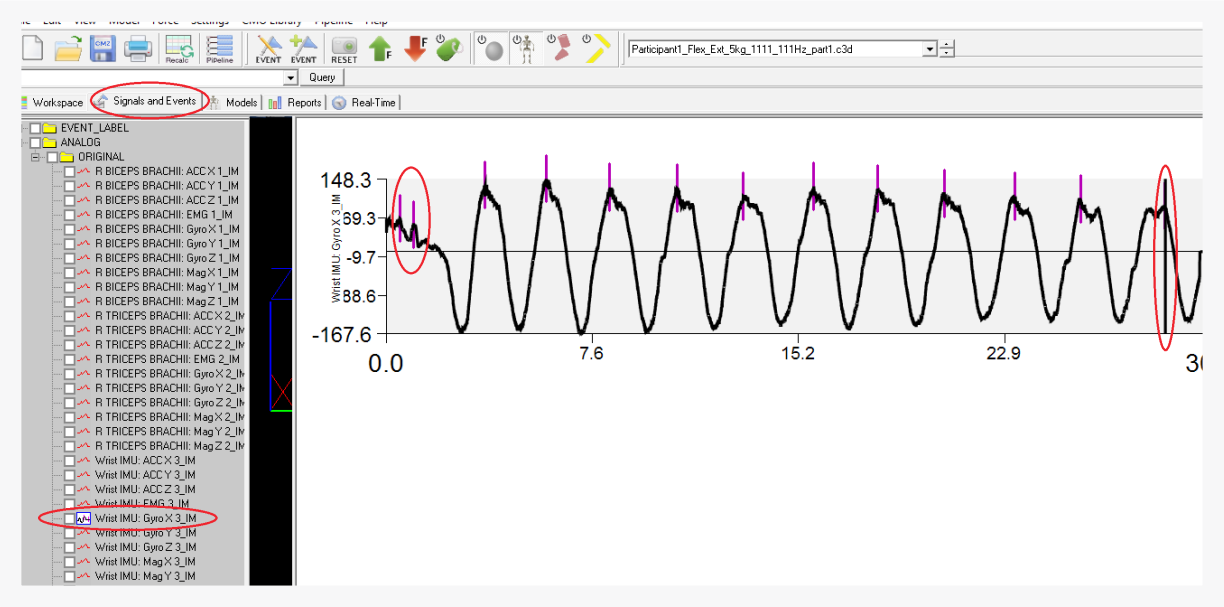


Figure 18: Inspection of the Events

These events may be seen by clicking the **Event** button. After their removal we can recalculate with **Recalc**, FIGURE 19.

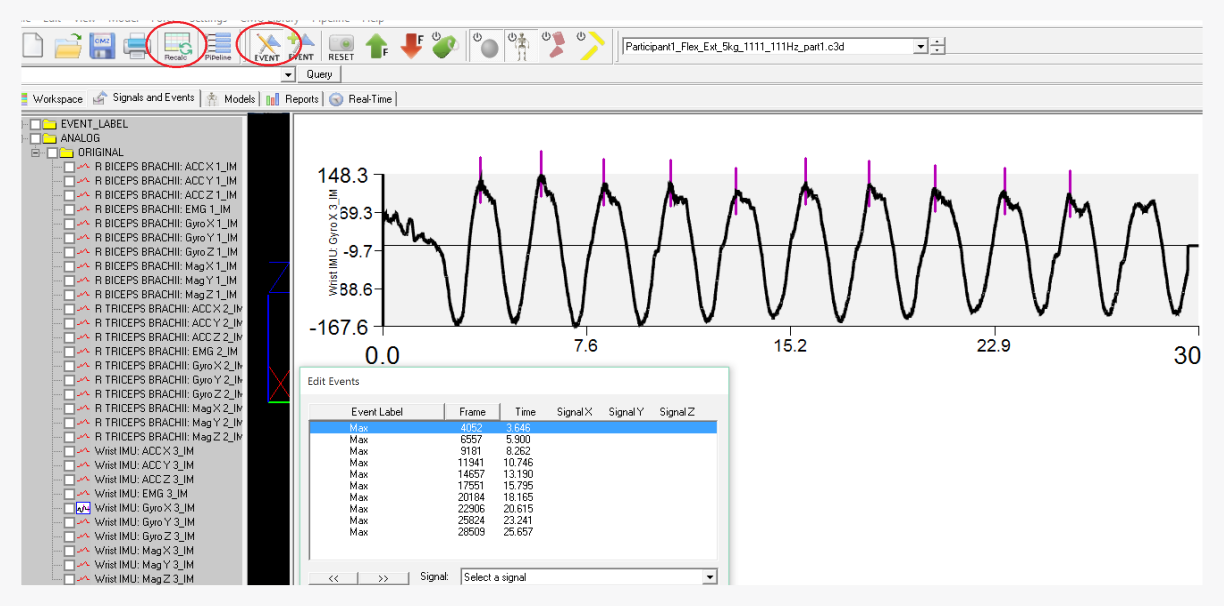


Figure 19: Modifying the Events

We can now go back to the Report and view Pages 1, 2 and 3, where we can see the Mean and Standard Deviation Forearm Angular Velocity and the Mean and Standard Deviation RMS EMG from Biceps and Triceps show excellent repeatability, FIGURE 20. The Forearm Angular Velocity shows that everything above the zero line is eccentric and everything below the line is concentric.

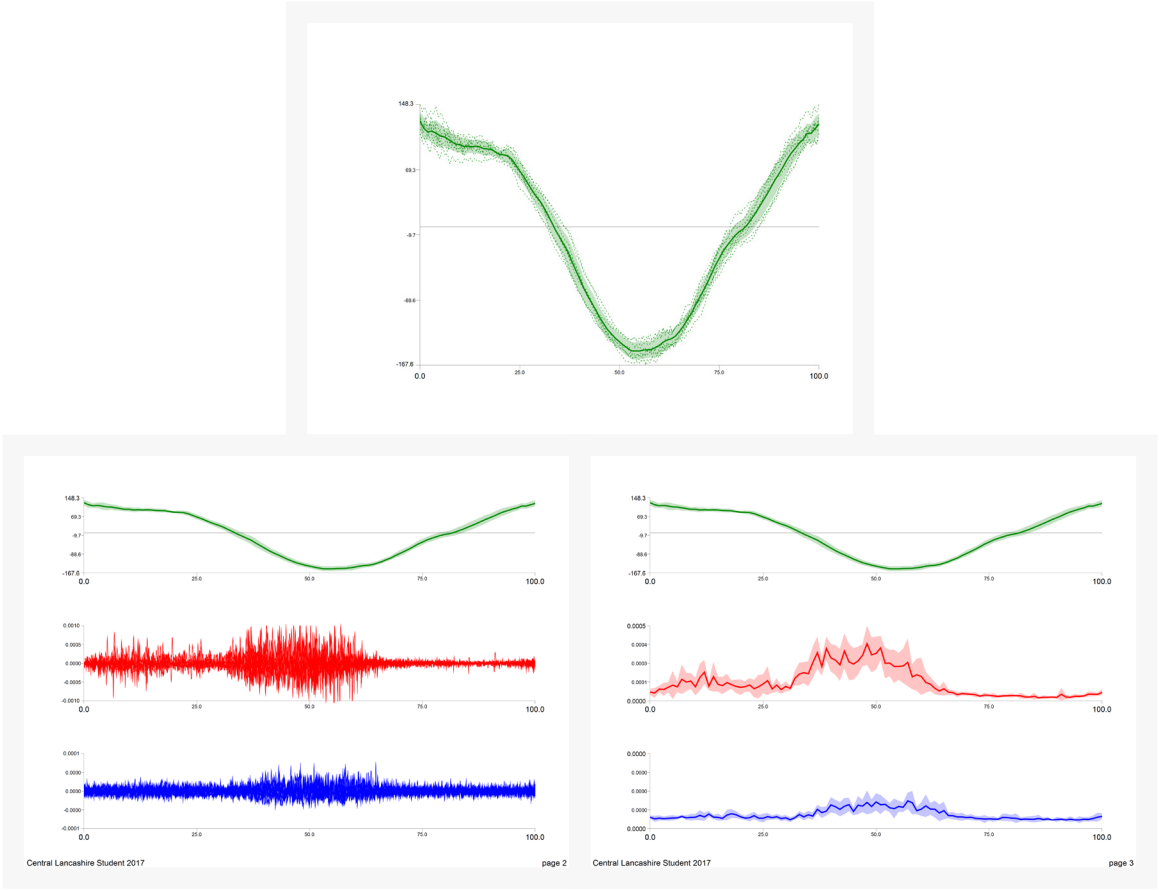


Figure 20: Mean and Standard Deviation RMS EMG from Biceps and Triceps

DELSYS INCORPORATED
23 Strathmore Road • Natick, MA 01760
(508)545-8200 • support@delsys.com
www.delsys.com